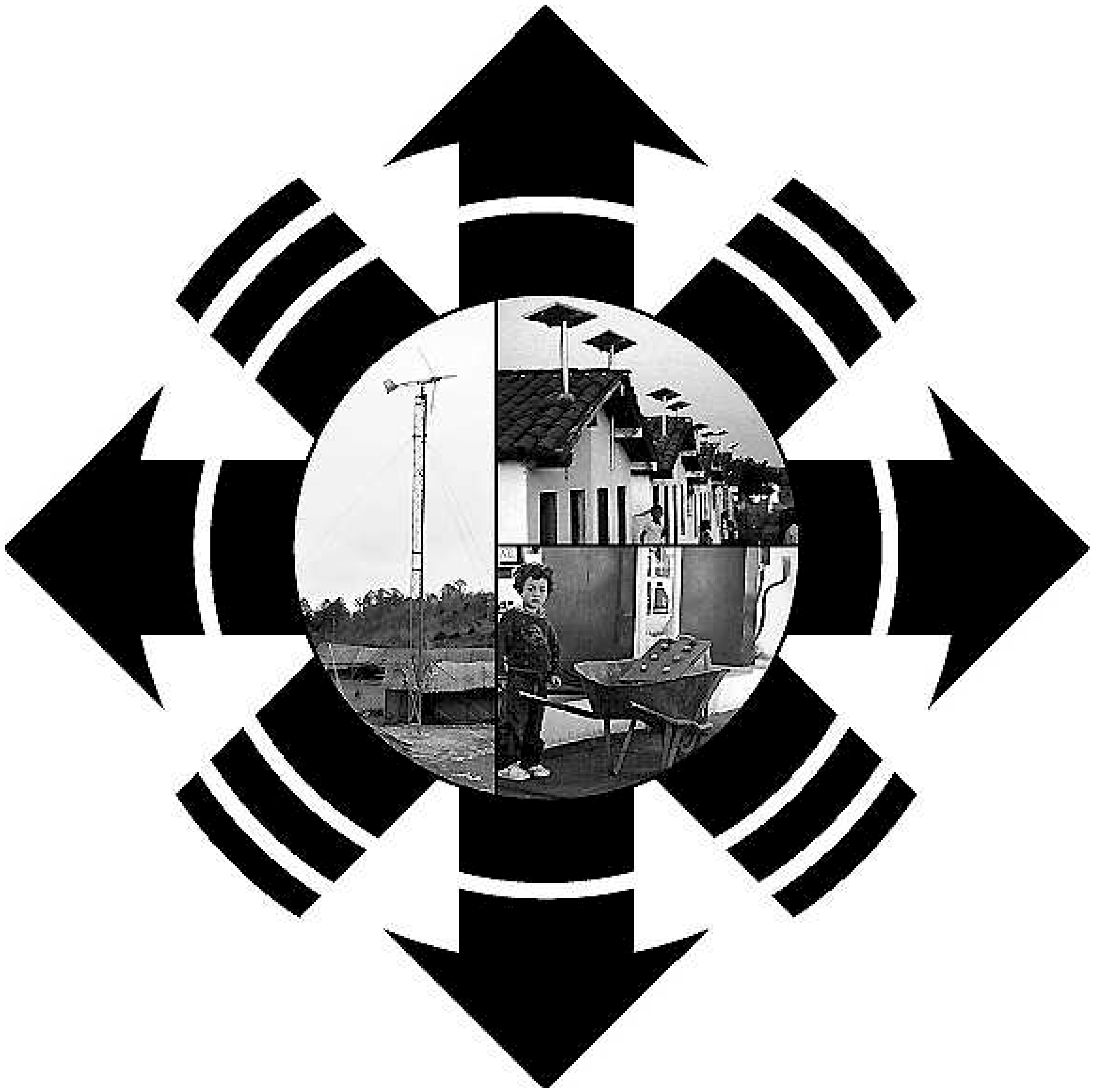

Proceedings of

Village Power '98

Scaling Up Electricity Access for Sustainable Rural Development

Volume I

Convened by the National Renewable Energy Laboratory
In collaboration with the World Bank
World Bank Headquarters, Washington, D.C.
October 6-8, 1998

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CP-500-26264

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A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

Printed March 1999

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Tuesday, October 6, 1998

09:00-09:30 **Opening Session**

- *Caio Koch-Weser, Managing Director,World Bank*
- *Richard Truly, Director, National Renewable Energy Laboratory*
- *Allan Hoffman, U.S. Department of Energy*

Brief Summary of Opening Comments at Village Power 98

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Richard Truly

Background

This is the fifth Village Power workshop sponsored by NREL. We have held these meetings every year since 1993, to focus, challenge, and provide a forum for interaction among practitioners working in the field of using renewable energy technologies as an economically viable pathway to electrification of rural populations throughout the world.

Starting with a small group of 30 colleagues in 1993, this "workshop" has doubled in size every year. When the NREL staff was planning for this meeting, they were hoping for something around 400 participants. We are now looking at over 500, and we apologize for the somewhat cramped accommodations.

This overwhelming response, however, shows that the use of renewable energy to solve some of the world's serious problems is coming of age. This meeting, this "conference" (it's clearly no longer a workshop) marks a transition.

A transition from the viewpoint that

> renewables are, and forever will be a technology of the future;
>
> to the reality that renewables have come of age,

We have technologies available today, at today's prices, that can make a substantive contribution to the pressing needs of environmentally sustainable development in the world.

Challenges

This reality is not without its challenges, of course:

Our key challenges now are:

> How to grow this emerging technical and financial opportunity into a business reality that is large enough to matter – an unprecedented scale of implementation that can have serious energy significance on the world's energy future.
>
> And how to do this quickly enough that it can begin to contribute to global environmental stabilization in a timeframe that matters.

Meeting these challenges and being effective supporters of renewable energy development and scale up, at a time of fiscal conservatism in the U.S. renewable energy sponsorship; and at a time of global economic slowdown in many of the countries with the biggest need for renewable energy deployment today – is itself a challenge.

But the community of dedicated practitioners is clearly growing. All you have to do is look around the room. A few years ago, everybody coming to the Village Power workshops knew a large percentage of their participating colleagues. I suspect that even the most experienced of you don't know more than 30 percent of the people in this room. This is good news! The community is growing, each of you with your own support, participating from your own unique perspective. Strength is in numbers. Strength is in diversity. You now have "critical mass" in both of these.

This Village Power '98 Conference, with it's subtitle: "Scaling up Electricity Access for Sustainable Rural Development" is clearly a timely event.

Have a great Conference, meet some new friends, and make your own mark on moving renewable energy technologies ahead in the global marketplace.

Brief Summary of Opening Comments at Village Power 98

Presented at Village Power 98
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Allan R. Hoffman

- It is a pleasure to welcome you on behalf of Secretary Richardson, Assistant Secretary Reicher and the U.S. Department of Energy

- It is good to see so many people in the audience - more than 500, compared to the 33 who attended the first Village Power conference in 1993

- The Carter Administration took the first serious look at Federal policy for renewables in 1978 by carrying out the 30-agency Domestic Policy Review of Solar Energy

- The past two decades have seen considerable progress in renewables development, and today renewables is becoming a big and growing business

- The World Bank, through its Solar Initiative and subsequent actions has a unique opportunity to advance worldwide use of renewable energy and make a real difference in people's lives

- Energy is key to rural development

- Use of renewables is key to reducing local environmental impacts of energy use in rural areas, particularly impacts on women and children in developing nations who often carry most of the burdens associated with gathering fuel and using energy

- Use of renewables is also key to addressing global climate change issues arising from energy use

- While today's energy system is largely dependent on fossil fuels, this situation cannot be projected into the long-term future

- We are in the early stages of an inevitable transition (50-100 years) to a new world energy system largely dependent on renewables

09:30-10:00 **Keynote Addresses**
•*Tim Wirth, Director, UN Foundation*
•*Ambassador Leonard Spearman, Director, Renewable Energy for African Development*

Keynote Address

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Ambassador Spearman

Good morning, and thank you for that introduction. I would like to begin by offering my gratitude for helping to make this conference possible to Mr. Koch-Weser of the World Bank, to Richard Truly of NREL, and to Allan Hoffman of the Department of Energy. I'd also like to recognize all of the staff at NREL and the World Bank whose attention to detail have helped us to frame the challenging agenda for this conference.

This Village Power Workshop is especially important coming on the heels of the recently concluded World Energy Conference in Houston. Finally, after many years, the World Energy Conference may be coming to recognize the importance of the renewable energy sector for rural development. I lived in Houston as President of Texas Southern University, and I can tell you that such a profound shift among those in the fossil fuel and utility industries has been a long time in the making. I believe that this shift is in large part a reflection of the efforts undertaken by the people in this room.

(THE CHALLENGE OF RURAL ENERGY)
I served as Ambassador in two African countries, and have followed the challenges and opportunities associated with village power most closely in Africa. To those of you with a focus elsewhere in the world, please bear with me if most of my examples come from the continent that I know well.

Despite the unrest which still beleaguers much of the African continent, I remain impressed by the emergence of many of the newer leaders as they embrace the basic tenets of democratic governance. They are well aware that accompanying increased freedom and self-governance, economic growth, access to education and health are essential ingredients to an improved social order. The role that energy plays in this process is too critical to rest solely on the statistical probability that power will eventually reach rural and urban communities. It is no coincidence that those countries embarking on the path to democracy—among them Uganda, Botswana, South Africa, and Namibia, are also launching ambitious village power programs.

All of us are cognizant of the reality that economic and social development throughout the developing world is hampered by a lack of access to economical and reliable sources of power. The advent and expansion of global communication-- or what might be called the "CNN Factor"-- has led to the misperception that city dwellers are modernizing, while the rural villages stagnate.

This misperception contributes to extremely high urbanization rates, not only in Africa, but around the world. Botswana has one of the world's lowest electrification rates, and its rural to urban migration rate is among the highest in the world. While I can't prove it, I don't think that this is a coincidence. Minister of Energy Mamadou Diouf of Senegal told me earlier this year that one his government's biggest concerns was Dakar's high urbanization rate. As such, he continued, the urban infrastructure is being strained in an effort to meet the increased health, education and job demands now placed on Dakar and other Senegalese cities. That same sentiment is frequently expressed to me by many Energy Ministries throughout the continent. And for the 40-60% who remain in the rural villages, a disproportionate share are women, as men move to urban areas seeking other forms of employment. These women who remain- aside from some subsistence gained from farming- often have little opportunity to earn a livable income. The irony, of course, is that women are the principal food producers in Africa, and stand to benefit most from improved access to energy in rural communities.

And yet, the people who flee their farms for the urban lights and amenities seldom find themselves better off. The infrastructure of the city does not have enough jobs to accommodate this burgeoning underclass. All of us-- even those in the Western world-- are painfully aware of the consequences that will accrue, i.e. rising crime rates, increased drug use, decaying schools, and the list goes on. The vicious circle is intensified when student test scores and family health suffer as fewer teachers and health professionals are willing to work in areas that are devoid of basic amenities like lighting and hot water.

I am not arguing that providing power in rural areas will keep people from migrating to the cities. Sometimes it will, and one of my observations from a study of a Botswanan village which received solar power is that some urbanized families were returning to their home village. In the words of one such family member, "Manyana looked like a real town now." However, even when rural power does not prevent migration, it can help to improve people's social and economic well-being, so that they are a benefit and not a burden to the urban community that they eventually join.

Village power can help people take advantage of economic development opportunities in rural areas. If farmers have access to markets, reliable power sources can help them increase the value of their products through regular irrigation, post-harvest processing, or improved storage and preservation. In Uganda, coffee farmers lose hundreds of thousands of dollars annually because they are unable to dry their crop sufficiently. The United States Government is supporting a dairy project in Kenya, but without power for refrigeration, much of the product spoils before getting to market. I believe that the promotion of productive applications is going to be critical to the success of village power programs.

(ROLE OF RENEWABLES)

The traditional approach to providing power in rural villages has been to expand the electric utility grid. As South Africa's municipalities and its utility are discovering, grid extension rapidly becomes too expensive. In a rural area near Durban, South Africa, the local municipality pledged a cost cap of 3,500 rands (about $700 at the time) per installation under its rural grid extension program. A local energy consultant reports that to date they have rarely spent less than one-and-a-half times that, and have now given up that grid extension effort.

With a line extension cost in excess of $10,000 per mile, most developing nations will never be able to bring electricity to the villages where most of the population lives. Instead households must continue to rely on smoky fuels like coal and wood for heat, and dangerous kerosene or expensive dry cells batteries for lighting. Burning wood and dung for cooking expose children and women to harmful indoor air pollution, reduces soil fertility, and accelerates deforestation rates.

I experienced this problem as a personal tragedy, when, as Ambassador to Lesotho, I received a call from the sister of my driver. It appears that on a cold night, he, like many Basotho, lit a coal fire. Unfortunately, he died from exposure to the fumes that built up in his one room apartment.

(THE ROLE OF THIS CONFERENCE)

So what can you in your deliberations over the next few days to overcome the barriers to the expansion of renewable technology and abate this serious state of affairs? Participants at the September 1997 World Solar Summit in Harare noted that the growth of sustainable renewable energy use in Africa faced many barriers:

- Lack of appropriate financing mechanisms for rural customers;
- Inadequate distribution and maintenance infrastructure for renewable energy technologies;
- Poor standardization and quality control measures; and
- Relative inexperience of developing country renewable energy enterprises.

We can overcome each of these barriers, and these topics will form the bulk of the deliberations over the next several days.

We know that the governments of most developing nations are anxious to cooperate in bringing energy to the rural sectors of their economy. In 1989, prior to the civil strife in Rwanda, we prepared a report in partnership with that country's government on the hidden economy-- which is another phrase for the rural economy. The reliability of the women in that sector convinced me that they are anxious to get on with the business of poultry production, making school uniforms, hairstyling and a host of other activities-- if they could only extend their day and get access to lights and power. Those of you here have the means of extending that day. You have the capability of reducing the plethora of debilitating diseases that plague their children by providing hot water and vaccine refrigeration.

You have the capability of making it possible for children to read at night and thus improve their educational opportunities. You have the ability to permit rural enterprises to flourish both day and night. This Workshop may be just the impetus we need to raise the role of renewables in addressing many of the problems affecting the millions who reside in our rural villages.

(THE CALL TO ARMS)

I've talked so far about the need for reliable sources of power in rural communities around the world, and about the promise that renewable energy technologies in particular hold for providing village power. Many of you have heard all of this before, so now I would like to pose a question:

"What's taking so long?"

The World Bank published its "Best Practices for PV Electrification" document several years ago. Why haven't those projects already been replicated worldwide? We're told that rural electrification is a multi-billion dollar opportunity for industry. Sales are increasing, but is anyone in the PV or wind industry in danger of threatening Bill Gates as the world's richest person?

Perhaps the answer is that many of us have been looking for a "magic bullet"-- a single fix that will jump start village power programs around the world. At first we believed the magic bullet was technical: let's make sure the battery is suited to the PV system; let's make sure the wind assessment is done correctly.

For most of this decade, we have believed the magic bullet is access to capital. "If only the perfect finance mechanism were developed," we were told, "thousands of village power projects would take off." Well, now there are a wide variety of large and small finance programs underway, with more acronyms than I care to count. And yet most rural villages remain without power.

Energy plays a fundamental but complex role in urban and rural society, and our approach to making reliable energy available has to acknowledge that complexity.

Taking a single approach to a problem is not unique to renewable energy. As a former Ambassador through two Presidential Administrations, I've learned that you focus on those battles that you have a chance of winning. But given the complexity of energy's societal role, it may prove useful, I think essential, to broaden our understanding.

Let's look at the issue of finance, as an example. We believe we have to address the problem that rural communities lack access to capital. We have developed beyond simply subsidizing rural electrification, and there now exist a growing number of public and private initiatives underway to provide affordable credit. As Chairman of Renewable Energy for African Development, my organization helped design and implement an end-user credit program for solar systems in Namibia, which has since been re-capitalized and expanded with European donor support.

But is addressing credit the only way to make systems affordable? What would happen to worldwide sales if we built PV systems that cost fifty cents per watt, instead of $4? If we can build better and less expensive systems, it might make the job of those providing rural credit easier.

But would even this be enough? If people cannot afford renewables, what can we do to increase their purchasing power? Can we jump-start a process, a "virtuous circle", whereby strengthening incomes helps people to afford renewables, which themselves can help provide direct economic benefits?

Let's look at another "magic bullet" -- technical training for ensuring system reliability. Many organizations have moved from providing expatriate trainers from the North to providing "Training of Trainers" workshops, where host country nationals are given the capability to develop and conduct technical training on their own. Properly done, this approach can be highly successful, and our group has trained dozens of technical instructors throughout Southern Africa, to the point that we have helped to change the way many technical subjects are taught in African schools and universities. There are even initiatives underway for worldwide trainer accreditation, and certification of those who have undergone that training.

But what if we had renewable energy systems that were so low-maintenance and easy to understand that only the most cursory training were required in the first place? I say this not to discredit the current training approach. Instead I want to stress that energy plays a fundamental but complex role in urban and rural society, and our approach to making reliable energy available has to acknowledge that complexity.

One dimension to this complex puzzle that is only now beginning to gain attention is gender. When I use the word gender, I'm talking about the different complex roles that men and women play in society around the world. One gender difference that has been well established: women are good credit risks. This point was discussed at some length during Monday's pre-conference workshop on gender and renewable energy, and I believe it is important that it be addressed in the many energy finance discussions that will take place over the next several days.

As I mentioned earlier, another gender difference is that women are often the primary energy users in rural communities, and thus the greatest beneficiaries of village power projects. In South Africa, a solar project initiated in the community of Maphephethe was stalled, seemingly against all odds. Realizing this, the project manager switched his approach and hired local women as outreach and sales agents instead of men. These women were able to identify the problems and concerns of their counterparts, and overcame some of the communications barriers that formed when local men addressed the same women. Loan subscription rates increased dramatically, and the South African government is looking to replicate that success.

On the technical reliability front, the fact that men are more likely to migrate to urban areas for employment affected the training component of the Zimbabwe GEF solar project. When Zimbabwe's Biomass Users Network trained rural men in system maintenance, these men promptly took their skills to the city, where they could make more money. The rural women, however, tended to remain in the village after training, and have proven crucial to that component of the GEF project.

Both of these examples point to how we must adjust our thinking in order to ensure both that our projects are successful, and that they reach those who will benefit from them the most. In terms of meeting our initial targets and achieving long term project sustainability, it is important that we make every effort to involve women as well as men.

(CONCLUSION)

There is no single magic bullet that will enable us to rapidly scale up the provision of power in rural villages. If it were that easy, we wouldn’t have taken the time-- once again-- to set aside our important day-to-day work, gather together from around the world, and share our ideas and experiences. However, we have learned a great deal working together over the years, and I’m confident that we’ll be able to report on our successes, and continue to chart a way forward, when we meet again next year.

Thank you all very much.

10:15-11:15 **Defining the Problem: Scaling-up Electricity Access for Sustainable Rural Development**
- *Chair, Callisto Madavo,* Vice President for Africa,World Bank

•The Asia Challenge - *Mieko Nishimizu, Vice President, South Asia, World Bank*

•Latin America and Caribbean Needs for Rural Energy – *Ambassador Christopher Thomas, Assistant Secretary General, Organization of American States*

•The Challenge and Needs in Africa - *Mark Tomlinson,World Bank*

"Coming out of the Darkness..."

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Mieko Nishimizu

I want to share with you this morning how my colleagues in the South Asia Region and I think about the centrality of "Village Power" to our mission -- poverty alleviation.

Ask any village woman you meet in South Asia, what she wants most of all.

"I want to come out of the darkness, and learn to read and write," she will say.

From Pakistan to Bangladesh, Sri Lanka to Nepal, Bhutan to India, from village to village, all over the subcontinent, their language may be different, but their dreams are the same.

In South Asia, people say:

"Educate a boy, one only educates a human being, Educate a girl, one educates generations to come."I mean no offence to you gentlemen, but am sure you understand me well.Girls' education, and women's literacy, is central to poverty alleviation, sustainable social and economic development, and nation building.

So, I walked the grass roots, listened to village sisters, and thought I understood them.

I thought "coming out of the darkness" meant out of their illiterate mental darkness.

How wrong I was...

In May this year, just before the nuclear tests of India and Pakistan, I spent 2 days and nights in a highland village of Azad Jammu Kashmir, Pakistan. There I met a widow, and she told me about her daily life.

"I get up before the sun, and fetch the water and fuel wood...
One hour going up and one hour coming down the mountain.
Start fire, make bread and tea for the children.
Feed my cow and goats.
Clean the animal shed, sweep the house.
I may eat, if anything is left.
Go out to the field, before the sun gets too hot.
I grow wheat and vegetables. No, I don't grow enough to sell.

Give children some tea, sometimes only warm water.
Go back to the field again.
I may do some wash.

Go fetch the water and wood again before the sun goes down.
Takes longer in the afternoon. It is hot and I am tired.
Start fire again, and make supper -- some bread and lentils.
Sometimes, only tea to drink.
More housework.

I talk with my children before sleeping -- I like this time best."

Then and only then I realized what "coming out of the darkness" really meant.

Imagine living your life like that -- day in, day out, 365 days per year, every year, for the rest of your life.

She taught me that "coming out of the darkness, to learn read and to write" means:

to break out of such sub-human drudgery,
to have that little precious time for their personal growth as a mother and human being, and
to come out of the mental darkness.

She has access to an adult literacy program. But, 24 hours a day is barely enough just to survive.

In 1996, a Rural Household Energy Survey studied 5,048 households across India. Can you guess how much time a literate Indian village woman spends in reading? 8 minutes and 24 seconds per day!

West Bengal is a state known for its literary tradition, but low rural electricity access.

An average West Bengali village woman reads 3 minutes and 36 seconds per day.

Punjab is a state with less literary accomplishments, but better rural electricity access. An average Punjabi woman spends more than 17 minutes reading each day...

South Asia's village women need desperately to save time, to gain literacy,

to look after their own health, and of their children,
to help their children learn,
to participate in income generating activities, and
to escape the poverty trap.

To come out of the darkness, of poverty of mind and of means, they need access to village power, to save that precious time.

And when they do, social and development impact of women's empowerment extends well beyond just one woman, to her family, to her community, and for generations to come.

That, is how my colleagues and I think about the strategic centrality of "Village Power" to our mission -- to alleviate poverty in South Asia.

South Asia has a total population of about 1.3 billion people, the majority in rural areas: (Bhutan - 94%; Nepal- 89%; Bangladesh - 81%; Sri Lanka - 78%; Maldives - 73%; India - 74%; and Pakistan - 65%)

About half, or 700 million, of South Asia's population have no access to electricity.

So, of 2 billion who lack access to energy worldwide, more than a third live in South Asia.

At least 350 million women in rural South Asia need electricity to free them from the bondage of traditional fuel transportation and water portage, smoky cooking, the dangers of lightless nights, and most of all, to gain the literacy they want so badly.

Yet, in many parts of the region, electricity distribution cables run through, over, and around villages, but the people lack access to this power.

Governments in the Region have invested tremendous amounts of resources in electricity generation, transmission, and distribution. But, these Utilities and the clientele they serve are:

bankrupt and insolvent;
inefficient and ineffective;
corrupt, steal the electricity, or unwilling to pay for it; and
benefit from subsidies intended for the poor and rural population.

Yes, we do get angry whenever we see these conditions, and become even more passionate in our power sector work for poverty alleviation. Country Assistance Strategies for all countries which are active borrowers in the region have clear and sector-wide strategies for addressing power and poverty alleviation.

We believe in a comprehensive approach that includes both radical power sector reform, and also Village Power and partnership with other agencies and entities, which can provide leadership and sustained support.

I do look forward, very much, to the fruits of this gathering of experts, to help us fight poverty in our region.

Thank you.

Latin American and Caribbean Needs for Rural Energy

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Ambassador Christopher R. Thomas

SPECIALLY INVITED GUESTS,
LADIES AND GENTLEMEN:

IN THE CONTEXT OF DEVELOPMENT FOR THE TWENTY-FIRST CENTURY, THE QUESTION OF ENERGY PRODUCTION AND SUPPLY IS A KEY FACTOR. OUR CURRENT INTERNATIONAL ENVIRONMENT CANNOT BE SUSTAINED WITHOUT ENERGY; AND ENERGY WILL CONTINUE TO BE A FUNDAMENTAL ELEMENT FOR OUR FUTURE PRODUCTION.

THE ORGANIZATION OF THIS CONFERENCE AS A JOINT VENTURE BETWEEN THE NATIONAL RENEWABLE ENERGY LABORATORY (NREL) AND THE WORLD BANK ON SCALING UP ELECTRICITY ACCESS FOR SUSTAINABLE RURAL DEVELOPMENT, REFLECTS A MERGING OF POLICY AND FINANCE IN THE INTEREST OF THE RURAL ELECTRIFICATION AGENDA FOR LATIN AMERICA AND THE CARIBBEAN. IT IS IMPORTANT THAT SUCH EFFORTS BE TRANSLATED INTO CONCRETE PROGRAMS AND PROJECTS WHICH WILL GENERATE DEVELOPMENT OF OUR RURAL AREAS IN THE IMMEDIATE FUTURE.

IT IS CUSTOMARY TO SEE RURAL AREAS AS HAVING VERY LIMITED NEED FOR ENERGY BEYOND THAT PROVIDED BY TRADITIONAL SOURCES SUCH AS FIREWOOD, BAGGAS, CHARCOAL, RICE HUSK OR KEROSENE OIL, DEPENDING ON WHAT IS MORE NATURALLY OR CHEAPLY AVAILABLE IN A PARTICULAR AREA. THESE TRADITIONAL PERCEPTIONS, HOWEVER, MUST CHANGE AS THE CIRCUMSTANCES AND NATURE OF DEVELOPMENT HAVE EVOLVED IN WAYS

WHICH REQUIRE WIDESPREAD DISTRIBUTION OF LOW COST ENERGY TO EVEN THE MOST REMOTE RURAL COMMUNITIES.

THE GLOBAL COMMUNITY HAS MADE GREAT STRIDES OVER THE LAST TWO DECADES. NOT TOO LONG AGO OUR GLOBAL SYSTEM WAS HEAVILY REGULATED BY NATIONAL GOVERNMENT AND CORPORATE POLICIES. TODAY, IT HAS BECOME A HIGHLY INTERCONNECTED SYSTEM, PROGRESSIVELY DEREGULATED AND RAPIDLY CONSOLIDATING A PROCESS OF GLOBALIZATION OF UNPRECEDENTED IMPLICATIONS FOR ALL COUNTRIES.

GLOBALIZATION IS NOT SIMPLY A PHENOMENON AFFECTING THE ECONOMIC, FISCAL AND EVEN SOCIO-CULTURAL DIMENSIONS OF INTERNATIONAL RELATIONSHIPS. IT IS RATHER A FORCE OPERATING WITH A DYNAMISM WHICH CAN ONLY BE SUSTAINED IF CERTAIN CONDITIONS EXIST. THESE CONDITIONS RANGE FROM READILY AVAILABLE TELECOMMUNICATION/INTERNET SERVICES, READILY AVAILABLE TRANSPORTATION FACILITIES, EASY ACCESS TO THE OUTSIDE WORLD, AND SUSTAINABLE USE OF NATURAL RESOURCE FOR INCREASED PRODUCTION OF GOODS AND SERVICES

GLOBALIZATION CAN ONLY BE SUSTAINED UNDER THOSE CONDITIONS IF THERE EXISTS A NON-DISCRIMINATE AND COMMERCIALLY VIABLE AVAILABILITY AND USE OF ENERGY – THE TYPE OF ENERGY, WHICH WILL OFFER CONTINUED ECONOMIC GROWTH WHILE AT THE SAME TIME OFFERING INCREASED ENVIRONMENTAL PROTECTION. THE INCREASING RURAL POPULATIONS OF LATIN AMERICA AND THE CARIBBEAN MAKE THIS TYPE OF ENERGY AN INDISPENSABLE REQUIREMENT. INDEED, GIVEN THE TREMENDOUS ECONOMIC DISPARITIES OF OUR REGION AND THE HEMISPHERIC PRIORITY NOW FOCUSSED ON THE ALLEVIATION OF POVERTY, THE OPTIMIZATION OF ENERGY SOURCES AND USAGE IS CENTRAL TO FUTURE DEVELOPMENT.

THE EXPRESSION ‘RURAL’ COMMUNITIES EVOKES IDEAS OF REMOTENESS, DISTANCE, AND INACCESSIBILITY. THE EXPRESSION SOMETIMES CONJURES UP A SENSE OF HOPELESSNESS IN THE FACE OF THE DIFFICULTIES TO BE OVERCOME IN BRIDGING THE GAP IN THEIR DEVELOPMENT. HISTORY HAS SHOWN US, HOWEVER, THAT WHENEVER IT WAS NECESSARY MAN CONQUERED THE SEAS, MOUNTAINS, RIVERS, AND FOREST IN SEARCH FOR WHAT HE CONSIDERED VITAL TO HIS SURVIVAL AND FOR THE FUTURE OF HUMANITY. THE CHALLENGE OF MEETING THE ENERGY NEEDS OF RURAL AREAS IN LATIN AMERICA AND THE CARIBBEAN IS THEREFORE MINIMAL IN THE FACE OF THE SOLID ACHIEVEMENTS WHICH TESTIFY TO THE EXTENT OF OUR POSSIBILITIES. I AM ALSO PLEASED TO NOTE HERE THAT THIS CHALLENGE IS NOW FRONTALLY ENGAGED BY THE LEADERSHIP OF OUR REGION.

IN THEIR PREPARATION FOR THE SECOND HEMISPHERIC SUMMIT OF THE AMERICAS HELD IN CHILE EARLIER THIS YEAR, WORKING GROUP NUMBER SEVEN, CHARGED WITH DEVELOPING STRATEGIES FOR RURAL ELECTRIFICATION IN THE HEMISPHERE, HAD THE FOLLOWING OBJECTIVES:

> “TO PROMOTE AND ACCELERATE THE DEVELOPMENT OF ECONOMICALLY SUSTAINABLE SOLUTIONS THAT WILL INCREASE ENERGY SERVICES IN RURAL AND INDIGENOUS COMMUNITIES THROUGHOUT THE HEMISPHERE;
>
> TO ESTABLISH HEMISPHERIC COOPERATION FOR IMPLEMENTATION OF SUSTAINABLE RURAL ELECTRIFICATION DEVELOPMENT;
>
> TO PROMOTE THE FLOW AND DISSEMINATION OF INFORMATION, FOSTER TECHNICAL COOPERATION, STIMULATE PRIVATE SECTOR INVOLVEMENT AND TO ESTABLISH COORDINATED STRATEGIES TO RESOLVE RURAL ELECTRIFICATION ISSUES AMONG THE COUNTRIES IN THE HEMISPHERE, TAKING INTO CONSIDERATION THEIR SOCIAL, CULTURAL, ENVIRONMENTAL, GEOGRAPHIC AND ECONOMIC DIFFERENCES.”

THESE OBJECTIVES REFLECT THE GROWING AWARENESS OF LATIN AMERICAN AND CARIBBEAN COUNTRIES OF THE NEED FOR ENERGY SUPPLY IN ORDER TO PROMOTE THE ECONOMIC GROWTH OF THEIR COMMUNITIES, IN THE CONTEXT

OF NATIONAL AND HEMISPHERIC OBJECTIVES. THESE OBJECTIVES ALSO UNDERLIE THE COMMITMENT OF THE HEADS OF GOVERNMENT OF THE HEMISPHERE WHEN THEY STATE IN THEIR PLAN OF ACTION THAT:

> "…SUSTAINABLE ENERGY DEVELOPMENT AND USE PROMOTE ECONOMIC DEVELOPMENT AND ADDRESS ENVIRONMENTAL CONCERNS. GOVERNMENTS AND THE PRIVATE SECTOR SHOULD PROMOTE INCREASED ACCESS TO RELIABLE, CLEAN AND LEAST COST ENERGY SERVICES THROUGH ACTIVITIES AND PROJECTS THAT MEET ECONOMIC, SOCIAL AND ENVIRONMENTAL REQUIREMENTS WITHIN THE CONTEXT OF NATIONAL SUSTAINABLE DEVELOPMENT GOALS AND NATIONAL LEGAL FRAMEWORK."

THEY FURTHER COMMITTED THEMSELVES TO "IDENTIFY FOR PRIORITY FINANCING AND DEVELOPMENT AT LEAST ONE ECONOMICALLY VIABLE PROJECT IN EACH OF THE FOLLOWING AREAS: NON-CONVENTIONAL RENEWABLE ENERGY, ENERGY EFFICIENCY AND CLEAN CONVENTIONAL ENERGY."

PROJECTS IN THE AREAS MENTIONED ABOVE ARE VITAL FOR THE FUTURE DEVELOPMENT OF RURAL COMMUNITIES IN LATIN AMERICA AND THE CARIBBEAN BECAUSE OF THE ENORMOUS DISADVANTAGE OF NEGLECT WHICH AFFECT THESE COMMUNITIES. WHEN FUNDS ARE LOW, THEY ARE USUALLY THE FIRST TO BE FORGOTTEN AND RURAL AREAS FIND THEMSELVES FACING A NUMBER OF HANDICAPS, MANY OF WHICH ARE AGRAVATED BY THE ABSENCE OF ELECTRICITY SUPPLY. THESE DISADVANTAGES RANGE FROM: ABSENCE OF PROPER SOCIAL SERVICES (E.G., HOSPITALS AND SCHOOLS), NON-EXISTENCE OF ALMOST ALL COMMERCIAL ACTIVITY, LIMITED POSSIBILITIES FOR DEVELOPMENT EVEN IN THOSE SECTORS WITH THE GREATEST POTENTIAL (E.G., TOURISM); TO LIMITED INTERACTION WITH THE OUTSIDE WORLD – A CONDITION WHICH REINFORCES THE RETARDATION OF THESE COMMUNITIES

ONE OF THE BASIC FINDINGS OF THE UNITED NATIONS CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY OF 1981 WAS THAT THERE WAS TREMENDOUS POTENTIAL SOURCES OF ENERGY IN MANY RURAL AREAS OF THE WORLD WHICH COULD BE TAPPED FOR PRODUCTIVE DEVELOPMENT. IN LATIN AMERICA AND THE CARIBBEAN, NON-CONVENTIONAL RENEWABLE ENERGY, SUCH AS SOLAR, WIND AND GEOTHERMAL POWER, ARE RELIABLE SOURCES WHICH CAN BE PROFITABLY EXPLOITED FOR RURAL ELECTRIFICATION AND PRODUCTION.

INVESTMENT IN RENEWABLE ENERGY INCREASES ENERGY SECURITY BY DEPENDENCE ON LOCAL RESOURCES AND THE APPLICATION OF ENERGY EFFICIENCY STRATEGIES IN CONSUMPTION PATTERNS. PROJECTS IN THE PRODUCTION OF SUCH ENERGY HAVE ALREADY BEEN IMPLEMENTED IN SOME COUNTRIES IN LATIN AMERICA. BOLIVIA IS A CASE IN POINT.

THERE IS NEED, HOWEVER, FOR MANY MORE SUCH PROJECTS IN OTHER RURAL AREAS OF LATIN AMERICA AND THE CARIBBEAN. SUCH PROJECTS COULD ALSO INCLUDE THE EXPORT OF ELECTRICITY FROM ONE COMMUNITY TO ANOTHER WITHIN AND ACROSS NATIONAL BORDERS. THIS WOULD, OF COURSE REQUIRE THE ELABORATION OF REGULATIONS GOVERNING INTERNATIONAL TRADE IN ENERGY. HOWEVER, WITH HEMISPHERIC POLITICAL WILLINGNESS FOR ACTION IN THIS AREA ALREADY IN PLACE, THE FUTURE SEEMS ENCOURAGING.

WHAT APPLIES FOR NON-CONVENTIONAL ENERGY ALSO APPLIES FOR SUCH CONVENTIONAL ENERGY SOURCES AS PETROLEUM AND NATURAL GAS. EXPERT STUDIES, HOWEVER, INDICATE THAT AT THE RATE OF PRESENT GLOBAL CONSUMPTION, MOST FOSSIL FUEL SUPPLY WILL BE SIGNIFICANTLY DEPLETED WITHIN THE NEXT TWO DECADES. WITH OR WITHOUT THAT DEPLETION, GLOBAL ECONOMIC DEVELOPMENT CANNOT BE SUSTAINED ON CONVENTIONAL

ENERGY SOURCES INDEFINITELY. SINCE GLOBAL DEVELOPMENT AND STABILITY MUST ULTIMATELY BE A FUNCTION OF RURAL DEVELOPMENT, FUTURE HEMISPHERIC DEVELOPMENT IS AN INTERRELATION RATHER THAN A PRODUCT OF RURAL DEVELOPMENT.

ONE BY NO MEANS ASSUMES THAT IMMEDIATE AND EFFECTIVE RESPONSE IN THIS CONTEXT WILL BE EASY. HARNESSING THE ENGINES OF GROWTH TO ENSURE DEVELOPMENT, ESPECIALLY RURAL DEVELOPMENT, HAS ALWAYS BEEN A DIFFICULT TASK IN LATIN AMERICA AND THE CARIBBEAN. BARRIERS APPEAR FORMIDABLE. HOWEVER, MANY OF THESE BARRIERS CAN BE GRADUALLY OVERCOME IF APPROPRIATE PUBLIC POLICY CAN BE ELABORATED AND IMPLEMENTED IN RELEVANT SECTORS AS THEY RELATE TO RURAL DEVELOPMENT.

IN MOST INSTANCES, PUBLIC POLICY CAN BE IMPORTANT ALSO IN THE NURTURING OF GROWTH. FOR EXAMPLE, IN THE CONTEXT OF A PUBLIC/PRIVATE SECTOR PARTNERSHIP WHERE PUBLIC SECTOR HAD BEEN UNABLE TO PROVIDE BASIC INFRASTRUCTURE, CREDIT OR OTHER BASIC INPUTS, IT COULD STILL OFFER INCENTIVES IN THE AREA OF LABOUR LEGISLATION, LAND AND RELATED CONCESSIONS. SUCH SECTORAL POLICIES IN THE AREA OF ELECTRICITY PRODUCTION FOR RURAL AREAS WILL ULTIMATELY BE SUCCESSFUL AND HIGHLY PROFITABLE IN THE LONG RUN BECAUSE THEY WILL FORM THE BASIS FOR EXPANDING OTHER SECTORS OF THE ECONOMY INTO THE RURAL COMMUNITIES. EXAMPLES OF SUCH POLICIES FAVOURING EXPANSION IN THE PAST HAVE BEEN THE CASE OF BASIC INDUSTRIES IN BRAZIL, TEXTILES IN COLOMBIA, MAGUILADORES IN MEXICO, TOURISM IN BARBADOS.

IN THE CONTEXT OF TWENTIETH CENTURY CIRCUMSTANCES, THERE IS NEED TO CORRECT INHERENT IMBALANCES AND INEQUALITIES IN THE

OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT AND THE DISTRIBUTION OF THE BENEFITS OF DEVELOPMENT INITIATIVES. LATIN AMERICA WILL CONTINUE TO HAVE A COMPARATIVE ADVANTAGE, GIVEN ITS SIGNIFICANT NATURAL RESOURCE BASE. BUT IN THE CONTEXT OF THE TWENTY-FIRST CENTURY CIRCUMSTANCE, THIS IS NO LONGER ENOUGH TO ENSURE ECONOMIC SUCCESS. NEW NON-TRADITIONAL EXPORTS ARE BEING SOLD AND MUST BE SOLD IN THE GLOBAL MARKETPLACE, WITH PARTICULAR AND EQUAL ATTENTION BEING PLACED ON QUALITY, DESIGN AS TO PRICE AND QUANTITY. THESE ARE COMMODITIES WHICH CAN BE PRODUCED EQUALLY WELL IN RURAL COMMUNITIES EQUIPPED WITH THE NECESSARY INFRASTRUCTURE AND CAPABLE HUMAN RESOURCE. ELECTRIFICATION OF THESE COMMUNITIES SHOULD THEREFORE BE AN INTEGRAL PART OF NATIONAL AND REGIONAL POLICIES FOR HEMISPHERIC DEVELOPMENT AND INTEGRATION.

THE ENERGY SECTOR HAS NOT ESCAPED THE ONSLAUGHT OF PRIVATIZATION AND LIBERALIZATION, WHICH IS SWEEPING THE GLOBAL ECONOMIC SPACE. ACCORDING TO THE 1998 CARIBBEAN BASIN PROFILE

> "INDEPENDENT POWER PROJECTS ARE EVOLVING FROM THE SIMPLE SUPPLY OF ELECTRICITY TO MEETING A COUNTRY'S BROADER ENERGY NEEDS, AND INDUSTRY EXPERTS CLAIM THAT COUNTRIES WHICH GO BEYOND PRIVATIZATION TO FULL DEREGULATION, ALLOW INDUSTRY TO SOLVE THE PROBLEMS AND PROVIDE BETTER SOLUTIONS… THE INDUSTRY HAS SEEN AN EXPANSION IN THE NUMBER OF POWER PLAN DEVELOPERS OFFERING A FULL COMPLEMENT OF SERVICES. THIS INCLUDES THE FIRST STEPS OF EVALUATING A COUNTRY'S INFRASTRUCTURE (E.G., AVAILABILITY OF INDIGENOUS FUELS AND THE ABILITY TO SELL ELECTRIC POWER AT AN ECONOMICAL RATE) TO CREDIT RATING AND INVESTMENT STUDIES."

AN OVERVIEW OF THE REGION'S ENERGY SITUATION WOULD SUGGEST THAT THE REGION IS IN A PERIOD OF TRANSITION. IT IS THEREFORE TIMELY TO ENSURE THAT POLICIES IN THAT SECTOR COVER THE ELECTRIFICATION AND SUBSEQUENT DEVELOPMENT OF RURAL COMMUNITIES. IT IS ALSO TIMELY TO

REINFORCE THE PUBLIC/PRIVATE SECTOR AWARENESS OF THE NEED FOR REALISM, EFFICIENCY AND COMMITMENT IN THIS REGARD.

11:15-12:00 **Meeting the Challenge to Rural Access**
 - *Chair, James Bond,World Bank*
•Private Sector Strategy to Increase Rural Electricity Access
– *Herre Hoekstra, Shell Renewables*
•UN Sustainable Energy Initiative - *Susan McDade,Energy and Atmosphere Programme, SEED and UNDP*
•Renewable Energy Finance: Matching Resources and Needs
- *Michael Allen,E&CO*
•Technology Options for Meeting Rural Electricity Needs
- *Larry Flowers, NREL*

Private Sector Strategy to Increase Rural Electricity Access

Herre Hoekstra

Business Development Manager Rural Electrification
Shell International Renewables

6 October 1998

Creating sustainable projects for Rural Electrification

Key success factors

- Financial institutional framework
  - to ensure affordability for large customer groups
- Right proposition
  - product, branding, communication, training
- Local presence and after sales service
  - with help of community based programs

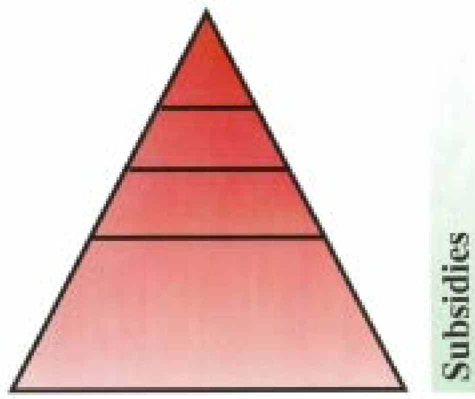
Enlarging the commercial opportunities

Cash sales

Scheduled loans

Fee for Service

Subsidies required



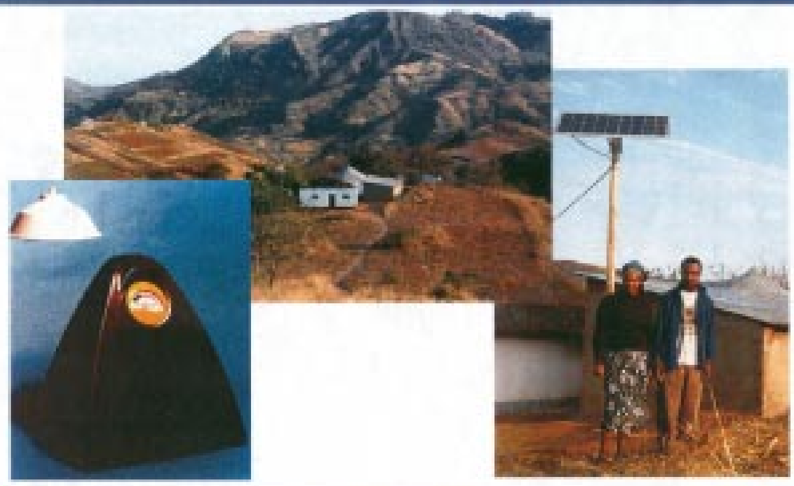
Shell International Renewables

Shell strategy for Rural Electrification

- Provide renewable energy instead of PV
- Develop customer focused propositions
- Maintain dialogue with Governments, Multilateral Agencies & NGOs
- Obtain support where it adds value
- Build-up experience by implementing projects

Shell International Renewables

Shell/Eskom Project



Shell/Eskom Project

- 50 000 homes in South Africa
- Fee for service - US$ 8 - 10 per month
- Uses unique Solar Home System designed by Shell Solar and Conlog (Pty)
- Marketing of the product through a network of local outlets

Lets create a win-win situation

for the rural communities, Governments, MLA's, NGO's and commercial organisations

Shell International Renewables

Energy for Sustainable Development
UNDP Initiative for Sustainable Energy
Energy and Atmosphere Programme
United Nations Development Programme

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Susan McDade

The United Nations Development Programme is the main grant window for technical assistance to promote sustainable development within the UN family of organizations. With Country Offices and programmes of cooperation in more than 130 developing countries, UNDP administers approximately $900 million of development assistance from its core budget each year.

UNDP has worked on energy issues for a long time. Like many organisations we traditionally approached energy from a sectoral point of view and looked at how to deliver supply options to meet growing demand in developing countries through capacity building and project level assistance. From 1974 to 1994 UNDP had 980 energy projects with a total programme value of $630 million, $430 million from UNDP resources and $200 million from government cost sharing. Only 12% of this assistance dealt with renewable energy and energy efficiency. Most cooperation dealt with supply expansion in conventional energy. This was largely focused on technology demonstrations, technical training and pilot projects. The approach was sectoral, dealing mostly with Ministries of energy and electric utilities and many efforts on training and capacity building were undertaken. There was an implicit assumption that expanded electricity supply would stimulate national development. Many good things were achieved and national capacity was strengthened. However overall trends in energy and development have become more unsustainable; unsustainable in economic, social and environmental terms.

In 1995 UNDP's Executive Board decided that UNDP's core mandate and programme focus should address poverty alleviation as goal number one. In this regard resources were prioritized for efforts focusing on jobs creation and sustainable livelihoods, environmental protection and regeneration, improving the status and participation of women in development, and support for good governance.

UNDP is also called upon to assist programme countries to implement the goals and commitments of the major UN conferences such as the Rio Conference on sustainable development, Beijing Women's Conference, the Cairo conference, Copenhagen Social Summit, Istanbul Habitat II conference etc.

Developing countries look to UNDP as a source of neutral policy advice, support for human and institutional capacity building, for access to information on technology and development trends in other countries and regions, and as the primary entry point to engage in international debate on development issues related to national development and growth. In this context it was legitimate to ask what role could UNDP have with regard to energy.

In 1996 UNDP initiated a major effort to fundamentally change our programming approach to energy. As a sectoral, infrastructure of investment issue, UNDP has little comparative advantage in supporting conventional energy supply expansion. While the multilateral development banks are an important source of funding for infrastructure development, they too are increasingly less relevant as a source of energy infrastructure financing as the total investment from the private sector expands.

Let me give you some general numbers to illustrate what I mean. In 1995 the total value of foreign aid from all sources worldwide was approximately $65 billion. The trend is downward from a previous $74 billion in 1986. This is still the trend in development assistance; resources are declining. Annual investments in energy supply in the mid 1990s were $450 billion/year and are expected to increase to $750-1000 billion by 2020 according to the World Energy Council. UNDP's development assistance value was not, and is not, in the strength of volume. Increasingly this is true for the multilateral development banks with regards to energy.

Meanwhile 2 billion people remain unconnected to electricity grids, 2 billion depend daily on wood, biomass or dung for cooking and heating purposes, mainly collected and cared for by women and girls. This is more than one third of the total population of our world. The poor pay more for poorer quality energy services on a unit basis than do the rich. Inadequate or poor quality energy services contribute to the lack of rural employment and contribute to urban migration as people search for jobs and better living conditions. The trend toward urbanization in developing countries means that there are a host of severe local environmental issues related to energy consumption patterns that are on the rise. We are all familiar with the growing importance of global climate change related to CO_2 emissions mainly from fossil fuels. While this is a critical global issue on which UNDP is working actively at the national and global level, climate change alone will remain an uncompelling national and local policy change driver while 2 billion people remain unserved and largely poor.

In this context total subsidies to conventional energy world wide in the mid 1990s were about $300 billion/year. While $250 billion of this is concentrated in industrialized countries, energy subsidies in developing countries are about $50 billion per year. This is roughly the same amount as all foreign aid from all sources. In this context even if UNDP, and indeed all development organizations were to programme every dollar of assistance to support for the energy sector, the question of relevance and impact would remain valid. There are indications that these subsidies, contrary to their objectives, do not benefit the poor, but distort markets blocking decentralized and renewable energy based approaches to the provision of energy services.

As a result, the UNDP Initiative for Sustainable Energy (UNISE) was elaborated and shared with all UNDP country offices in 1996. It was adopted as corporate policy by our senior administration. It explains how UNDP's core development areas, poverty, jobs, women and environment are directly related to trends in the production and consumption of energy. Current approaches to energy are unsustainable in economic, social and environmental terms. Poverty cannot be addressed without a fundamentally different approach to the provision of energy services. UNISE suggests that UNDP development efforts in energy should focus on energy as an instrument for socio-economic development. Activities to promote energy efficiency in the production and use of energy, renewable energy commercialisation and dissemination, and the introduction of modern, clean energy technologies are the three pillars of this strategy. UNISE argues that the goals and recommendations of the UN global conferences cannot be realized unless there is a fundamentally different approach taken to energy. This is true for both official development assistance and commercial investment.

Energy needs to be approached as a complex development issue, involving a number of sectors and institutional actors. The provision of energy services that meet the economic and social needs of populations in developing countries is the key and this cannot be achieved only through the extension of electricity grids. Energy services include cooking, heating, illumination, and mechanical power.

Mainstreaming energy in our poverty programmes is our key programme goal today. We are attempting to shift our programme focus to an integrated approach to energy. Energy and gender, energy and environment, including the local environment, energy and the generation of productive employment, energy and governance or how to stimulate the appropriate legal regulatory, policy and financial frameworks to enable more sustainable approaches to energy, including renewable energy, to advance in developing countries. These are all key areas for programme assistance.

This new approach advocates cross sectoral dialogue involving multiple government ministries and agencies, private sector interests, producer and consumer stakeholder groups, civil society organisations, technology innovators and other partners. This is consistent with the recommendations of Agenda 21 and more closely relates to UNDP's development mandate and comparative advantage as a donor agency. UNDP activities shall increasingly focus on policy and legal frameworks to promote sustainable energy, capacity building to link energy to other development activities, integrated sustainable development planning at the national and regional level and facilitating the introduction on modern cleaner energy technologies. This will not be easy.

The current UNDP prgramming cycle runs from 1997-2001. An initial review of national programme outlines and approved projects indicates that in over 40% of programmes at the country level, there are sustainable energy elements planned or under implementation. This includes not only programming of UNDP core resources, but also those additional resources provided by the Global Environmental Facility. The GEF programme resources focusing on renewable energy amounted to $63 million in 1997 and energy efficiency activities $56 million. The GEF Small Grants programme administered by UNDP also funds NGO-led national projects on sustainable energy with climate change benefits for up to $50,000. There are currently 44 such projects. UNDP also provides project-level assistance through the Energy Account with the support of bilateral donors. These focus on the sustainble energy approach.

UNDP also contributes to the international debate on energy. The General Assembly of the UN met in June 1997 to look at a five year review of progress since Rio. To contribute to the discussion of on energy as a development issue, UNDP prepared "Energy after Rio Prospects and Challenges", which was widely distributed and made available in six languages. It stressed that current approaches to energy are unsustainable in economic, social and environmental terms and a major shift in approaches to energy services delivery is needed if poverty and development goals are to be met. The General Assembly took the decision that a special focus on energy was needed to agree on how to move forward with these complex issues. As a result the ninth session of the Commission for Sustainable Development (CSD9) will meet in 2001 and focus on energy specifically.

This will be an important opportunity for both the public and private sector to come together on operational issues to achieve sustainable energy objectives. In preparation for this UNDP, together with the World Energy Council and the Secretariat of the CSD, are preparing a World Energy Assessment to share what is known and agreed on sustainable energy and where additional policy decisions and market reorientations are needed. We view the preparatory process for this, which is now underway, as an important opportunity to debate what operational changes are needed in current approaches to energy in order to meet sustainable development goals. We are very pleased to be able to engage with a major private sector organization such as the WEC on this effort.

In addition to country level programming UNDP supports regional and global programmes on sustainable energy. At the HQ level we do this through the Global Programme, the Energy Account, and regional programmes with the geographic bureaux of UNDP. These efforts support strategic policy, technology and environmental issues related to energy. We provide support and strategic advice to country offices where the majority of UNDP programme resources are delivered through projects designed and managed at the national level. Recently the UN Foundation was established based on the Turner gift to support UN causes. One of the three main areas of focus is environment, and in particular the link with energy and climate change. This new funding source offers an important new opportunity to work with NGO's on sustainable energy efforts of common interest.

Challenges remain. These are challenges for UNDP and the UN in general, and for all. They include:

- How to link development assistance effectively with the private sector so that markets can be created for sustainable energy?
- How to link commercial scale energy financing with pilot projects in order to scale up approaches that work?
- How to effectively focus international debate on policy actions rather than objectives which are already agreed upon in order to operationalise sustainable energy?
- How to stimulate national level activities that place energy issues within the overall development context in a way that is relevant to poverty reduction and local development needs of both women and men?

- How to stimulate energy activities that increase the number of energy entrepreneurs, create jobs and income, and support new productive opportunities, especially in rural areas?

- How to enable the 2 billion people without access to electricity to partake in the global information and communication changes that potentially open up new access to learning and information to overcome poverty?

- How to ensure that development assistance especially for renewable energy, does not distort markets at the national level and create unintended barriers to more sustainable approaches to energy?

- How to address the phenomenon of the urbanisation of poverty and the energy trends and local pollution trends that this is creating?

- How to involve women as participants, rather than objects, of development assistance regarding energy, especially household cooking needs, energy planning and new financing mechanisms?

Finally energy does not equal electricity. It does not equal a sector. It is not only a supply issue. It is a complex issue related to how to deliver the energy services that people need (cooking, illumination, heating, cooling) in an affordable, environmentally and economically sustainable fashion to enhance the development opportunities of men and women and to overcome poverty.

UNDP is looking for new partnerships, increased relevance, how to stimulate not implement sustainable energy changes, links with other UN agencies, multilateral development banks and the private sector. Cooperation with ESMAP, the GEF, WEC, NGOs, technology developers, and consumer associations may provide this.

Thank you very much.

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Rural Energy – Matching Needs and Resources

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

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INTRODUCTION

It was perhaps a foreseeable irony that as the energy industries in the developing world move increasingly closer to the "free market" model, there is a real threat that the gap between those that have access to reliable energy supplies and the unserved in rural areas will widen. Much has happened in the world of the "IPP's", dominated by large fossil fueled projects, each of which has presented a series of challenges before reaching financial closure. Enormous amounts of resources, time and money, have been poured into restructuring an industry that we know performed poorly in the past. But have these resources been well used in the broader interests of those whose countries are now the recipients of this restructuring? We can't have our time over again, nor should we seek to return to the past, but what are we learning and are we more able to address the shortcomings of those systems that we are so eager to replace?

Few of you here need any introduction to the issues facing rural communities around the world as they seek to provide themselves with even the most basic energy resources on a sustainable basis. So where can they turn for support as the world moves into the market driven age, setting aside many of the social responsibilities that government owned agencies at least acknowledged, even if they achieved little in addressing them?

Recognizing the importance of energy as both a tool of development and as a crucial determinant of environmental quality the question was raised, *where can small amounts of money be placed at critical times to create a substantial social and environmental benefit*? Through trial and error, the Rockefeller Foundation and E&Co, an independent organization created by the Foundation in 1994, have come to realize a few simple but nearly universal truths. Most good ideas die for lack of small amounts of money to make them real enough for later stage investors and many ideas to promote environmentally sound, affordable energy services are ideas that involve creating business-oriented initiatives.

E&Co Activities

It is on this basis that E&Co has developed its strategy for intervention in the renewable energy market – the investment of modest amounts (from $50,000 or less, to US$ 250,000 in any one case) into what are perceived to be economically, socially and environmentally sustainable *energy* *enterprises*. To many this will seem an anathema – particularly to those still captured by an ongoing search for subsidies and government leadership, or who question the concept that smaller scale rural energy developments could ever be considered sustainable, commercial ventures. True, this is far from universal, but there are a growing number of successful projects lending increasing credence to this approach.

To date E&Co has invested some US$ 4.7 million in 36 enterprises in 21 developing countries. One key lesson that has been learnt through these investments is that money is not always the problem. It is the link between money and the good ideas that is often missing in this sector. The need to promote and strengthen private enterprises is therefore a key element to overcome these issues. This is the gap E&Co is trying to fill.

There are a number of projects in which E&Co has played a part that can be provided as examples, many of which may well be known to a number of you:

- Lotus Energy is a small photovoltaic company that has for several years served an increasingly important role in the PV market in Nepal. In a move to address the cost of imported balance of systems items, it established a small but well regarded local manufacturing capability. Its market was small but the company had built up an excellent network and strong working relationship with the Agricultural Bank of Nepal, through which subsidized loans have been available for system purchase. The company needed additional working capital to expand but local sources were unwilling to lend against the limited assets that Lotus had available. E&Co took a small equity position (investing $150,000) in the company allowing them to bulk purchase imported components, expand their staff to 60 and further develop their distribution network – no mean feat when many clients can be a two week trek from the end of the nearest access road. Today Lotus has installed over 1000 systems, has a competent servicing and backup program and is strongly positioned to participate in a Danish project that will provide funds for some 30,000 PV systems throughout Nepal. Importantly, this program is designed to progressively reduce the subsidy offered for the purchase of the PV systems (over a five year period). Lotus acknowledges that they have a responsibility to find ways to offset this reduction through cost savings on the units that they supply.

  In addition to this involvement with Lotus, E&Co has had a long-term involvement in the PV industry with groups like SELCO, Soluz, NOOR and others. We see this as an entry point into the business of rural electrification that is not capital intensive, can engage a number of individuals at various tiers within the industry and, well structured, can grow to have a significant impact. Others directly involved with some of these activities will speak later during this meeting.

- In Bolivia, the installation of a 7 MW hydroelectric plant has provided not only a much needed electricity source, but improved both the supply and quality of fresh water to the city of Cochabamba. At a time when regulatory issues were threatening progress on the project, E&Co provided a $250,000 loan ensuring that others funders would honor their commitment to the project, which is now due for commissioning late this year.

- In 1996, the Cooperativa Eléctrica Riberalta (CER) of Bolivia requested a $100,000 loan from E&Co to complete its 1 MW biomass generation project, fueled by Brazil nut husks and residual scrap wood from local sawmills. Construction was underway but substantial increases in equipment shipping costs and additional equipment left insufficient funds to complete it. The loan from E&Co, and the support of the National Rural Electric Cooperative Association (NRECA) from the United States, provided the necessary financing for the project to move forward to where it is now fully operational.

- In Viet Nam, Oxfam Quebec has worked for several years with a national agricultural association, Vacvina, introducing a simple but effective biogas system for farmers. Each systems costs around US$ 50. With the success of the 200-300 demonstration systems, the challenge was how to move the program to a stage where it could have significant impact. Vacvina has a national membership of over 250,000 and hence an extensive network within the farming community. Following a six month period, in which fundamental business planning issues were addressed with the organization, E&Co provided a $60,000 loan for working capital. Within the first three months of operations over 400 systems have been sold into 11 provinces throughout the north of Viet Nam. A national promotional campaign is planned and Vacvina is targeting annual sales of 3,000 systems. The systems provide an effective method of treatment of animal wastes and, with a minimal number of animals, provide sufficient gas for daily cooking needs. This removes the need for firewood, relieving women from the burden of collection, and provides an effluent stream that can be safely used for irrigation and aquaculture.

- Génesis Empresarial, a micro-credit NGO from Guatemala, received a $100,000 loan from E&Co in 1996 to expand its credit program and introduce electric energy in rural areas. Without this loan, for which E&Co offered long -term support (five year repayment) and below-market rates, the fund could not expand because the transaction costs of lending for rural off-grid PV, wind and hydro projects are too high in Guatemala. Génesis, with 20,000 clients, was thus able to charge a lower than commercial interest rate and to extend the repayment period from the traditional maximum of two. In addition, the micro-lender became familiar with renewable energy technologies and began using its training system to build human capacity for renewables at the local level. The renewable energy systems are currently being successfully delivered to rural villages and Génesis is being repaid as agreed.

- In China, E&Co has provided support to the Xiangtan joint venture being established by Bergey Windpower, allowing the local manufacture of small-scale wind turbines. Bergey's strong market reputation and the significant wind market in China, and elsewhere in Asia, make this an important opportunity. Even before manufacture has begun, other potential market expansion has been identified. The Chinese government clearly supports the use of wind power and it is significant that the World Bank's PV program in Mongolia has been expanded to include wind generation, a change needed to match the electricity demand level already reached by many rural consumers.

- From a recent trip through Viet Nam and other parts of Asia it has become apparent that there is a potential market for *good quality* micro-hydro turbines, along the lines of the "Chinese" turbines so prevalent in Viet Nam. The challenge is to identify and underwrite an entity that can bring this potential to market.

These are just a few examples which I hope demonstrate an approach that we believe offers concrete solutions to what many still see as a daunting and insurmountable obstacles to effective rural energy supplies. We could debate at some length the penetration that these projects have in reaching the most needy– we are convinced however that without these initiatives it is unlikely that any sustainable support system could be established for the least fortunate individuals within these societies.

Funding Initiatives
Over the past three years, there has been significant activity targeted to the establishment of dedicated institutions for renewable energy and energy efficiency finance. The following examples are funding mechanisms in which E&Co has been actively involved. While we are excited about the prospects of these mechanisms, we are also very cautious as they must succeed. A failure to move forward would greatly harm the attraction of private capital to renewable energy and energy efficiency enterprises.

- REEF: the Renewable Energy and Energy Efficiency Fund an investment fund managed by a private sector team, to finance renewable energy and energy efficiency projects that is currently fund raising. It will have three components: equity funds, debt funds and a concessionary finance window with which it will finance on-grid renewable energy in the 5 to 50 MW range as well as smaller off-grid renewable energy projects and energy efficiency undertakings. The REEF's lead sponsor and investor is the International Finance Corporation. The Global Environment Facility has agreed to provide a grant of up to $30 million in proportion to the size of the equity pool that is expected to be of around $100 million. With a matching debt facility from the IFC, the fund is expected to grown to $180 to $230 million.

- The Solar Development Corporation: the SDC is to be established as a stand-alone, eventually commercial company providing business development and financing for solar PV operations, particularly in rural areas. Now in development by the International Finance Corporation, the World Bank and a number of United States Foundations, the SDC is expected to open for business in 1999 and its financing will be in the pre-commercial and parallel to commercial stages. The target initial capitalization for the pilot period is $50 million of which approximately $15 million will be for business development and $35 million for direct finance. The GEF has been asked to provide between $10-15 million to support the market and business development component.

- Energy Capital Holding Company: ECHCO provides integrated (engineering, insurance and financing services) project financing for medium size –10 MW to 250MW- environmentally and commercially sound energy projects in Latin America and the Caribbean. With 19 senior in-country managers in 15 LAC countries, it enables energy projects to enjoy the funding advantages of international banking, non-banking and capital markets previously available only to large projects.

There are a number of other institutions with interest in renewable energy financing, including Environmental Enterprises Assistance Fund (EEAF), Triodos Bank in the Netherlands and bilateral and multilateral programs which play an important role in their own sectors of interest. A range of international banks have now participated in the financing of geothermal, wind and hydro-electric power production, but typically with a focus on larger scale projects.

Where Now?

The challenge now is no longer to demonstrate what works but to achieve scale impact on the one hand and build the distribution channels of product and finance that will electrify the 400 million or so households world-wide that today require affordable and reliable basic energy services.

I would refer you to a paper delivered by Phil LaRocco of E&Co at a recent meeting in Quito. In this he outlines an approach that would allow us to take our best experience and apply it to a realistic rural electrification goal. He asks, "*what would it mean if we were to set a goal to electrify 20% of rural households in three Latin American countries such as Peru, Ecuador and Bolivia?"* Building on a model of the "MacSolar" concept, that formed the basis for the original approach to the Solar Development Corporation, he outlines a mechanism that could establish a US $350 million initiative to provide electrification to 20% of the rural market addressing the needs of about 550,000 family units. The approach envisions a franchise type operation, needing some 120 "entrepreneurs", whereby there is a core regional support group that provides finance, standardized product and training and assistance to allow individual entrepreneurs, or sales and distribution points, to grow and service a base of energy end-users. It is feasible that a national operation would develop once a number of regional enterprises are in existence.

With financing available to the "bundled" regional and national operations, the local entrepreneurs can access finance at reasonable rates. A franchise approach allows profit to be earned at each of the tiers of operations, with the customer benefiting through the energy services they now receive.

Conclusion

Four years of experience in financing small renewable energy projects around the world have taught E&Co that one of the major challenges is still the need to envision energy as a development component that must be closely interconnected with private sector initiatives. The linkage between energy, development and finance must clearly be understood.

There are a growing number of success stories that can provide models for future development in rural electrification. As these successes gain wider recognition there will be an increasing demand for sustainable sources of finance. The market recognizes this need but to build the renewable finance industry will require initiatives that drive *order of magnitude changes* in the business of renewables. These in turn will require a focus on the link between money and the good ideas that is often missing in this sector and the promotion and strengthening of *private enterprises*, a key element in the successes to date.

Renewable Energy Financing Matching Needs and Resources

Dr Mike Allen
E&Co

Village Power '98
World Bank Washington DC
6th October 1998

Introduction

- Impact of the free market model
- The IPP world v rural needs
- Energy - a tool of development & a crucial determinant of environmental quality
- *Where can small amounts of money be placed at critical times to create a substantial social and environmental benefit?*

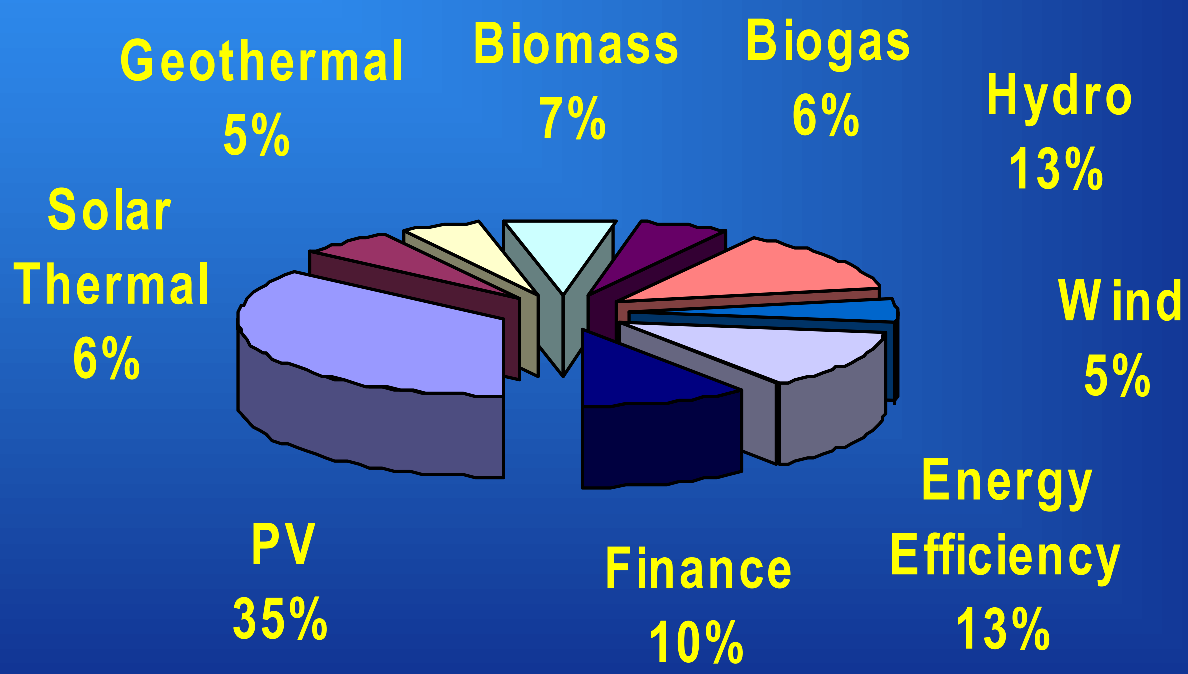
E&Co

- Developing in country energy enterprises
- High risk early stage direct investment $50,000 to $250,000
- Leading to next stage investment
- 36 enterprises, 21 Countries, US$4.7 million

Funding Activity

$4,700,000 in 36 projects in 21 countries

(percent by investment)



E&Co Projects

- Lotus Energy - Nepal
  - BOS manufacture
  - Limited capital for expansion
  - Challenging distribution needs/network
- Kanata Hydro - Bolivia
  - Water supply and energy
  - Regulatory uncertainty

E&Co Projects

- Riberalta Biomass - Bolivia
  - Brazil nut husks
  - Displacing diesel generation
  - Increased construction costs
  - NRECA support
- Vacvina Biogas - Viet Nam
  - Initiated through Oxfam Quebec
  - Move to “commercial” operation
  - Aim to broaden impact

E&Co Projects

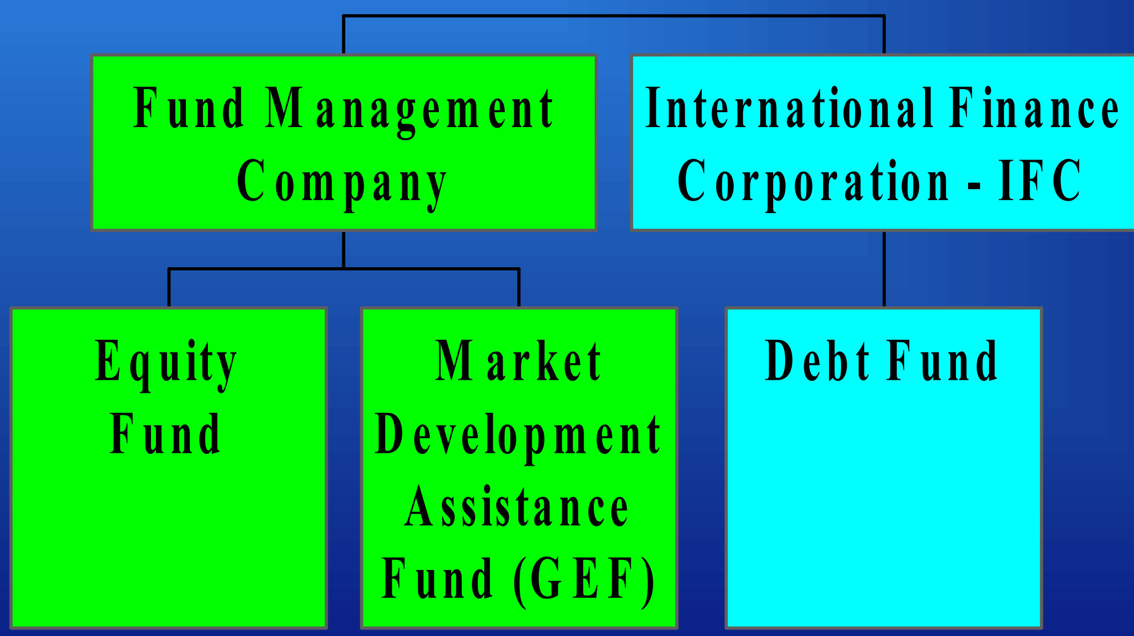
- Genesis Empresarial Fund - Guatemala
  - Micro-credit facility
  - Introduce energy loans
  - Assist in providing affordable funding
- Bergey Xiangtan Windpower JV - PRC
  - Establishment of in-country manufacturing
  - Demand for high quality product
  - Potential for expansion within China

REEF
Renewable Energy & Energy Efficiency Fund

- IFC sponsored three window fund with commercial and non-commercial funding
- Debt, equity and market development funding $150-$200 million
- Privately managed funds, renewable energy, developing countries, enterprise development

“Three Window” Fund

Three Window
Renewable Energy Commercialization Fund



Solar Development Corporation

- Joint Foundation World Bank Initiative
- Standalone Corporation
- $50 million initial capitalization
- $15 million for promotion and business development
- $35 million for end user credit
- RFP out for management group

Where Next?

- Need to achieve scale impact
- Need for effective distribution channels for
  - product
  - services
  - finance
- A concession approach
- An approach in Latin America
  - 20% of rural households, 550,000 homes, $350m
  - Would require > 120 “entrepreneurs”
  - A franchise approach - bundled financing

Conclusions

- Envision energy as a development component closely interconnected with private sector initiatives
- Understand the linkage between energy, development and finance
- There are successful development models to follow

Conclusions (cont.)

- Need initiatives that *drive order of magnitude changes* in the business of renewables and smaller scale electrification
- Build the links between finance and the good ideas
- Promote and strengthen private enterprises

Technology Options for Rural Electricity

Larry Flowers, NREL

Village Power '98

Washington, DC

October 6, 1998

Technology/System Determinants:

- application
- renewable resources
- economics of competing conventional options
- physical dispersity of loads
- quality of service
- institutional considerations

Applications:

- lighting
- household appliances
- water pumping, potable and irrigation
- water treatment/desalination
- cold storage/refrigeration/ice making
- health clinics
- schools
- power tools and village industry
- agro-processing
- communications

Resources:

- solar
- wind
- hydro
- biomass
- geothermal

Types of Village Power Systems

•General categories

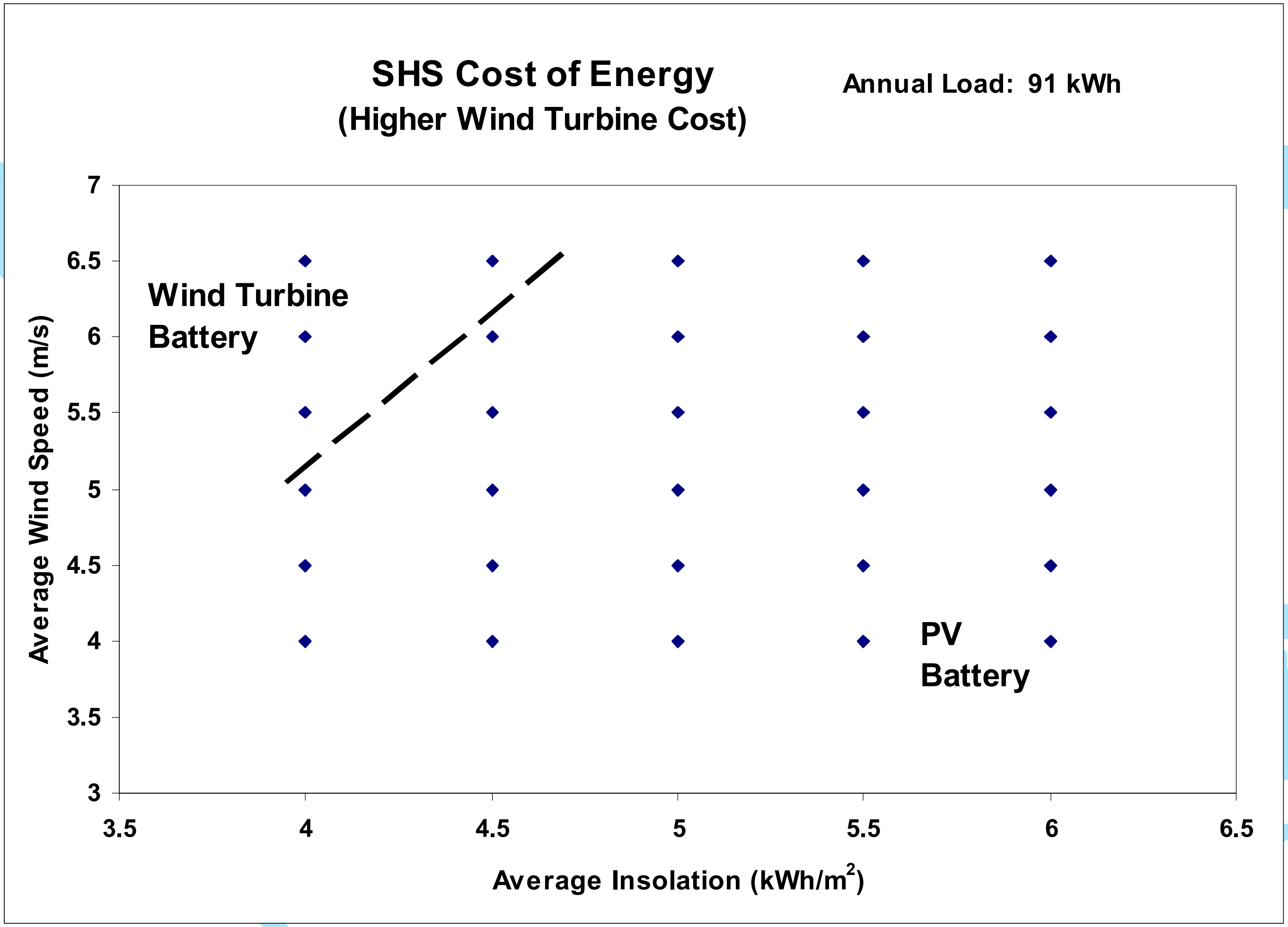
--Individual systems - compete with PV

--Micro-grids - Storage is primary backup

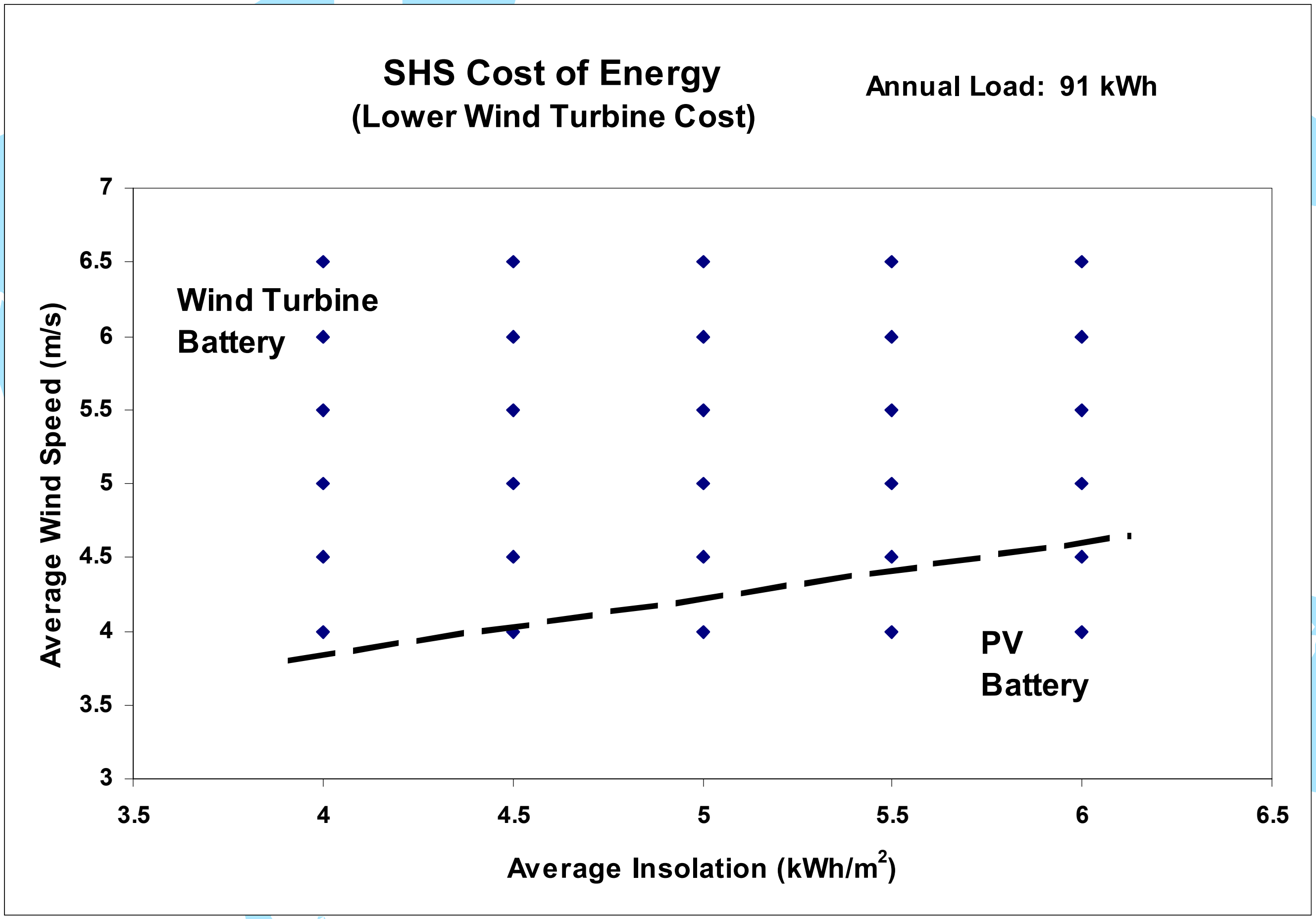
--Mini-grids - Diesel is primary backup

--Interconnected diesels - Multiple diesel dispatch, T&D

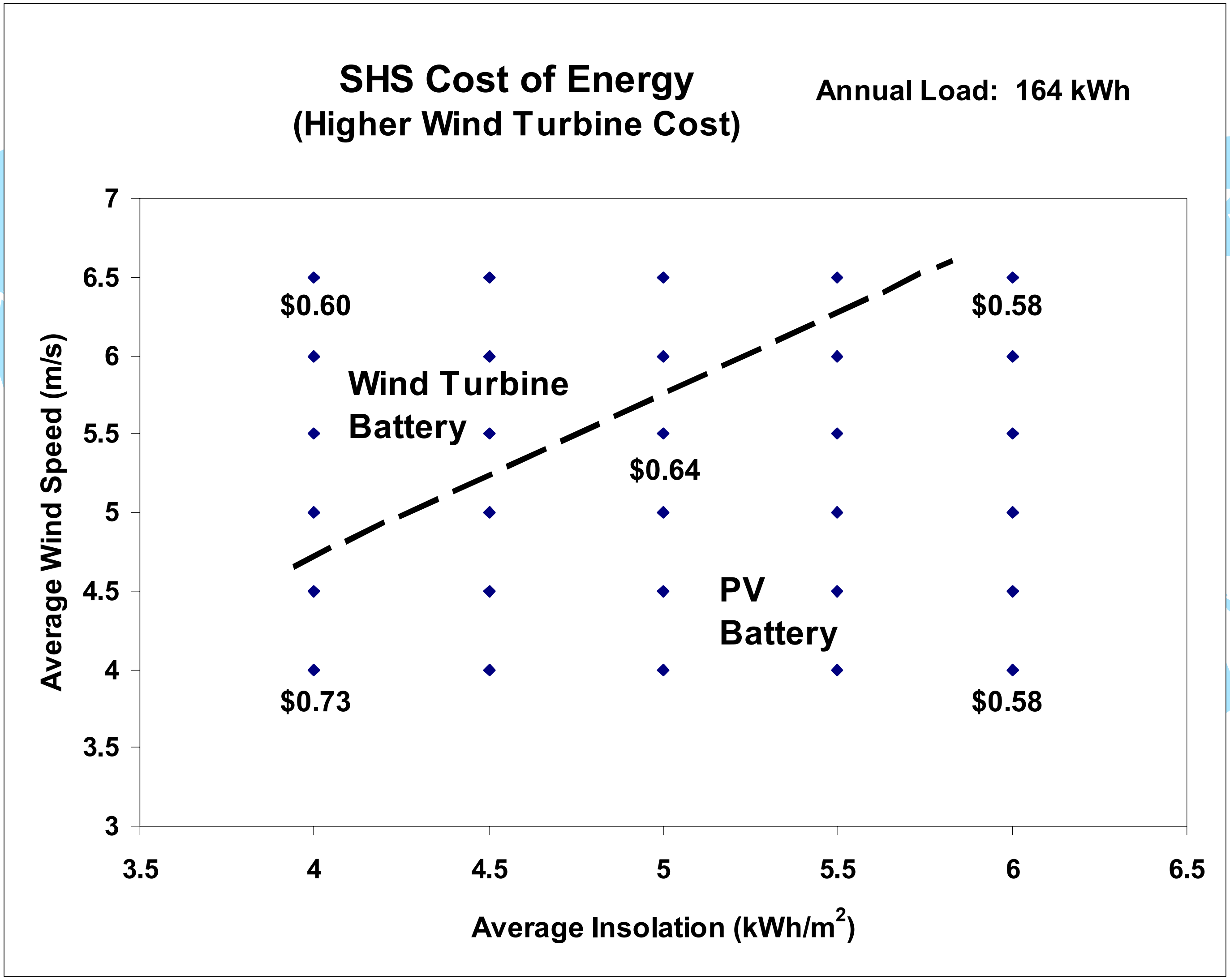
One region may contain a mixture of types

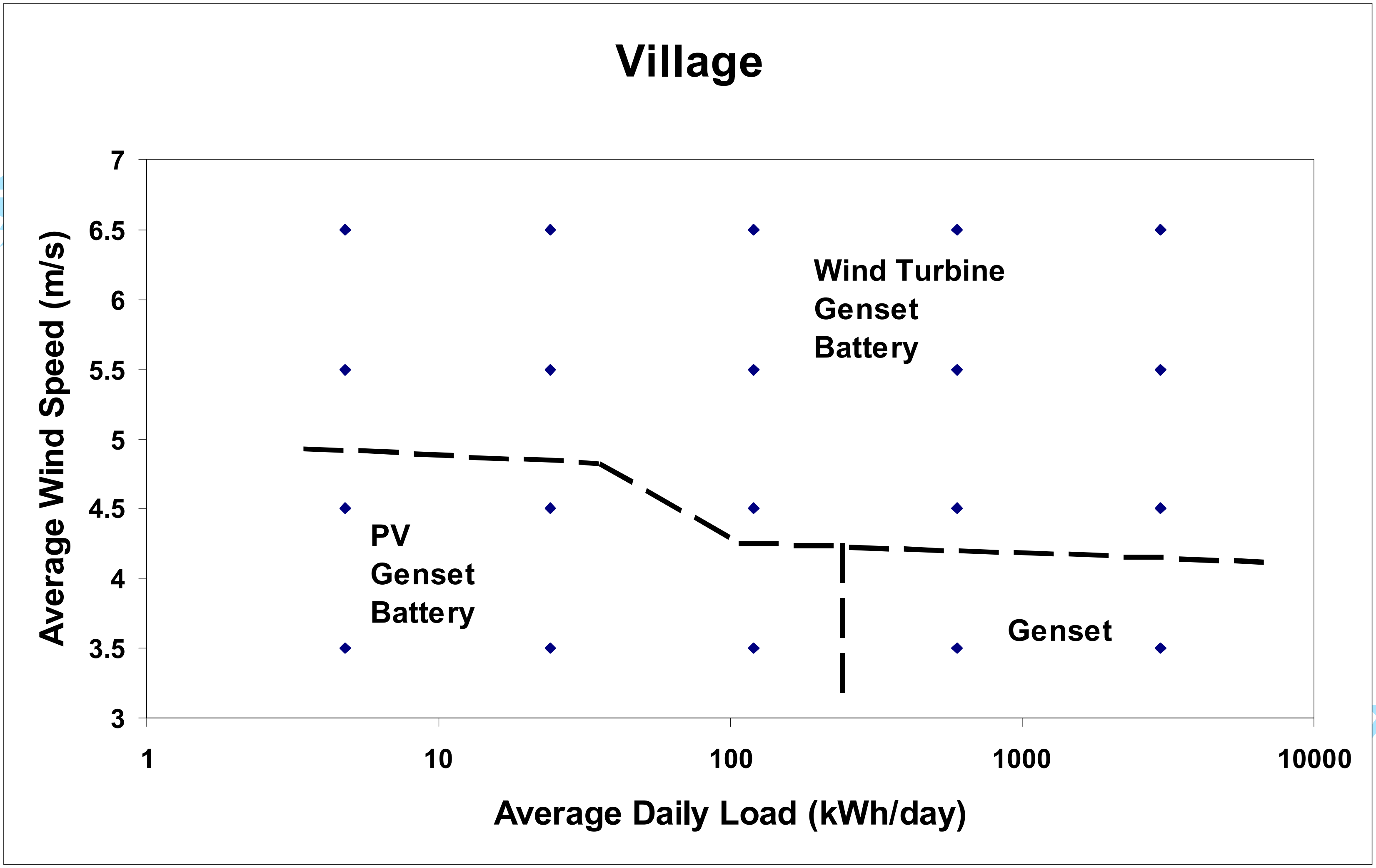


SHS Cost of Energy
(Higher Wind Turbine Cost)
Annual Load: 91 kWh
Wind Turbine
Battery
PV
Battery
Average Wind Speed (m/s)
7
6.5
6
5.5
5
4.5
4
3.5
3
3.5
4
4.5
5
5.5
6
6.5
Average Insolation (kWh/m2)


SHS Cost of Energy
(Lower Wind Turbine Cost)
Annual Load: 91 kWh
Wind Turbine
Battery
PV
Battery
Average Wind Speed (m/s)
Average Insolation (kWh/m2)
7
6.5
6
5.5
5
4.5
4
3.5
3
3.5
4
4.5
5
5.5
6
6.5

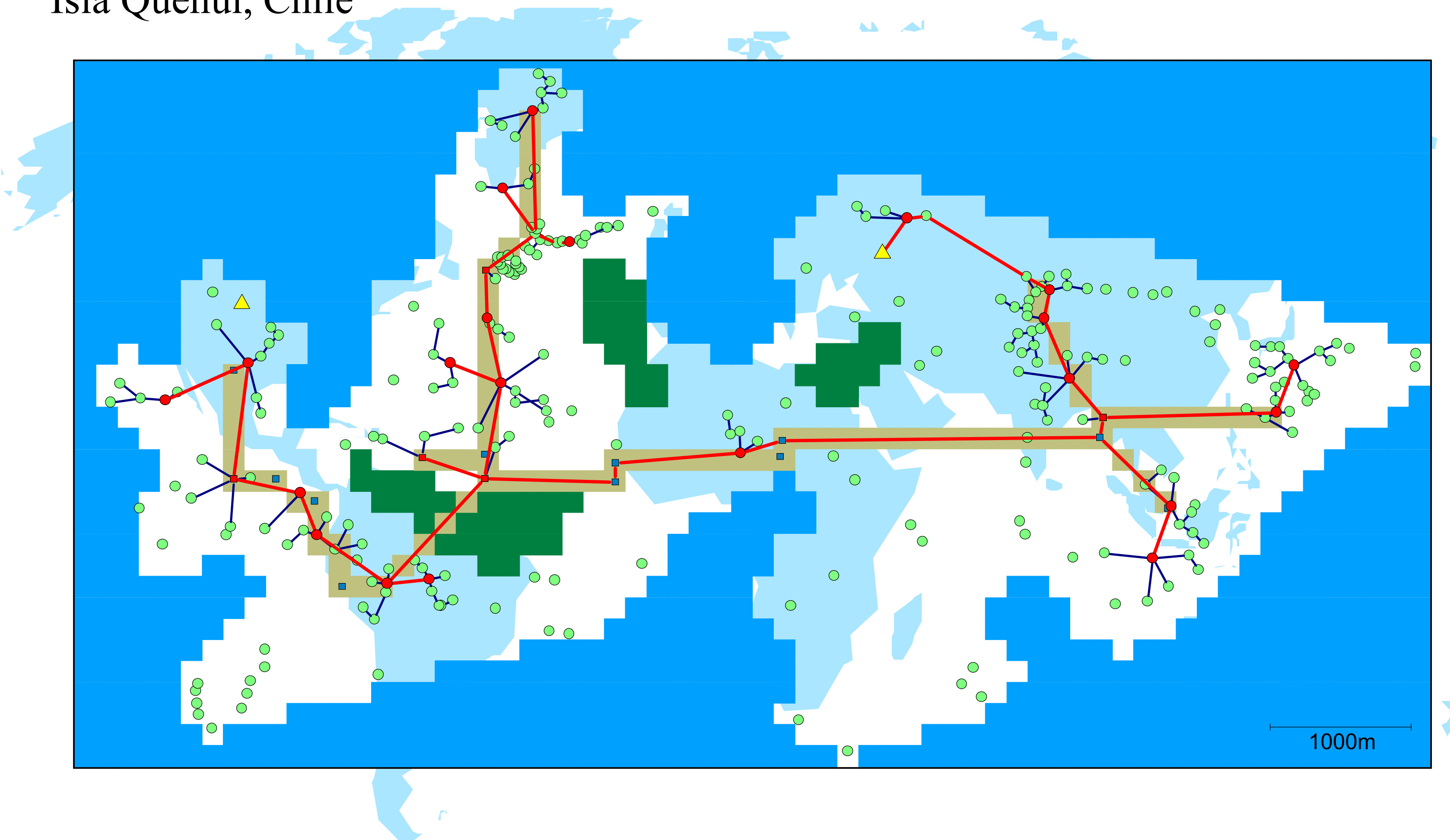
National Renewable Energy Laboratory



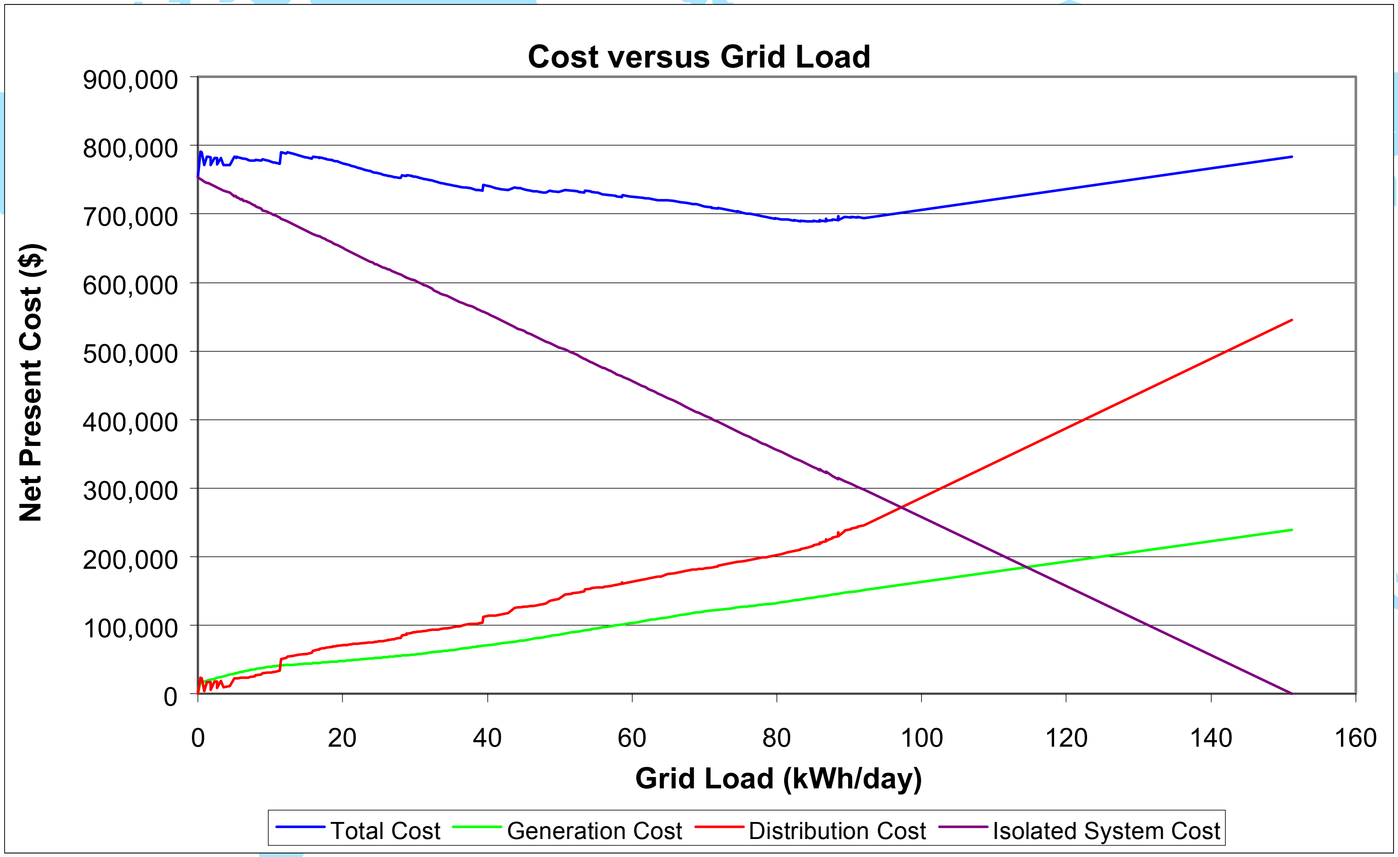

Village
7
6.5
6
5.5
5
4.5
4
3.5
3
Average Wind Speed (m/s)
1
10
100
1000
10000
Average Daily Load (kWh/day)
Wind Turbine
Genset
Battery
PV
Genset
Battery
Genset

National Renewable Energy Laboratory

Isla Quehui, Chile



Isla Tranqui, Chile



Technology Requirements:

- economically competitive
- reliable
- serviceable
- load matching
- scaleable

Institutional Issues:

- ownership
- operations and maintenance
- financing
- tariff design
- metering
- ability and willingness to pay
- training

Institutional Issues (cont.):

- load growth
- quality of service
- economic development vs. social services
- cultural response
- institutional cooperation

Future Technology Developments:

- lower cost solutions
- more robust systems
- more options:
  - small-scale biomass gasification
  - concentrated solar-sterling engine
  - small scale geothermal
  - hybrids
  - mixed systems
  - integrated systems

Future Technology Developments (cont):

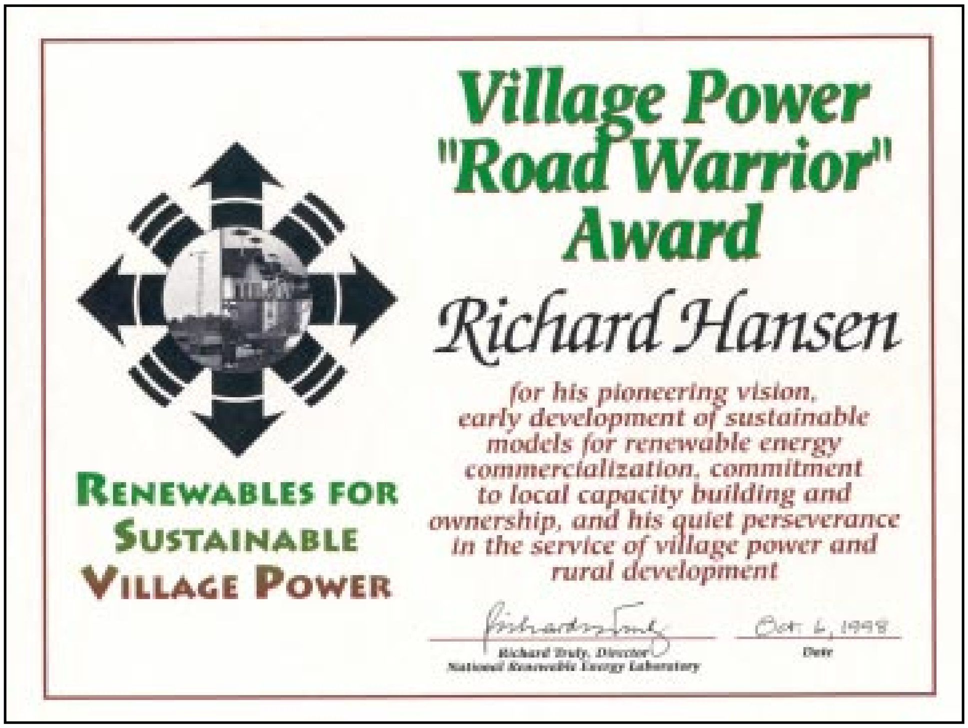
- applications development
- storage subsystem development
- smarter controls

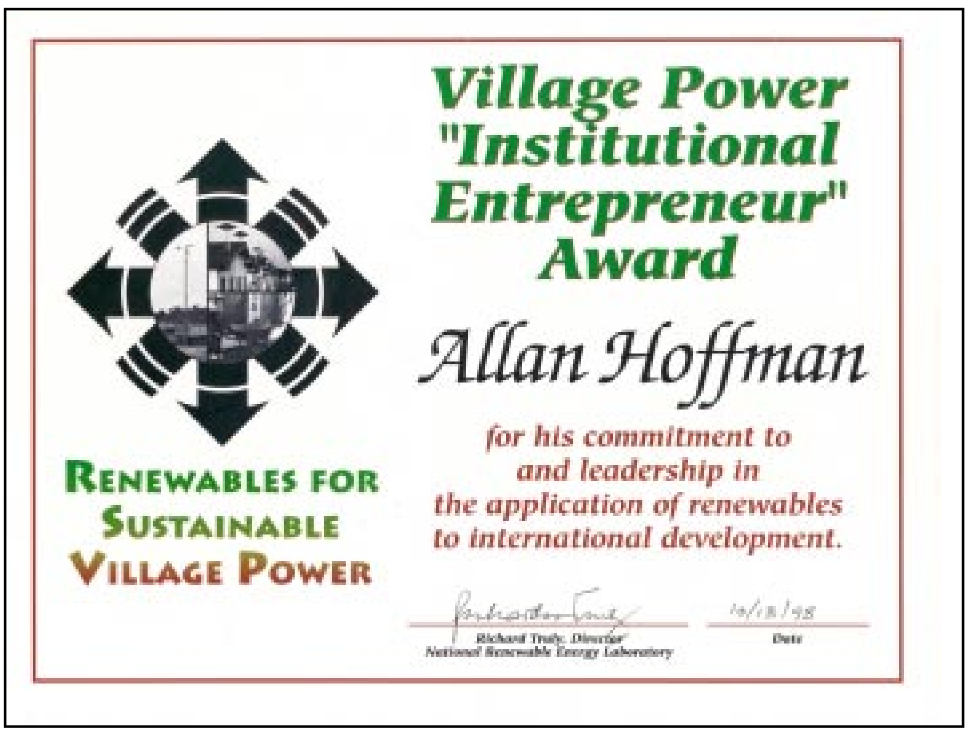
Summary: Technology and the system are the dependent variables; the application, the resource, the economics, and the institutional aspects are the drivers.

Therefore: We need to focus, not on the technology, but on the applications and resources and present the options that most appropriately meet the village applications and needs.

12:00-12:30 **1998 Village Power Road Warrior Award**

•Village Power Road Warrior Address - *Bud Annan*


Village Power "Road Warrior" Award
Richard Hansen
for his pioneering vision, early development of sustainable models for renewable energy commercialization, commitment to local capacity building and ownership, and his quiet perseverance in the service of village power and rural development
Renewables for Sustainable Village Power
Oct. 6, 1998
Richard Truly, Director
National Renewable Energy Laboratory
Date


Village Power "Institutional Entrepreneur" Award
Allan Hoffman
for his commitment to and leadership in the application of renewables to international development.
Renewables for Sustainable Village Power
10/13/98
Richard Truly, Director
National Renewable Energy Laboratory
Date

Moving Forward: A Proposal

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Bud Annan

Since the start, the promotion of renewable energy has been a difficult challenge, and as a national priority, it has never ranked high. Beginning with the 1973 oil embargo, U. S. policymakers attempted to assemble “windows of opportunity” to drive the development and create markets for wind, solar, biomass and geothermal technologies. The first window was energy security supported by research and development and tax credits. PURPA and its regulatory requirements built an adjoining window. Opening these windows helped develop the first generation of renewable energy technologies and create a startup U. S. industry but the windows closed without establishing the momentum necessary for sustainability. With the decline of the energy prices in the 1980’s and with an emphasis on free markets, no special windows were framed. However, the industry and technology continued to make incremental improvements. The 1990’s window constructed in 1993 attempts to integrate environmental and energy policy while maintaining a focus on voluntary actions within free markets.

The renewable energy strategies resulting from the current policy window include:

- Increased government research and development support.
- A call for the removal of historical barriers.
- Proactive cabinet level support.
- Greater cooperation between U. S. federal agencies and between donors.

The implementation of these strategies created a drumbeat of progress. For example:

- Renewable energy product costs have come down and conversion efficiencies have increased resulting in a more cost competitive product particularly for remote markets.
- The Agency for International Development reprioritized its resources and initiated a comprehensive set of sustainable energy for development projects.

- The U. S. Department of Energy cooperating with the Dutch Ministry of Assistance and the World Bank created a special organization to promote energy efficiency and renewable energy projects in growing economies.
- Regional initiatives were designed and implemented in the Americas and Asia.
- Pilot projects in household systems and village hybrids in India, China, Brazil, and South Africa, were designed and implemented using bilateral cooperation.

The World Bank record reflects the progress, particularly in developing niche markets. From a minimal level of effort in sustainable energy at the start of the 1990's, it now supports thirty projects. These projects valued at upwards to $3 Billion include $1.2B in World Bank loans and represent the displacement of 1.6 gigawatts of fossil based generation.

The issue now is scale up to a meaningful and measurable level. It is about progress across 160 countries displacing thousands of gigawatts. However, there is cause for concern regarding the ability to achieve scale-up under the current conditions.

First, the policy dialogue has lost its technology emphasis. In its place is the more controversial issue of targets and timetables. The proposed goal developed in Kyoto for reducing global CO2 emissions by 7% below 1990 levels by 2010 is criticized as being unrealistic and economically unsound. There are fears of unjustified restrictions on the economy and an adverse impact on the operational readiness of U. S. armed forces. The lack of developing world agreement has brought forward movement to a crawl. The Kyoto agreement and its implementing mechanisms remain controversial.

Second, creating sustainable markets is more difficult than originally believed. The Village Power Conferences, present information that demonstrations to reduce technical risks are not sufficient to ensure sustainability. Roger Taylor of the National Renewable Energy Laboratory correctly points to the institutional aspects necessary for building markets including partnering, maintenance, cost recovery, development coordination, planning tools, economics, language and culture. There is also new information that confirms the importance of commercial replication and attractive long term financing in achieving successful market development. Further complicating sustainability is that as demonstrations move from household systems to village and even grid tied systems, the investment and risks go up. The Brazil village hybrid indicates an investment upward from $200,000 is needed. In order for the village systems to be a viable business, it is estimated that a developer would need a market of 15 to 20 such systems in a tight geographical area in order to support the necessary repair and maintenance infrastructure. Finally, the new complexities of the energy market worldwide created by privatization and restructuring coupled with the large risks of new technology in new institutional settings are influencing the ability to create sustainability. Before the customer was the local utility, but with privatization defining the customer becomes less clear.

The changes in the renewable industry worldwide have added a third difficulty. Manufacturers have become commodity suppliers, pushing system integration as close to the end user as possible. This segment of the industry is very dispersed, generally unorganized, and lacks resources for market development. Thus, an industry already undercapitalized has little incentive to expend corporate resources and time in demonstrating technology, developing new markets and underwriting the development of distributor and system integration businesses in high-risk economies. The industry now no longer forces programs to happen. It has allowed itself to wait for programs to be designed by others.

The biggest concern regarding the ability to move forward with scale-up including the ability to deal effectively with these difficulties is the lack of leadership both public and private. The lack of agreement between administration and Congressional officials over budget, the importance of environmental issues, and the role of the federal government has created a polarized and cautions policy environment. At best, it is a shared leadership too willing to compromise. The renewable energy industry is short on resources, lacks a collective drive, and has become only marginally effective. Bechtel, Battelle, and the Midwest Research Institute recently awarded the operation and management of the National Energy Laboratory, is well positioned to assist in building bridges between the public and private sectors. Nevertheless, its capability for leadership is tied to federal actions. Non-governmental organizations remain an active catalyst for sustainable development, provide the analytical, and project underpinnings for an energized leadership.

If the problems are our making, then we can generate the solutions, and we must act quickly. We cannot afford to mark time because world economic development does not stand still and every energy decision from building buildings to power plant construction is a 30- to 50-year decision. Old power plants need to be retired not relicensed. If increases in fuel prices through tax increases are politically unthinkable then policies must turn to regulation, technology support, and a new value system. These elements when combined with electricity restructuring and concerns about the environment frame a new window of opportunity.

First, we reestablish industry leadership. However, the new leadership is much different from the leadership of the early 1990's. It is a new membership of energy technology providers and technology users. These industry leaders not only recognize their environmental responsibilities but also recognize the market potential of growing economies.—the need for energy that provides access to new communication, learning and entertainment products and services. This new industry leadership seeks engineering solutions and new opportunities not excuses. The new leadership has a sense of urgency and a commitment to put into place policies, strategies, and projects so as to have measurable impact by 2010.

The first priority for this new industry leadership is to bring the policy focus back to technology development and its deployment. It seeks to raise the priority of renewable energy as a matter of national policy. Working with the Administration, Congress, multilateral financing agencies and nonprofit organizations, the leadership works to reestablish trust and a cooperative attitude in finding a common baseline and commitment for sustainable technology based growth. There is new fresh information to support this new dialogue. It includes the comprehensives report submitted by the President's Committee of Advisors on Science and Technology entitled "Federal Energy Research and Development for the challenges of the 21st Century", the study produced by the eleven National Laboratories entitled " Technology Opportunities to Reduce U. S. Greenhouse Gas Emissions", the new information produced by the Village Power Workshop on critical elements for sustainable success, as well as the new realities of today's energy marketplace.

Next, the leadership establishes a dialogue with the leaders of national and international agencies to reach a consensus on a set of sensible strategies. The strategies flow from the 1990's drumbeat of progress but with a greater attention to incentives and creating preferences for renewable energy. Strategies focused on fundamentals that unlock value are needed. They include:

- A thirty-percent increase in government funding for technology development and deployment. In addition, fiscal incentives in support of state restructuring efforts and greater support for bilateral cooperation are needed.
- Putting market forces to work by changing the economic signals. Tradable credits appear to be a promising new dynamic market force. Every renewable installation should carry with it tradable credits that has value to the energy industry as well as to governments.
- Designing and implementing a worldwide initiative on renewable energy based rural electrification that moves beyond household systems. The demonstration of household systems is a success. Attention must now turn to policies that replicate the success and move on to energy for productive uses—communication and education and job creation.
- Building Capacity. There are many models that show promise in building in country capacity. The Winrock Foundation is one. There needs to be a strong long lasting commitment to build capacity at all level of the economic and political system of growing economies.
- Enhancing technology transfer. Governments of growing economies need to strengthen intellectual property laws, relax tariffs on imported equipment's, and implement tax policies that stimulate investment while at the same time create performance standards. Long term technology transfer is effective if there is a movement away from grants and gifts. The private sector demands transparent and fair standards for competitive investment and financial markets that live up to international standards.

The third and final element of the new leadership strategy is to create a sense of urgency. Large scaled-up projects that are not government selected projects or politically connected ventures are a good way to focus. Industry needs to create ten such fast track projects. It should also spearhead the creation of an international team of technology and business experts to review in place projects. Development oriented agencies desperately need a set of best practices, legal frameworks, and financing strategies that allows the rural poor access to energy. Finally, the leadership should promote the successes and fix the failures.

We are fortunate to see corporations responding to this leadership challenge. British Petroleum with its announced strategy to cut greenhouse gas emissions by 10% of their 1990 levels by 2010 has “set up a whole new level of expectations for other corporations.” Shell has joined with its announced effort to bring solar-based electricity to 50,000 homes in South Africa. Arizona’s Corporation Commission is leading with its mandated solar portfolio standard as a critical element of the electricity restructuring to take effect January 1, 1999. Northern States Power joins the leadership with the world’s largest single wind generation facility--enough electricity to provide for the residential needs of about 43,000 Minnesota households. The Village Power Conference will create other world leaders. These leaders challenge conventional thinking and change the vocabulary on the way we explain progress. They educate us and create a new sense of opportunity. It is the start.

14:00-16:00 **Organizing for Scaling-up Electricity Access; Models for Sustainable Energy Delivery**
- *Chair, Karl Jechoutek,World Bank*
•Key Issues in Scaling-up Rural Electricity Access
- *Arun Sanghvi,World Bank*
•Scaling-up Rural Photovoltaic Enterprises in Emerging Market Economies: *The Case of China*
- *Noureddine Berrah,World Bank*
•Mexico: Achieving Universal Coverage
- *Carlos Gonzáles, CFE, Mexico*
•Brazil Prodeem Program – *Eugenio Mancini, National Department of Energy Development (DNDE), Brazil*
•South Africa ESKOM Renewable Energy Experience
 - *Thulani Gcbashe, ESKOM*
•Solar Electric Energy Delivery - A Business Model
- *Richard Hansen, SOLUZ, Inc.*

Key Issues in Scaling-Up Electricity Access

Arun P. Sanghvi

Thematic Group Leader Rural and Renewable Energy

The World Bank

Village Power '98 Conference

October 6-8, 1998

Washington, DC.

The Challenge of Inclusive Development

- Worldwide, over 2 billion people
  - Do not have access to electricity
  - Rely on traditional biomass fuels and use them in inefficient/unsustainable ways
- Most people without modern energy are rural
- “Challenge of inclusion”--reduce poverty, improve quality of life, reduce disparities--key development challenge of our time
- In South Asia and Africa, we are loosing the race

The Challenge of Scale and Pace:Ethiopia

- Household access under 5 percent--that too, many in urban areas
- New connections rate for rural households (about 10 million households) is around 5,000/year
- At this rate……

“We must look at these issues, with a sense of urgency and a sense of scale”

The Challenge of Scale and Pace: Bangladesh

- Household access overall about 15 percent--in rural areas about 10 percent
- New connections rate for rural households (about 15 million households) is around 120,000/year
- At this rate….

"We can continue business as usual, focusing on a project here, a project there, all too often behind the poverty curve."

Challenge: Renewable Energy Is Underutilized

- Many small-scale renewable energy technologies are:
  - cost competitive, particularly with environmental cost considered
  - near-ready for wide-spread use in developing countries
- Yet, share of renewable energy in energy supplies remains small.

Key Issues

Starting on the Right Foot--Getting the Problem Definition Right

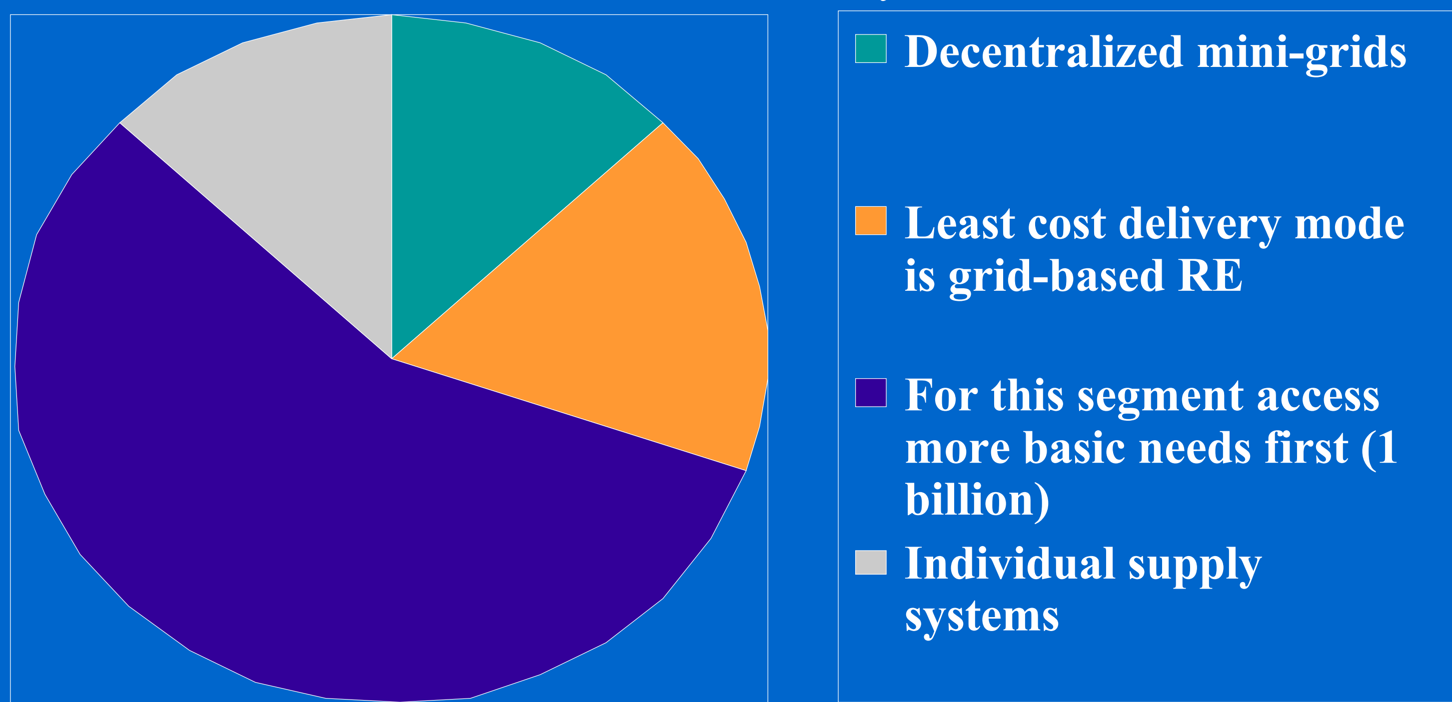
- ❍ Introducing an environmentally friendly technology
- ❍ RET market development
- ❍ Addressing global externalities
- ❍ Supporting inclusive development through scaling-up electricity access and facilitating non-farm income generation

★ Implications for strategy are quite different depending on which land whose problem we trying to solve.

Key Issues

Multiple Supply Options Necessary to Expand Access

2 billion Unserved Today



- Don’t count grid-base RE out
- Diesels will and should continue to have role

Private Sector Participation is Essential, Yet...

- Technology specific barriers
  - lack of technological familiarity
  - poor quality of resource information
- Energy sector specific barriers
  - lack of regulatory and enabling environment
  - misdirected Government policies/programs
  - market prices of competing fuels are often subsidized and do not reflect externality costs
- Economy-wide barriers
  - tariffs, duties
  - poorly functioning local capital markets, financial institutions, legal system

Key Issues

Lowering the Barriers to Private Sector

- Policy Changes
  - Provide “public good” resource information
  - Level playing field through tariff, policy and regulatory changes
  - Shift government agencies form market maker/technology distributors to market enablers

Key Issues

Lowering the Barriers to Private Sector (continued)

- Lower key costs and risks of private developers, and suppliers of capital
  - pre-investment costs
  - incremental transaction costs
  - Facilitate technical and social intermediation

Key Issues

Universal Access or Targeted Access

- Can we afford to go from one extreme today--little or no access--to the other extreme of universal access?
  - Depends on starting point and political commitment
- In most instances "electricity for all"is not feasible for the foreseeable future on account of the subsidy requirements
- The silver lining and one way out is to recognize that affordability varies substantially across the excluded population

Key Issues

Even When Expanding Access is Economically Viable Financial Viability is Not Assured

- Within the target market segments it will be necessary to expand access to end-user credit and term-financing, to local service funders by opening low cost and low hassle (efficient) financial intermediation channels
- Promote judicious use of GEF grants to lower first cost of obtaining access
- New financing mechanisms that place a market value on carbon avoided as well as trading mechanisms that offer a premium price of renewables maybe on the way

Key Issues

Facilitating Non-Farm Income to Increase the Benefits Stream is Key

- Introduction of electricity, even in areas with potential for increased productive uses off-farm, does not necessarily and quickly catalyze such benefits
- Programs aimed at scaling up rural electricity access to households should incorporate provisions to increase the capacity of potential off-takers electricity for productive uses.

The Role of Non-Conventional Stake-holders and Delivery Agents in Expanding Rural Electricity Access

- Continued reliance on urban-centric contributions will not get the job done in most instances
- We must find ways to attract local rural-centric entrepreneurs and other big stake-holders and intermediaries such as NGOs to help us design and implement our program
  - Social and technical intermediation are essential
- Upstream capacity building is a key to make this happen
  - A technical, financial skills, business, management, marketing, community relations

Conclusions

“ We have to ask ourselves not just whether this or that project has worked, but the much larger question-What development impact have we catalyzed?”

Conclusions (continued)

Think Fundamentally Radically and With a Long View

Shift Mind-Set From To

- Anecdotes Thinking Big Picture and Strategically
- Demos/Pilots and little "activities" Mainstreaming for scale up and development impact
- Solving our problems Solving their problems
- Projects/Transactions Country, Division Programs; High Selectivity; Establishing a Few Good Practice Programs for Others to See and Develop Upon
- Government as market makers Governments as market enablers

Need a Radical Shift in Mind-sets

Shift Mind-Set From	To
❍ Technology/money dumping	Develop efficient and sustainable delivery mechanisms and other by elements required for a functional market
❍ Technical assistance	Rural partnerships between the various donors agencies and multilateral institutions
❍ Road Warrior and Crusaders	More aggressive and upstream capacity building, but coordinated with a big impact on rural access investment program
❍ Road Warrior and Crusaders	- a very fertile ground for partnerships between donor agencies, and the World Bank.
	Unleashing local armies of entrepreneurs, NGOs, and other local intermediaries

Getting a Feel For How Fast Can We Achieve Scale Up For Some Segments of the Excluded Population

An Example-The Case of SHS Market Penetration

- Overall world market size today: 50+ million households
- Market Scale Today: About 150,000 units per year
- Number of years for First Million: 8-10 years
- Number of years for Ten Million: 30+

Eskom's Renewable Energy Experience

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Thulani S. Gcabashe

1. BACKGROUND

Eskom is the largest electricity utility in Africa, generating approximately 60% of the electricity consumed on the continent and having installed capacity of some 39 000 Mw. Up until the early 1990's, its distribution business had operated largely as a wholesaler of electricity supplying in bulk to municipal distributors and large industrial customers. Its direct domestic customers, who reside mainly outside proclaimed urban areas amounted to half a million in 1992. This changed dramatically from 1994 when Eskom, along with other municipal distributors, agreed to electrify 2.5 million homes by the year 2000 as part of the Government's Reconstruction and Development Programme. This coincided with the ushering in of the new democracy whereby underdeveloped areas became the focus for development investment. At this stage, 65% of households did not have access to electricity. These households were largely Black, and lived in peri-urban and informal settlements, as well as rural areas. The programme sought to reduce this to 30% by the year 2000. Although the electrification programme envisaged the use of both grid and non-grid technologies, the entire residential electrification programme has been off grid electricity. The main reasons for grid electrification were firstly, that there already existed a well established distribution network in most parts of the country; secondly the relative costs of non-grid technologies were considered prohibitive; and that grid electrification was the more effective way to bring about rapid electrification.

2. THE ELECTRIFICATION PROGRAMME

The electrification programme which began in 1994 was estimated to cost a total of $2 billion over a 5 year period, with investment peaking at $333 million. Some of the underlying assumptions of the programme were:

- The programme would be financially viable and sustainable.
- Project selection would be transparent and involve the relevant role players.
- Rural electrification would be a focus area.
- Equity would be maintained between the various area to be electrified.

Eskom committed to electrify 1,75 million households out of the total programme of 2,5 million. The programme has thus far met the targets and will meet the total obligation by the year 2000. As a result of what has been done so far, for the first time in the history of South Africa there are more houses with electricity than those without.

By end of 1997, approximately 59% of homes had access to electricity. Between 1994 and 1997, the percentage of rural people with access to electricity rose from 12% to approximately 27%, an increase of 15% over 2 years. In urban areas, the percentage of people with access to electricity by the end of 1996 was around 79%. As with many such endeavors, it quickly became apparent that the assumptions regarding financial viability would come into question. This led to a number of supply and demand side interventions that were to see the cost per connection reduced from $711 in 1994 to $530 in 1998. (Projected to $465 in 1998).

This has been achieved in spite of the fact that the programme has been moving into less densely populated areas for some time now. This has been achieved by technology optimisation in the following way:

a) Network designs were optimised to lower load requirements. Initially they were based on 60amps per point of supply and an after diversity maximum demand (ADMD) of 1,5kVa. The standard is now based on 20amps per point of supply and an ADMD of 0,4kVa. Upgradeability is built into the design philosophy.
b) More appropriate technology has been applied such as single wire earth return and single phase medium and low voltage systems.
c) Other design improvements related to standardisation and efficiency initiatives. Ratios and indicators were developed to assist in the process of capital release. For example number of structures per kilometre per conductor type, transformers per kilometre and number of connections per transformer.

To further enhance the viability of the electrification programme Eskom embarked on a number of demand side initiatives.

Through interaction with the customer and measurement of consumption patterns Eskom developed a basket of products to ensure that the areas being electrified have a higher take-up rate and therefore reduce the cost per connection through more efficient utilisation of the reticulation network. These products include a 60amp and 2.5amp option in addition to the standard 20Amp option.

Various marketing initiatives to create electricity awareness and demand have also been initiated. These include talks at schools and social institutions on the safe and efficient use of electricity, sponsorship of sporting and cultural events, and the distribution of appropriate literature to customers.

Electricity supply to the various market segments has been branded to enable a more focused interaction between Eskom and its customers.

Through this programme, Eskom has contributed to achieving critical mass in terms of access to electricity. Although overall electrification rates of 70-80% will be attained through this programme, it is unlikely that more than 30% electrification in rural areas will be achieved through grid-electrification alone.

3. ESKOM'S INVOLVEMENT IN NON-GRID ELECTRIFICATION

Eskom's contribution to the development of non-grid energy provision has been in three main areas: through contribution to the development of national policies for energy and electrification, initiation of the Energisation Programme which develops and implements options for meeting customer's energy requirements in conjunction with other energy suppliers and in implementing the non-grid Schools Electrification Programme.

3.1 NON-GRID SCHOOL ELECTRICIATION PROGRAMME

The Non-Grid School electrification programme grew from a commitment to the South African Government to manage the electrification of some 16 000 remote schools which would not be grid electrified in the medium term. This programme was to utilise funding from international donors and other government sources who were concerned about developing the country.

Eskom has developed a number of procedures and activities in order to make this programme a success. This has included the following:

- Equipment standard specifications.
- Installation procedures
- Commissioning procedures and test equipment
- Component evaluation facilities
- Training programmes for first time installation contractors
- Business training programmes for new contractors
- Evaluation and feedback processes.

This programme is specifically aimed at bringing the benefits of effective educational opportunities to those who previously had to rely on very rudimentary teaching aids. Each school is provided with:-

- Adequate lighting for four hours a day for 3 of the classrooms, the staff room and the headmaster's office.
- 220V AC power for 1 to 2 hours a day to run television, video recorder, overhead projector and computer.

The direct benefits to approximately 400 pupils per school are realised immediately, while the longer term benefits from adult education programmes like literacy training, business skills and upliftment of the community lifestyle will impact many more people.

An integral part of the programme is the employment of local contractors who are given installation training and the employment of local labour for installation. Through this process jobs are created in the community, as well as a sense of ownership developed.

Systems installed are designed for a lifespan of 15 years, with the batteries having to be replaced at regular intervals.

While a number of issues still need to be resolved around the optimum utilisation of these systems by the pupils and teachers a great level of commitment is being displayed by the Provincial Department of Education to the modernisation of all aspects of schooling in the shortest possible time. The one great pity of this exercise is that very little international donor support has been forthcoming and only 1 300 schools have been electrified to date.

3.2 ENERGIZATION PROGRAMME

"Engergization SA" is essentially the matching of energy supply side resources with (community) energy demand requirements and optimising to form a combined energy offering which can provide economic growth opportunity for long term viability. As it involves balanced energy solutions, this requires the optimal combination of different energy sources which takes into account their efficiencies, availability and costs. LPGas, for example, is an excellent energy source for thermal applications, such as cooking, while electricity has the competitive advantage in the applications of lighting, entertainment, refrigeration and the running of motors. Energization is therefore a best combination of energy sources to ensure an efficient, cost effective energy package that is available in the community and is within their economic means.

The energization process comprises a number of elements, which can vary depending on the energy resources available and the circumstances of the community.
The start-up product offering consists of LP Gas hardware and a PV system:

- 2 of 4,5kg LP Gas cylinders, filled,
- 2-plate gas stove with connections,
- 49W PV panel, roof or pole mounted,
- Battery with regulator,
- 2 lights of 9W,
- Outlets for a black and white television set and radio (depending on product compatibility)

It is expected that the above system would be used in 95% of the cases, however, there are larger systems to take care of the needs of the customer requiring a more sophisticated system.

The capital to purchase the system is either payable in cash or financed over a period. In the current pilots, Hire Purchase financing is available.

As the Energization offering is seen as one package, one flat rate payment per month will be made and collected by the Energy Agent. For this, the Energy Agent is paid a collection fee. The payment pays off the hardware and entitles the customer to refill one bottle with LP Gas. The charge for extra gas refills will be determined by the Energy Agent (as recommended by LP Gas supplier) and collected on a cash-on-delivery basis.

The selection and training of the Energy Agent is of utmost importance, as the Energy Agent will play a pivotal role sustaining the Energization process.
The agent will be required to offer a full service to the community in terms of their energy needs. This includes:

- The installation of the PV panels,
- Their panels,
- The sale of the LP Gas equipment
- The sale of additional gas and
- The collection of revenues

For each of these duties he will receive an appropriate fee. As part of his customer service and satisfaction programme, he will also provide energy advice to customers as to the most effective use of their energy package.

3.3 JOINT VENTURE PROJECT FOR RESIDENTIAL NON-GRID ELECTRIFICATION

Another development is that Eskom and Shell are in the process of establishing a joint venture agreement whereby a fee for service programme will be implemented in a number of different rural areas. This programme is believed to be a world first on the scale involved and will provide lighting, communication, cooking and heating.

The customer will not need to buy the technology, as the hardware will remain the responsibility of the Joint Venture company, while the customer only pays on a monthly basis for the level of service installed and received.

6 000 installations are planned in phase one to extend to 50 000 if all evaluation points are met. This programme includes newly developed security technology and electronic prepayment devices. The emphasis in the implementation process is on empowerment of local black organisations and on full commercial sustainability.

3.4 OTHER PROJECTS

Eskom is further involved in economic evaluation and technical assessment of larger scale renewable programmes within the context of the South African climatic and economic environment, included in these are:-

- Grid connected wind farm (4.8Mw)
- Solar thermal electricity generation (200Mw)
- Medium size hybrid systems for agricultural application
- Biomass electricity generation

In order to have a reliable foundation on which to make long term decisions, a national renewable energy resource database and evaluation platform is being developed in conjunction with other interested stakeholders in the country.

To conclude, our country is at a stage where viable grid electrification for rural areas is approaching its full potential. We need to continue to pursue renewable energy technologies in order to continue energization in rural areas. I have no doubt that the experiences of other nations grappling with similar problems will assist us in this endeavour.

ESKOM

ESKOM'S RENEWABLE ENERGY

EXPERIENCE

THULANI S GCABASHE
ESKOM

VILLAGE POWER '98
Washington DC
October '98

BACKGROUND ON ESKOM

- **Vertically integrated national Utility**
- **39 000 Employees**
- **Nominal generating capacity 38 497 MW**
- **National Transmission Grid integrated with Southern African Power Pool (SAPP)**
- **1997 Sales 172 000 GWH (4% Growth)**

BACKGROUND ON ESKOM (CONTINUED)

VISION

- To provide the world's lowest-cost electricity for growth and prosperity

MISSION

- To satisfy all our customers' electricity needs in the most cost-effective way

STRATEGY

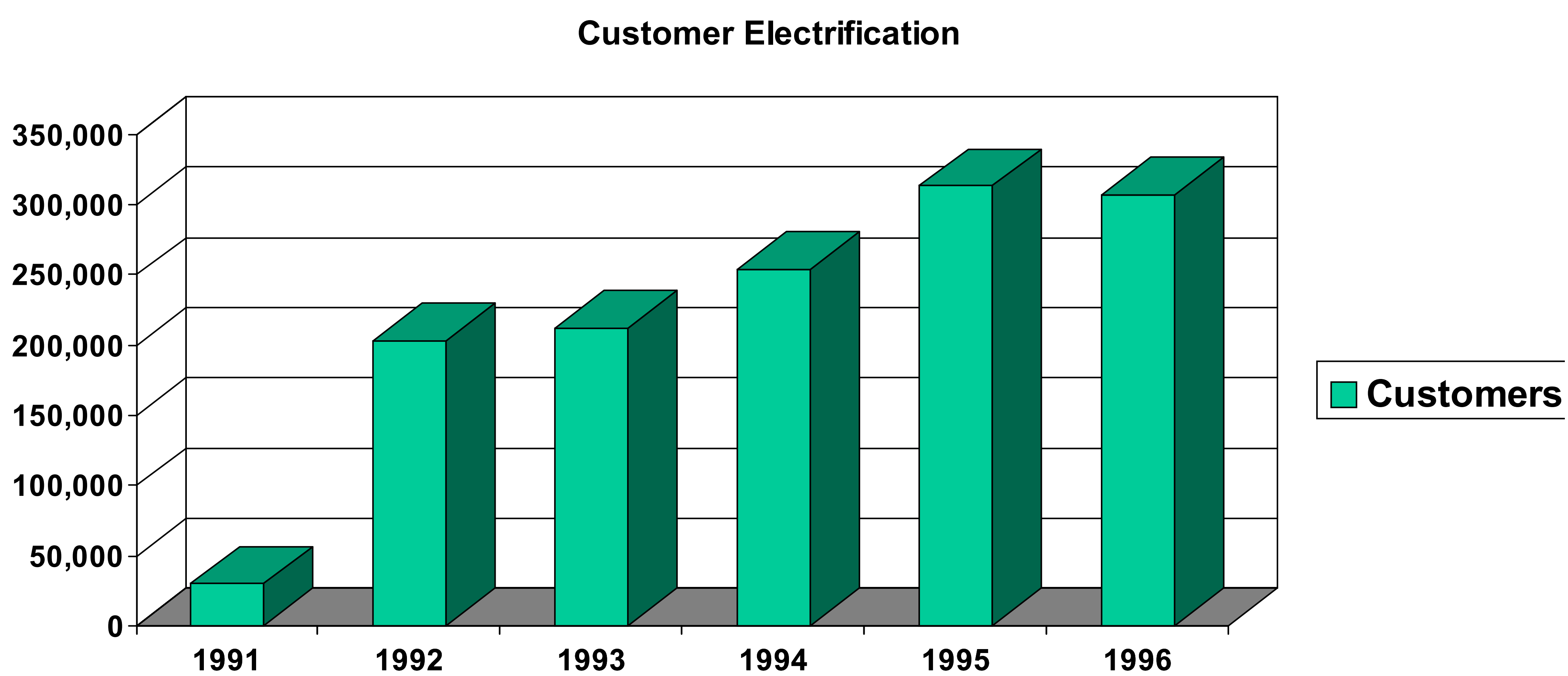
- To develop ESKOM as a business that maximises the value of its products and services to South Africa.

ESKOM

4.

CUSTOMER ELECTRIFICATION PROGRAMME

1991	1992	1993	1994	1995	1996	1997	ITD TOTAL
30,000	202,877	211,798	254,383	313,179	307,047	274,345	1.593,629



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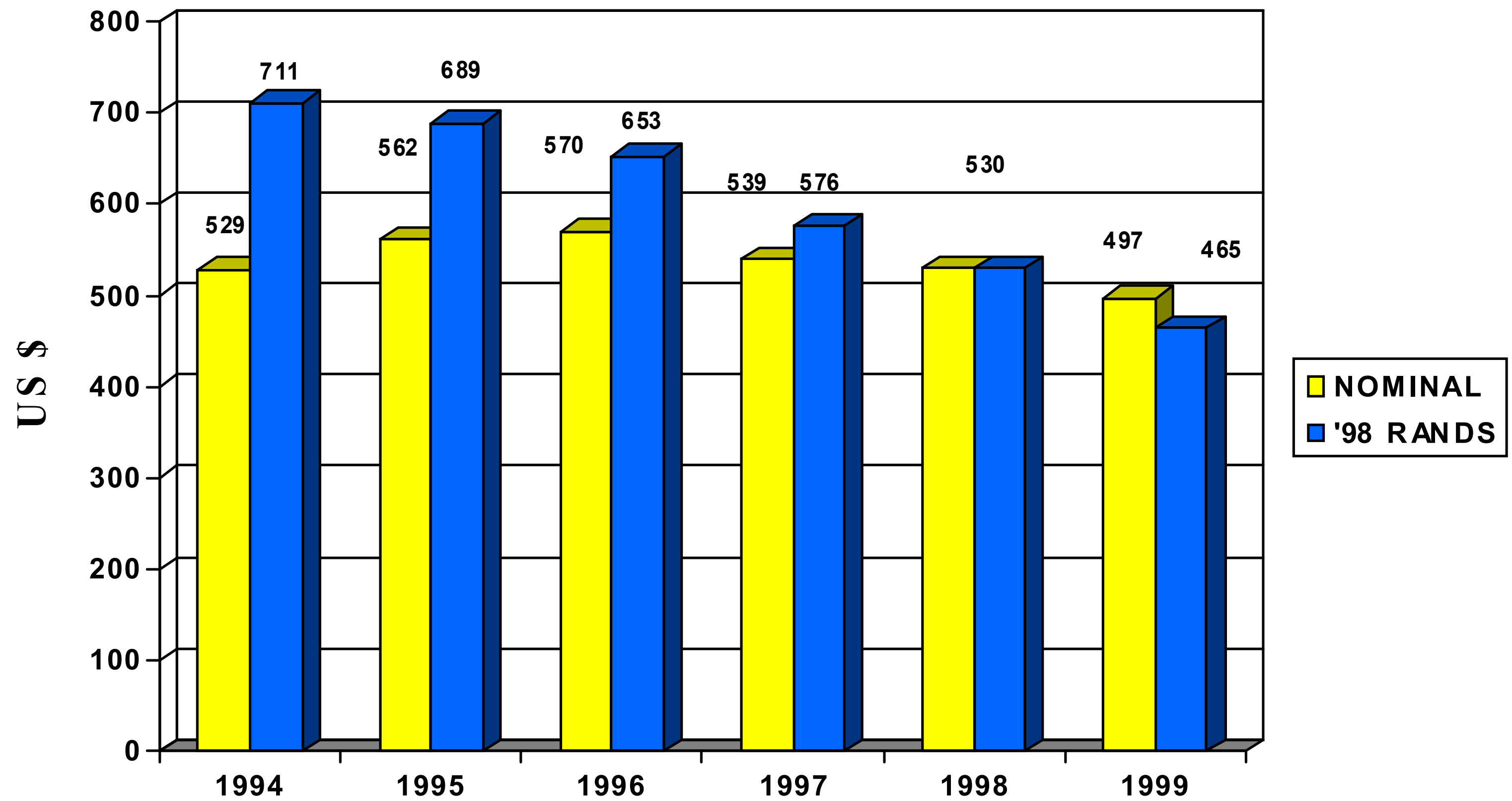
COST PER CONNECTION 1994 - 1999 (US $)



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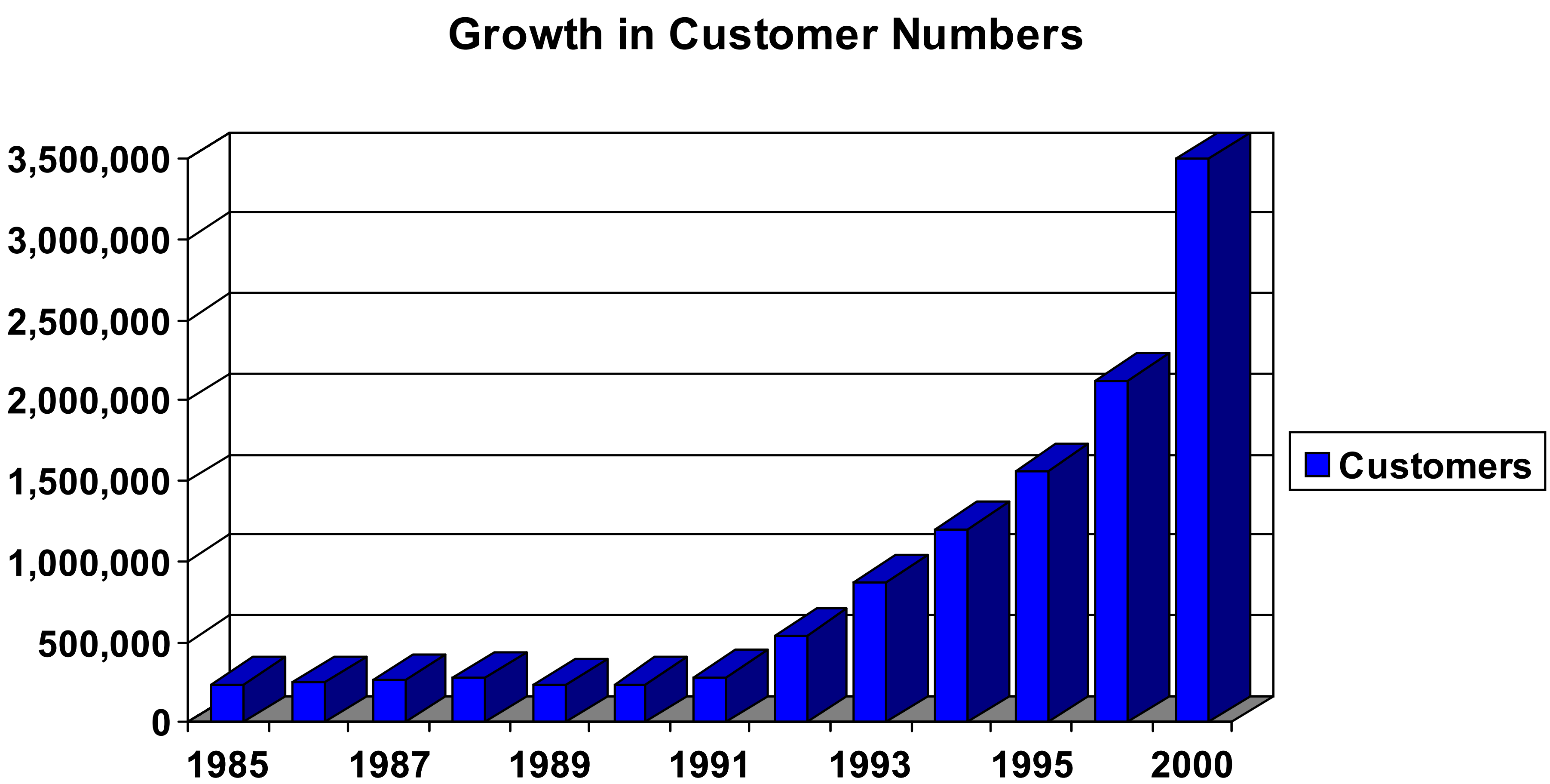
Growth in Customer Numbers

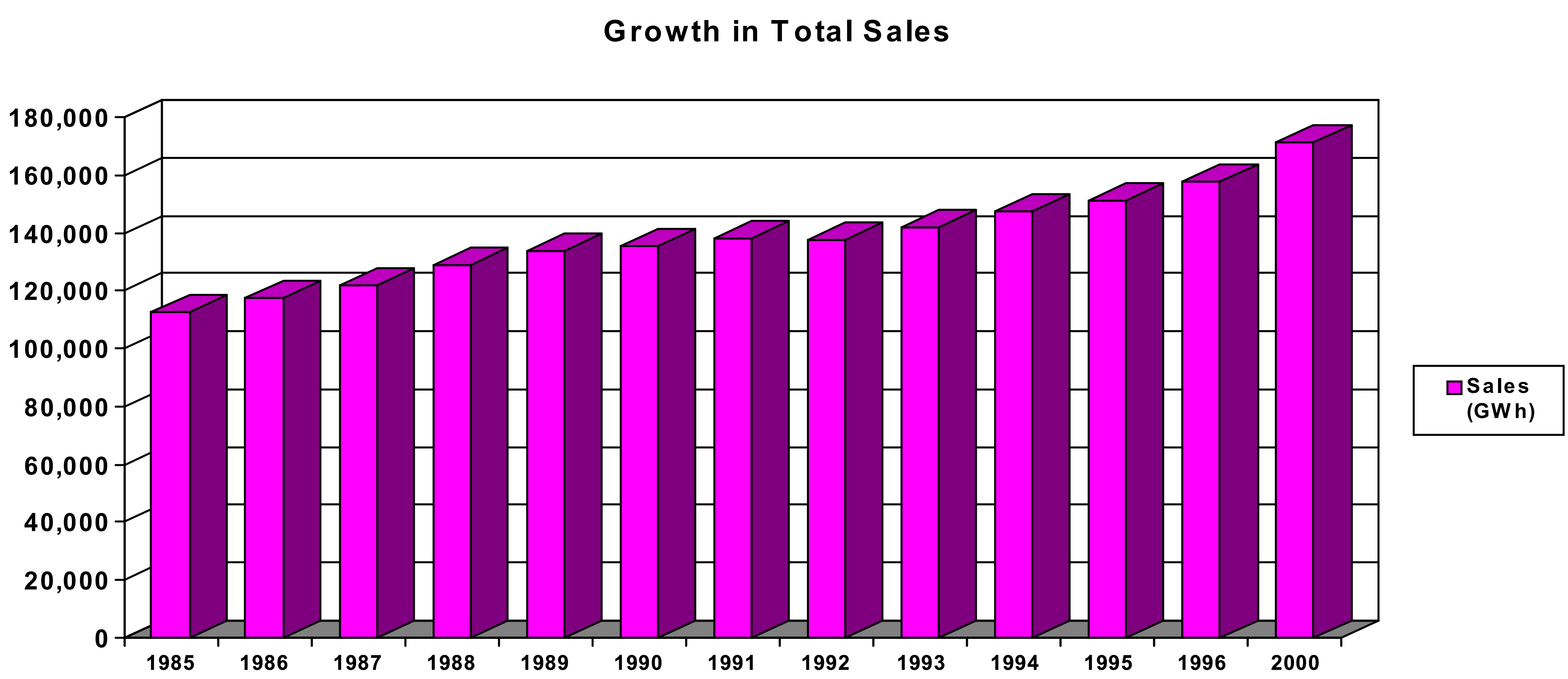


Customer Electrification Programme

		1991	1992	1993	1994	1995	1996	ITD Total	Target
Electrification	Customers	30,000	202,877	211,798	254,383	313,179	307,047	1,319,284	1,750,000

8.

Growth in Total Sales



CUSTOMER SERVICE BUSINESS ARCHITECTURE

- **CHANGE DRIVERS**

  - ✧ Change from wholesaler to retailer
  - ✧ Rapid growth and change in customer mix
  - ✧ Systems antiquated and not flexible
  - ✧ Business approach not customer focused
  - ✧ Positioning for changes in the Electricity Distribution Industry

STRATEGIC ALIGNMENT

- Standard and uniform customer service
- Distribution Business to be process orientated
- Transformation Objectives
  - ✧ Improve customer satisfaction
  - ✧ Reduce service transaction cost per customer
  - ✧ Adhere to National Electricity Regulator's Standards

ESKOM

11.

CUSTOMER RELATIONS PROGRAMME

- August 1993 development team set up - defined future state
- Understanding the customer
  - 101 service requirements
  - Service standards per customer segment
  - Service charter

ESKOM

CUSTOMER RELATIONS PROGRAMME

- **Key value chains defined**

Customer orders

- ✧ **Fault management**
- ✧ **Account payments**
- ✧ **Customer queries**

- **Benchmarking against overseas utilities**

CUSTOMER RELATIONS PROGRAMME

- **BUSINESS ARCHITECTURE**
- **Architecture Building Blocks**
  - ✧ **Corporate Head Office**
  - ✧ **Regional Head Office**
  - ✧ **Customer Care Centre (call centre, account operations, processing centre)**
  - ✧ **Service Representatives**
  - ✧ **Customer Advisors**
  - ✧ **Customer Executives**
  - **Sales Persons**

CUSTOMER RELATIONS PROGRAMME

- PROGRESS TO DATE
  - Front line practices standardised (3 000 employees)
  - Completed Customer Interface Training)
  - 140 Managers completed Customer Leadership Programme
  - Definition and documentation of Management process
  - Customer Service System with 30 application modules 450 functions in near completion

FUTURE CUSTOMER SERVICE ISSUES

- Service culture
- Payment for services
- National Electricity Regulator requirements

Village Power '98

Solar Electric Energy Delivery: A Business Model

Richard D. Hansen
SOLUZ, Inc.

October 6, 1998

Overview

- The need
- A business model (SOLUZ experience)

  Customer ⇒ Technician ⇒ SSC ⇒ Country Op.
- Scale-up potential

» Market

» Investment Capital

» Operational Capacity

Global Household Need

- 2 billion people without access
- 400 million households
- 10% coverage is 40 million HHs
- 10,000 technicians working 10 years

Country Characteristics
for Soluz Model

- Geographical area/population density
- Ability to pay in rural areas
- Government attention to rural electrification
- Capability of commercial sector
- Programs of the NGO sector
- Degree/quality of market conditioning

Market Overview
Dominican Republic

- Population = 7.5 million
- Area = 45,000 sq. km.
- Rural population = 3 million = 65/sq. km.
- 30% electrified by national grid
- ~ 400,000 non-electrified households
- ~ 8,000 SHSs = 2% penetration

SHS History

Dominican Republic

1984	1 demonstration SHS
1985-87	Market seeded with 100 SHS
1988	Enersol tech./micro training prog., import duties reduced
1989-93	10 micros $\Rightarrow$ 2000 SHS
1993	Total 4000 HHs = 1% penetration
1994	SOLUZ begins renting SHS

Existing Slide

- Potential for PV

Existing Slide

- Energy Expenditures

Capital Requirements

Dominican Republic

Households	Capital
200,000 (50%)	$100 Million
40,000 (10%)	$20 Million
5,000	$2.5 Million

SOLUZ SEED™
(Solar Electric Energy Delivery)

- PV rental or "fee-for-service"
- Target 50% of local population
- Scale-up to min. 5,000-customer blocks

Near-Term Business Objective: Soluz Dominicana is building a commercial 5,000-home PV fee-for-service business operation to satisfy the electrical energy needs of rural households.

Existing Slide

- Map of DR

Photos of systems

(Discuss system sizes, fee structure)

Technician Service/Collection Structure

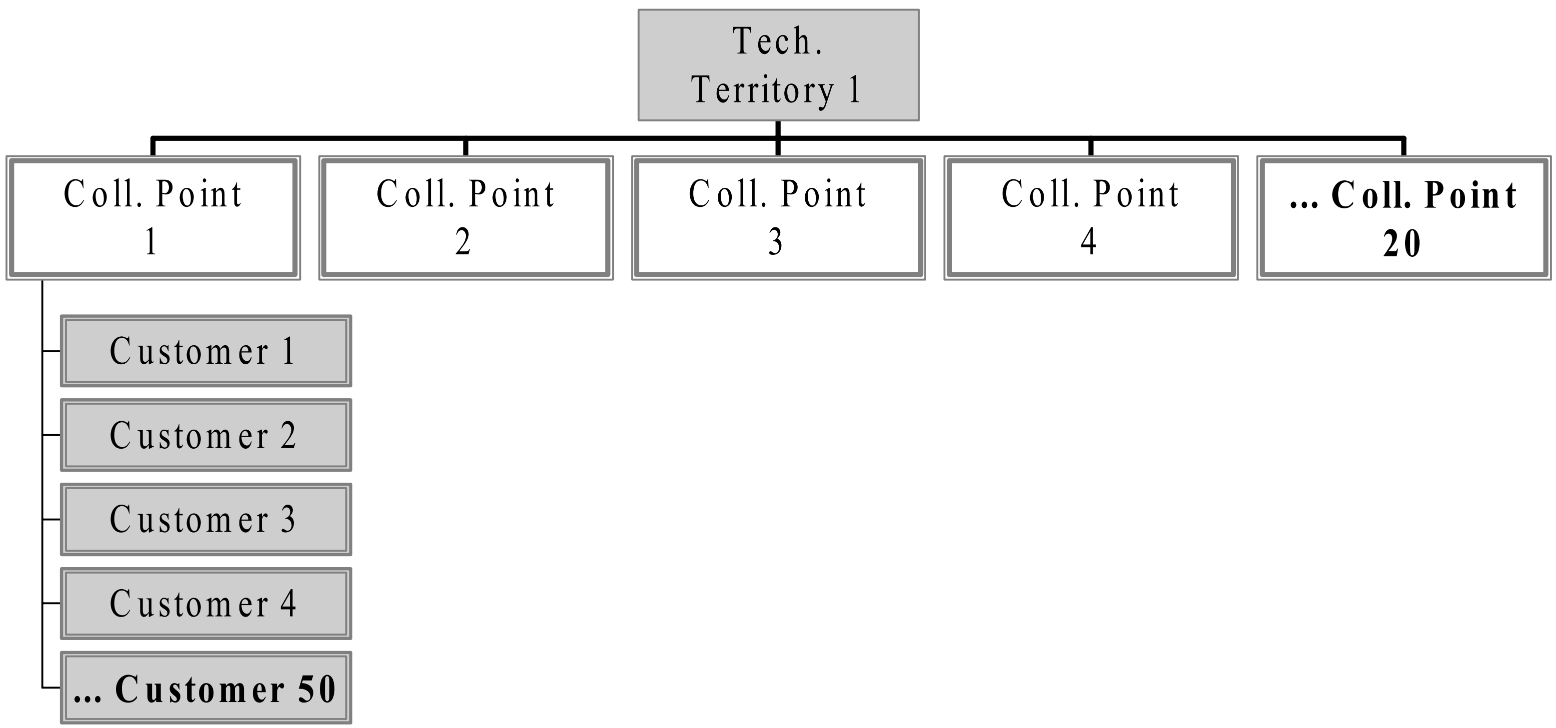
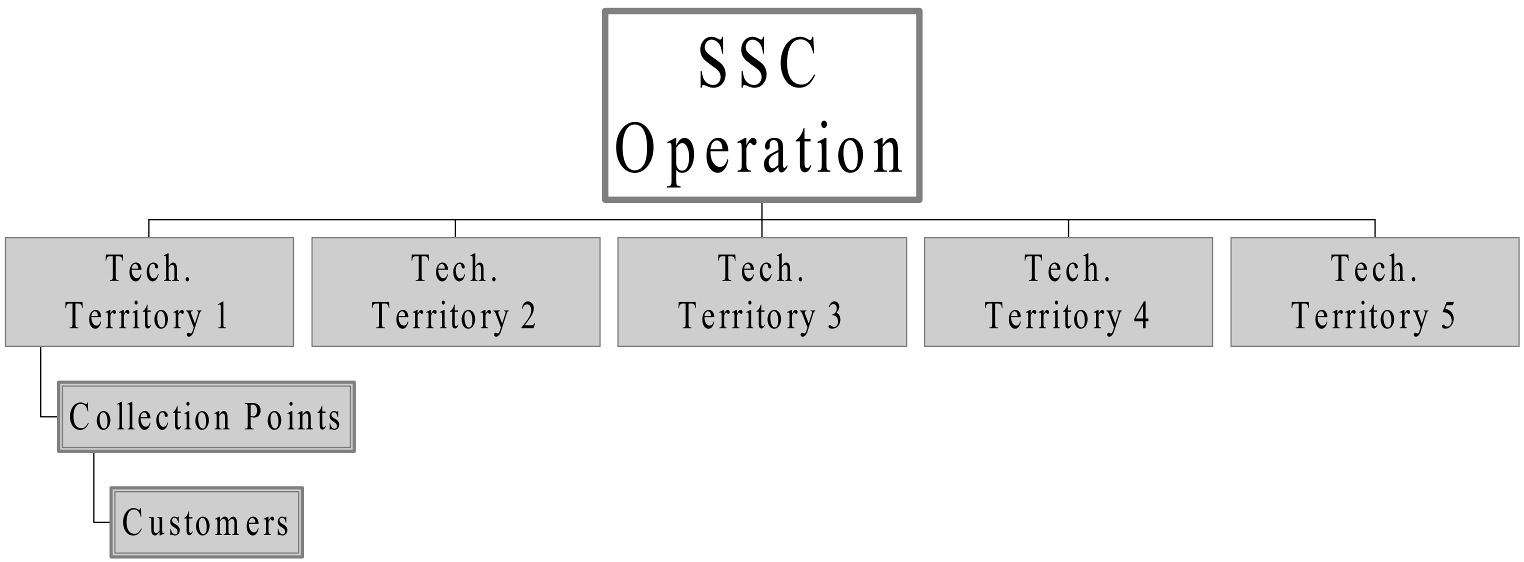


Photo Slide

- Photo of Technician (Jose "Chepe" Mella)

5,000-Customer Business Unit



5,000-Customer Business Unit

(2 MW Equivalent)

Financing Requirements:

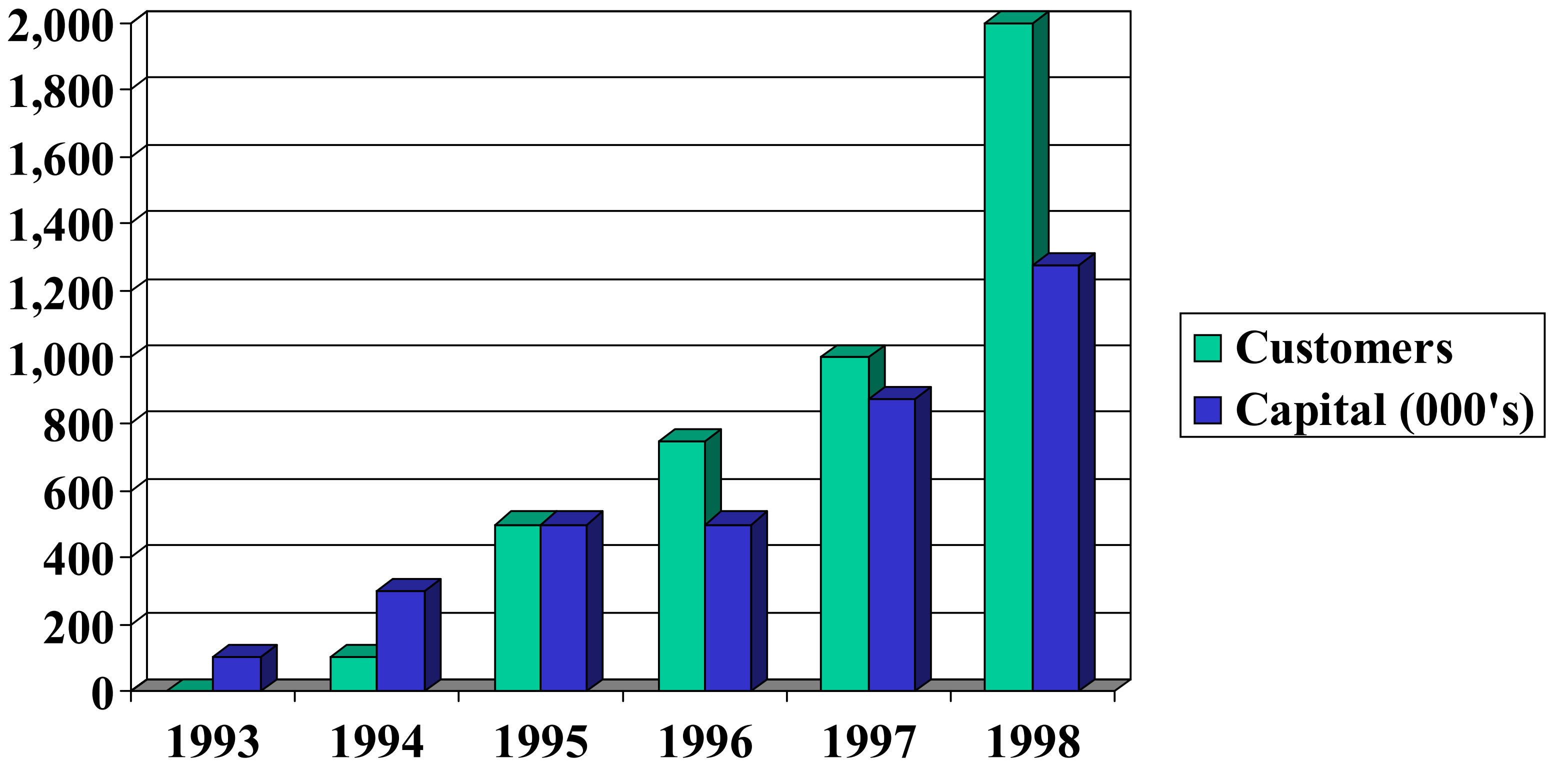
Equity	Debt	Off-Balance Sheet	Total
$500K	$1,000K	$1,000K	$2,500K

Revenues:

$1,000,000 annual (90% fee-for-service)

SEED™ Progression

Dominican Republic



DR Transactions ($1.275M)

Oct 93	$100k	RF
Dec 93	$200k	RF
Jun 95	$200k	EEAF(AID)
Apr 97	$75k	EEAF(IFC)
Jul & Sep 97	$75k & $75k	E&Co (IDB)
Sep 97	$150k	Calvert
Mar 98-Oct 98	$400k	SunLight

Replication

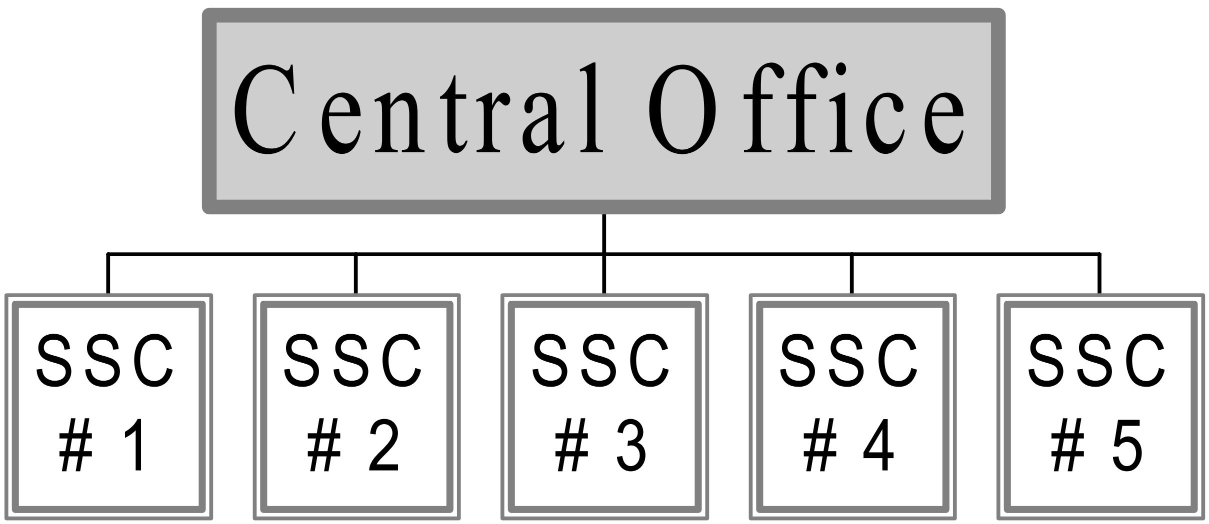
Honduras

SOLUZ, Inc.

- Soluz Dominicana, S.A.
- Soluz Honduras, S.A.

Year End	Customers
Yr 1	500
Yr 2	2,500
Yr 3	5,000

Business Expansion to 50,000 Customers



50,000-Customer Business Unit

(20 MW Equivalent)

Financing Requirements:

Equity	Debt	Off-Balance Sheet	Total
$5M	$10M	$10M	$25M

Revenues:

$10,000,000 annual (90% fee-for-service)

Scale-Up Potential: Parameters for Growth

- Market/Customer Demand
- Investment Capital
- Operational Capacity

Market-Customer Demand

- Willingness and capacity to pay
- Customer Payment Plans
  - Cash
  - Credit
  - Fee-for Service
- Concentrated Demand

Investment Capital

- Standard issues
- Rural PV = new business activity
- Limited operational track record
- Potentially lean profit margins
- Uncertainty of sector restructuring
  - Private or government leadership?
  - Competitive PV market or rural concessions?
- High transaction costs

Operational Capacity

- Need to train rural technicians
- Limits to rate of organizing/mobilizing human resources

The Next Step?

ABC GLOBAL SOLAR, Inc.
1,000,000 Customers
($500M PV Assets)

Country 1
100-200,000
Customers

Country 2
100-200,000
Customers

... Country 10
100-200,000
Customers

16:30-18:00 **Panel Discussion: Roles and Consequences of Bilateral Donor Programs**
- *Chair, Matthew Mendis, AED*
•USA - *Jeff Seabright, USAID*
•Netherlands - *Paul Hassing, DGIS*
•International Energy Agency - *Bernard McNelis, IT Power*
•United Kingdom – *Clive Caffall, DFID*

USAID and Renewable Energy: A Continuing Commitment to International Development and the Global Environment

Presentation to Village Power '98

Jeff Seabright
Director, Office of Energy, Global Bureau
U.S. Agency for International Development

October 6, 1998

The U.S. Agency for International Development (USAID)

- USAID is the foreign assistance agency of the U.S. Government, with 0.5% of the federal budget
- Programs in 84 countries for environmentally-sustainable economic development
- USAID in-country offices determine the portfolio and manage programs in areas including education, health, agriculture, forestry, energy, micro-credit, democracy building, family planning, etc.

USAID

USAID Center for the Environment (Washington, DC)

- **Mandate**: Provide leadership on global environmental issues and assist USAID field offices in program development, implementation, and evaluation

- **Three Areas:** Energy, Natural Resources, Urban**.**

- **Office of Energy:** Renewable Energy, Energy Efficiency, Clean Energy Technologies

Energy and Development - the Missing Nexus for 2 billion people

- Two billion people lack access to electricity and clean fuels.
- Electricity alone does not lead to economic development, but development impeded without it.
- Renewable energy systems are often the preferred options for off-grid development.
- Changing relationship between private and public sector poses new challenges and new opportunities

USAID

Characteristics of Rural Markets

- Geographically dispersed - high installation and maintenance costs
- Low volume usage concentrated in evening hours
- Willingness and ability to pay
- Poor access to finance

Rural Electrification Before Privatization

- Responsibility of government
- Focus on grid extension
- Operating costs assumed by utilities
- Expansion of service and supply of power limited by availability of funds

Rural Electrification Post Privatization

- Focus on least cost approaches
- Limited interest from private sector
- Government influence through regulation
- Role of subsidies?

Financial Crisis: Implications for Renewable Energy

- Accelerate sector reform, but constrain capital flows
- Higher energy tariffs likely
- Tendency to focus on urban/industrial rather than rural policy, but ...
- … still an opportunity to rethink fundamentals

Needed: Market-Based Solutions

- Making markets work is key to sustainability and replicability.
  - Active engagement of local stakeholders is essential for project **sustainability**.
  - Commercial viability essential for **replicability**.

- Grants/concessional finance distort markets and impede development of sustainable solutions.

- “Pump priming” and market opening initiatives still needed

- Focus on transparent subsidies (where needed) to meet social goals in partnership with private sector

• USAID's Renewable Energy Program

- **What:** Accelerate market penetration of commercial technology

- **How**: Policy reform, institutional capacity building, information dissemination, pre-investment support, credit, technical assistance, and training

- **Where**: Mexico, Central America, Dominican Republic, Brazil, India, Indonesia, Philippines, South Africa .

USAID's Principal Collaborators in Renewable Energy

- Winrock International
- US DOE
- US/ECRE and trade associations, including SEIA
- Sandia National Laboratories
- National Renewable Energy Laboratory
- National Rural Electric Cooperative Association
- Environmental Enterprises Assistance Fund
- The World Bank
- Inter-American Development Bank

USAID/World Bank Collaboration

- USAID assisted World Bank in designing major solar loan packages for Indonesia and Sri Lanka, and provided training of in-country PV distributors
- Through Winrock International, USAID is assisting the World Bank in preparing a loan package for rural uses of renewable energy for Brazil
- Provided funding assistance to the IFC for development of the business plan for the Renewable Energy and Energy Efficiency Fund (REEF)

Global Climate Change Commitments: Implications for Renewables

- USAID implementing President Clinton’s commitment of $1 billion over 5 years for global climate change (GCC) programs.

- Clean Development Mechanism (CDM) offers new source of support for renewable projects,but must show carbon offsets.

- Climate Technology Cooperation pilot program another opportunity to focus on renewable energy initiatives.

USAID

U.S. Agency for International Development
Washington, D.C. 20523
http://www.info.usaid.gov
climate@usaid.gov

For further information on USAID energy programs,
contact: Jeff Seabright (jseabright@usaid.gov)
202-712-1750 202-216-3230 (fax)

Sustainable Energy Services and Development

Paul Hassing
Head of Climate, Energy, and Environmental Technology
Netherlands Ministry of Foreign Affairs

IN THE EIGHTIES THE EMPHASIS WAS ON ENERGY AS A TOOL FOR RURAL DEVELOPMENT

POLICY PRIORITIES

- Technology Development of RE
- Village Forest Plantations
- Rural Electrification

TYPE OF ACTIVITIES

- Training Courses
- Pilot Projects at Field Level and in Demonstration Centres
- Subsidized Hardware Supply
- Import Support

THE EMPHASIS OF PRESENT POLICY FOR THE NINETIES IS ON SUSTAINABLE ENERGY SERVICES AS A BASIC NEED FOR DEVELOPMENT

POLICY PRIORITIES

- Energy Policy Adjustment
- Capacity Building
- Market Development
- Financial Instruments

TYPE OF ACTIVITIES

- Formulating Policy Programs (Countries and Concepts)
- Training Programs on RE and EE
- Project Development for Investment
- Investment Funds
- Technological Innovation
- Sectoral Support

LESSONS LEARNED

- Rural energy supply based on conventional energy sources is expensive (politics versus willingness to pay). Cross subsidizing might still be needed.
- Privatization of the (rural) power sector might not be the right answer.
- Good entrepreneurship and and local capacity at rural level are crucial.

LESSONS LEARNED
Cont.

- Availability of credit at favorable terms and able to take risks.
- Need for large programs to overcome high transaction costs and interesting to commercial partners.
- A limited capacity of project developers and not familiar with financial engineering.

FUTURE PLANS OF NETHERLANDS DEVELOPMENT ASSISTANCE (NEDA)

- Look for new partnership between public and private sector (suppliers and investors).
- Promote marginal cost for energy services.
- The instrument of subsidizing technology should be differently used: To overcome initial costs and forward pricing.

IEA International Energy Agency
Photovoltaic Power Systems Programme

Task IX

DEPLOYMENT OF PHOTOVOLTAIC TECHNOLOGIES

CO-OPERATION WITH DEVELOPING COUNTRIES

presentation by

Bernard McNelis

Village Power '98
World Bank 6-8 October 1998

itPower

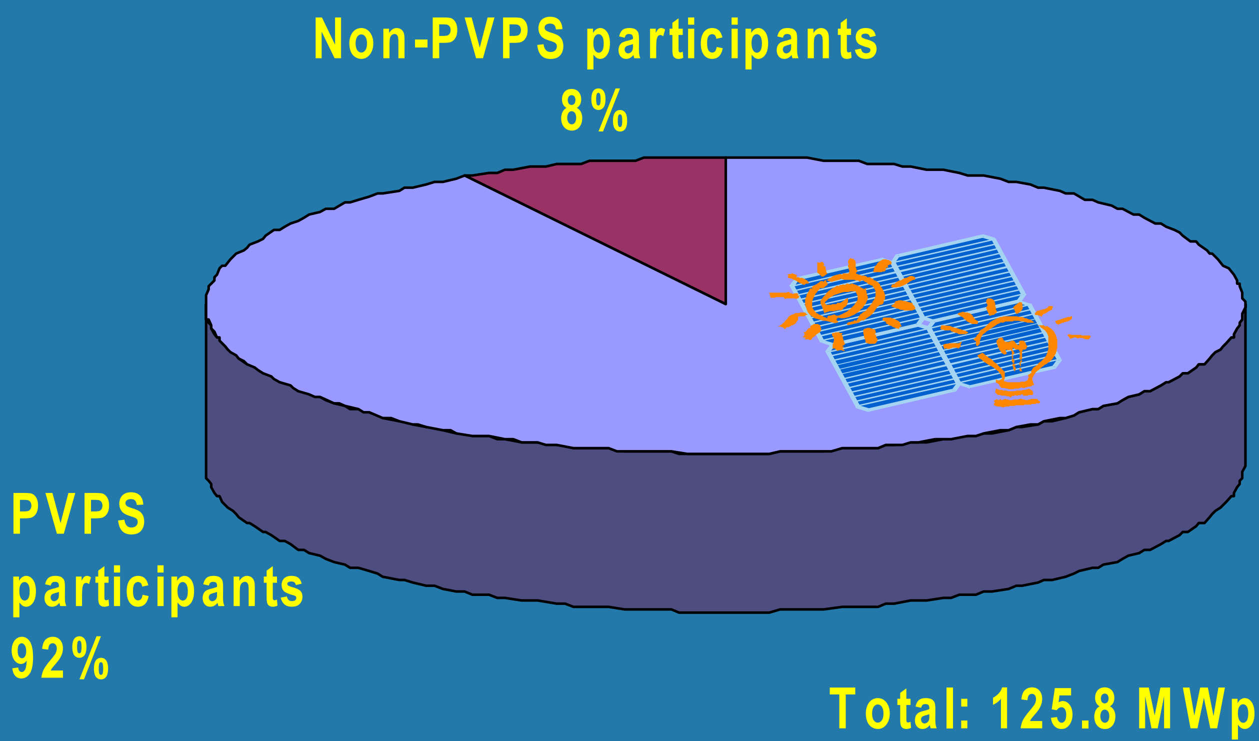
OBJECTIVE

To increase the overall rate of successful deployment of PV systems in developing countries, through increased co-operation and information exchange between bilateral and multilateral donors and the IEA PVPS Programme.

PVPS Participating Countries

- •Australia
- •Austria
- •Canada
- •Denmark
- •European Union
- •Finland
- •France
- •Germany
- •Israel
- •Italy
- •Japan
- •Korea
- •Mexico
- •The Netherlands
- •Portugal
- •Spain
- •Sweden
- •Switzerland
- •United Kingdom
- •United States

World PV Manufacture: is in PVPS Participating Countries



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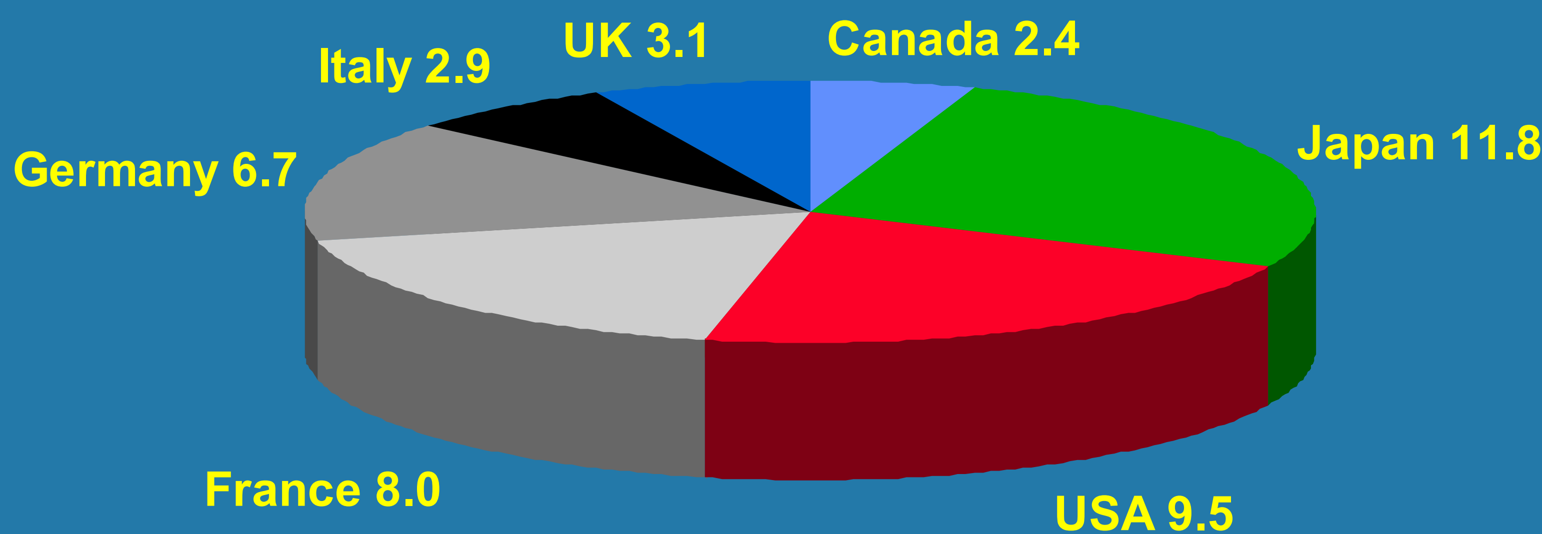
AID SPENDING BY THE 7 MAJOR PLAYERS (AVERAGE FOR THE LAST % YEARS) ($BILLION)



PVPS Tasks

I -	Information Exchange
II -	Performance data-base
III -	Stand-alone systems
V -	Grid interconnection
VI -	Large-scale (multi-MWp)
VII -	Building integration
VIII -	Very large-scale (multi-GWp)
IX -	Co-operation with Developing Countries

itPower

Task IX Workshop, IT Power 1-2 October '98

- Australia
- Canada
- Denmark
- France
- Germany
- Italy
- Japan
- Sweden
- Switzerland
- The Netherlands
- UK
- USA

RATIONALE

- Enormous potential market exists, does not require dramatic PV cost reductions
- Can be developed into a sustainable commercial market and at the same time deliver basic services, health care, water supply, contribute to poverty reduction
- 92% of PV production is in PVPS member countries. Companies from these countries will be major beneficiaries
- Huge new investment in PV production by serious players which require sustainable markets, or investments will be cancelled. Industry welcomes enhanced international co-operation.
- Financial resources required exist in PVPS member countries - *Official Development Assistance* (ODA) is more than $50 billion/year
- PVPS will use its expertise and status to bring together the consumers, PV industry and the financial resources required for widespread MARKET DEPLOYMENT

MOTIVATION

- PVPS Implementing Agreement has the overall mission to assist PV to become a significant energy option, through international collaboration
- PV could become a significant energy option in those areas of the world (developing countries) which have a demand for new sources of electricity, before areas which already have reliable and low-cost electricity supplies
- PV is already economic for small individual supplies in developing countries. 2 billion plus people without electricity and unlikely to receive grid supplies is an enormous potential market
- IEA has announced a policy of increased co-operation with Developing Countries
- Task IX will provide the framework for PV co-operation

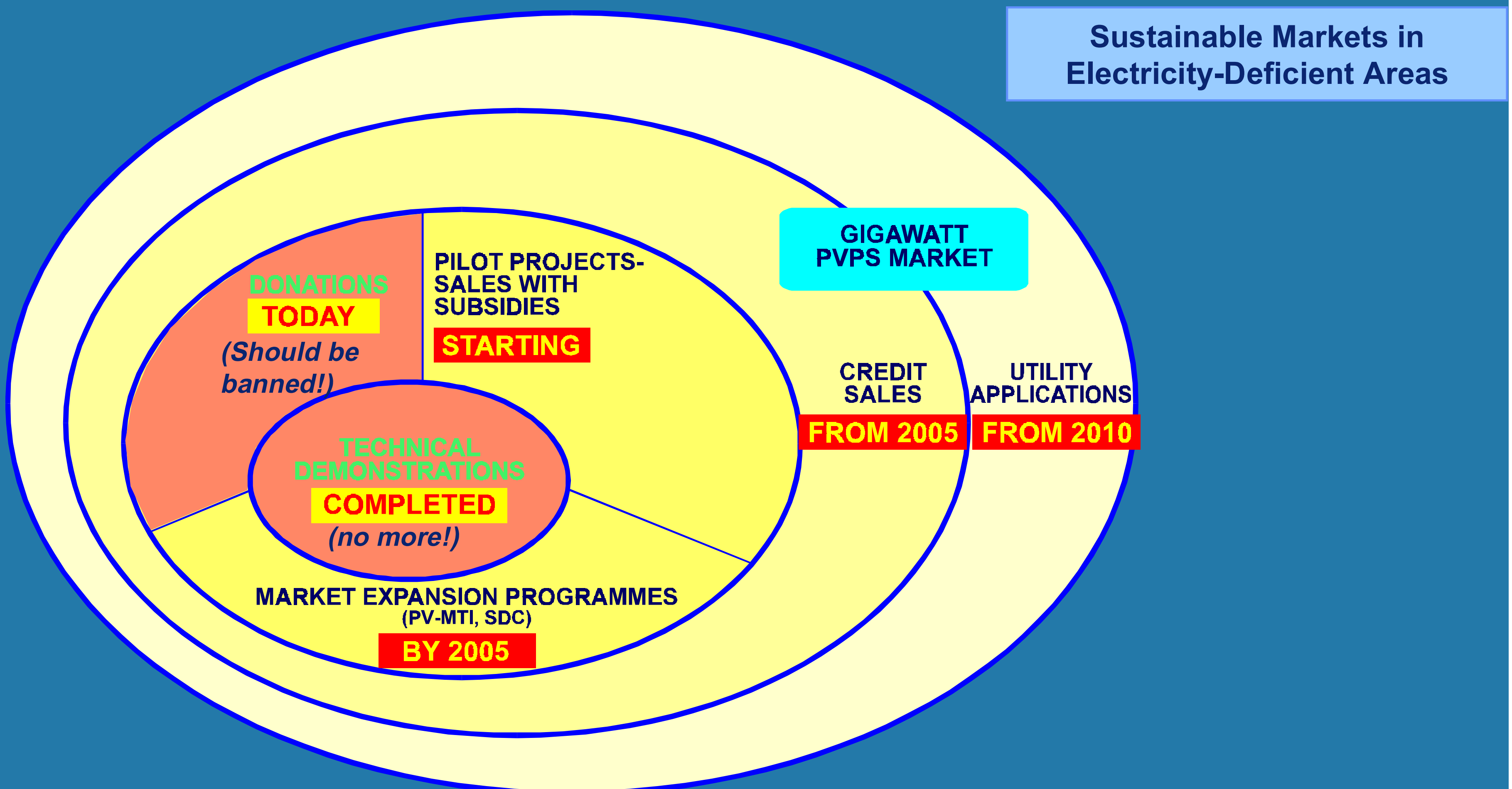
Traditional PV Co-operation

Developing Country	+ Science Ministry	+ Donor	= joint research, demonstrations, studies. <u>NO</u> SUSTAINABLE MARKET BUILDING
Developing Country	+ Donor		= demonstrations, lotsa studies. <u>NO</u> SUSTAINABLE MARKET BUILDING
Developing Country	+ Donor	+ PV Manufacturer	= more hardware, less studies. <u>NO</u> SUSTAINABLE MARKET BUILDING
Developing Country	+ Donor	+ Consultant	= even more studies. <u>NO</u> SUSTAINABLE MARKET BUILDING

Results of traditional PV Co-operation

- Studies, more studies and even more studies
- Demonstrations, often of unproven systems (ie, “flemonstrations”)
- Demonstrations without market building
- Lots of person-years of management, study, research, record PhD/MWp
- Few MWp of PV

PV MARKET DEPLOYMENT STRATEGY



SUBTASKS

SubTask 10: Deployment infrastructure

Contribute to overcoming the critical barrier to large-scale PV deployment - lack of infrastructure - recommended practice guides

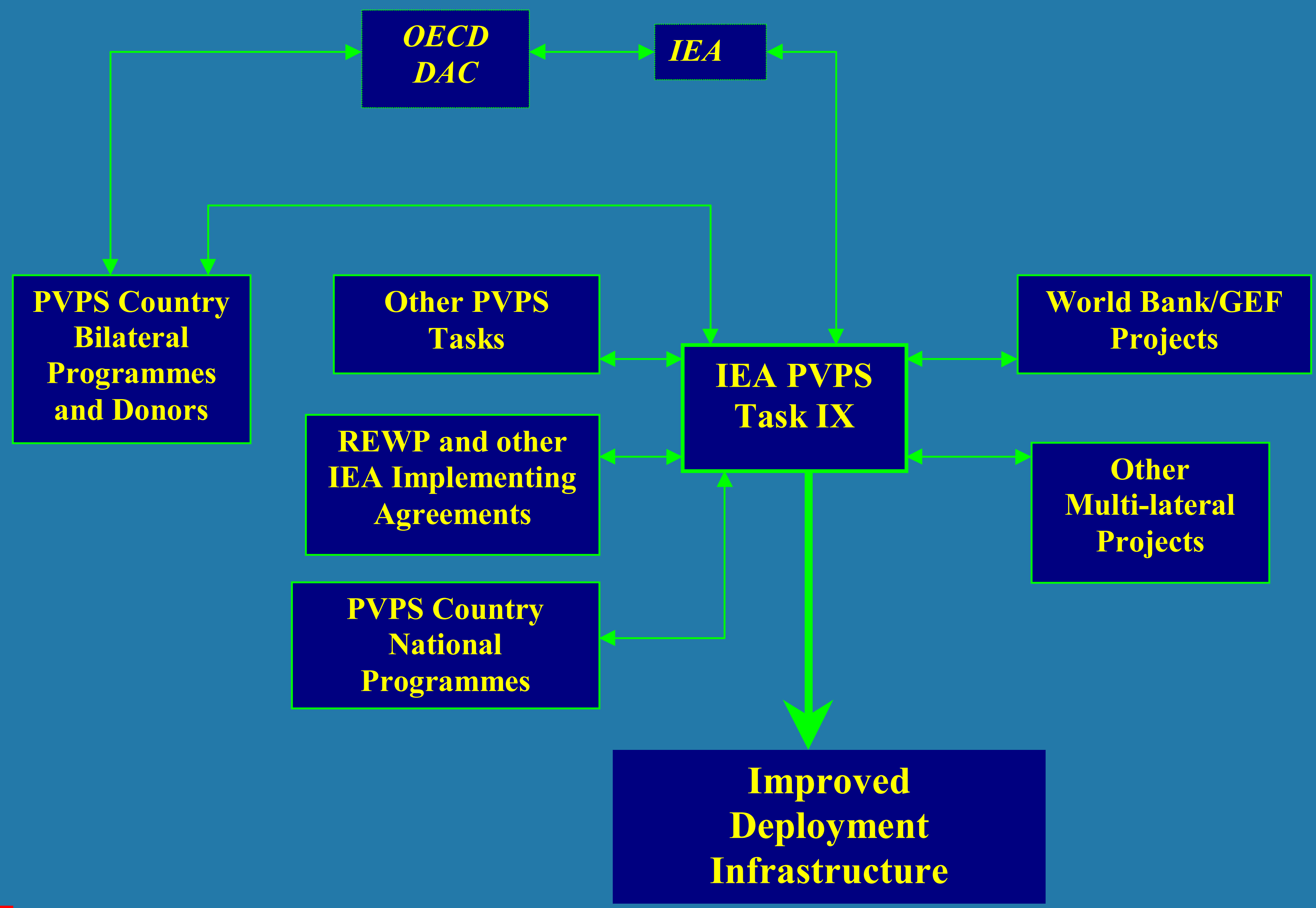
SubTask 20: Support and Co-operation

Facilitate the flow of information to international agencies & others outside PVPS

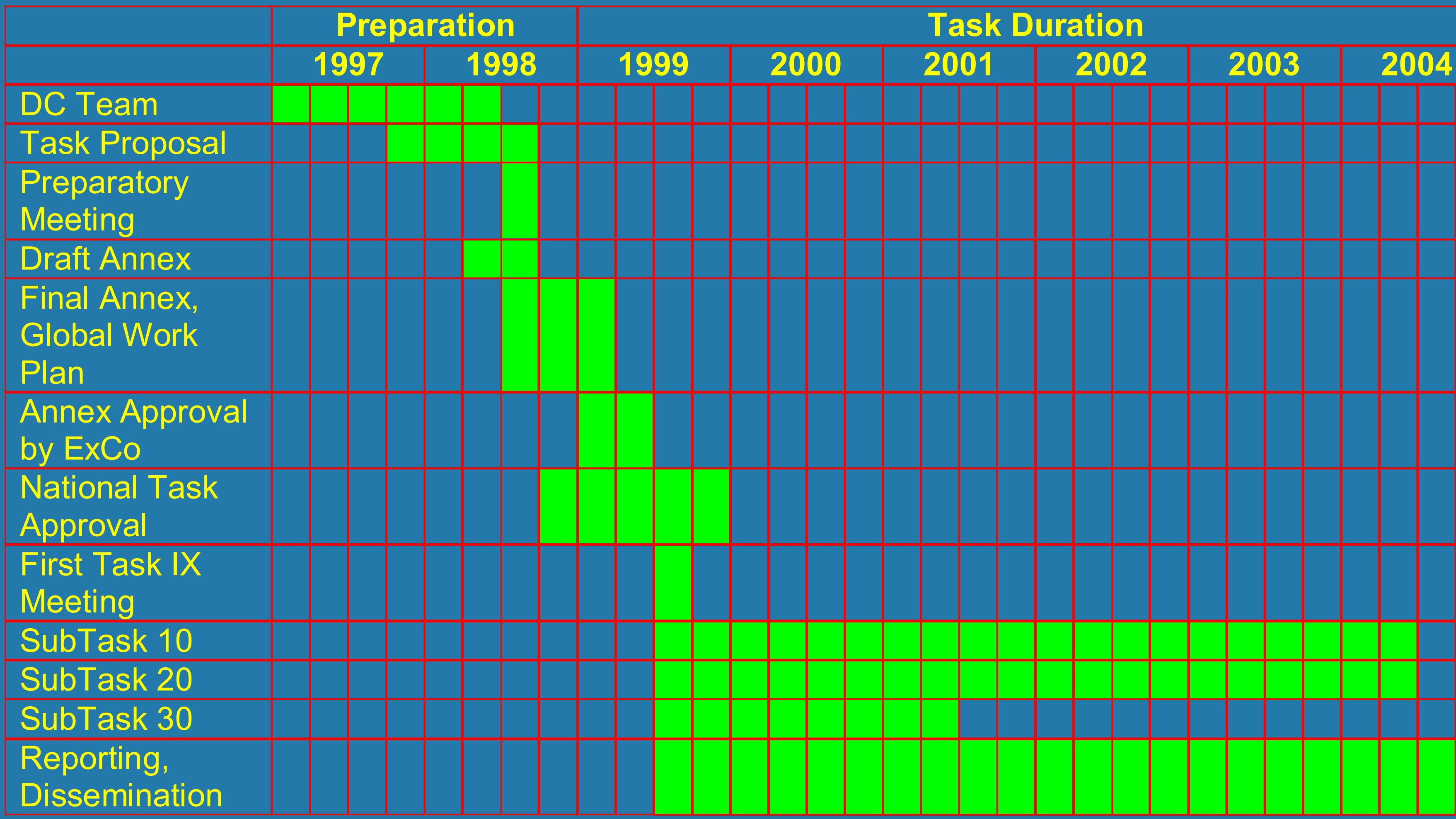
Special professional workshops to catalyse projects and programmes.

SubTask 30: Techno-economic aspects of PV in developing countries

Investigate the technical and economic aspects for feeding technical information to other PVPS Tasks


OECD DAC
IEA
PVPS Country Bilateral Programmes and Donors
Other PVPS Tasks
World Bank/GEF Projects
IEA PVPS Task IX
REWP and other IEA Implementing Agreements
Other Multi-lateral Projects
PVPS Country National Programmes
Improved Deployment Infrastructure

TIMETABLE



Preparation
Task Duration
1997
1998
1999
2000
2001
2002
2003
2004
DC Team
Task Proposal
Preparatory Meeting
Draft Annex
Final Annex, Global Work Plan
Annex Approval by ExCo
National Task Approval
First Task IX Meeting
SubTask 10
SubTask 20
SubTask 30
Reporting, Dissemination

CONCLUSIONS

Co-ordination between bilateral donors and National PV Programmes will maximise the impacts of PV in developing countries, and move in the direction of sustainable commercial markets

The International Energy Agency is supporting establishment of the necessary dialogue

This will deliver benefits to both the PV companies and the people of the developing world at one and the same time

DFID and Energy

Clive Caffall
Energy Adviser

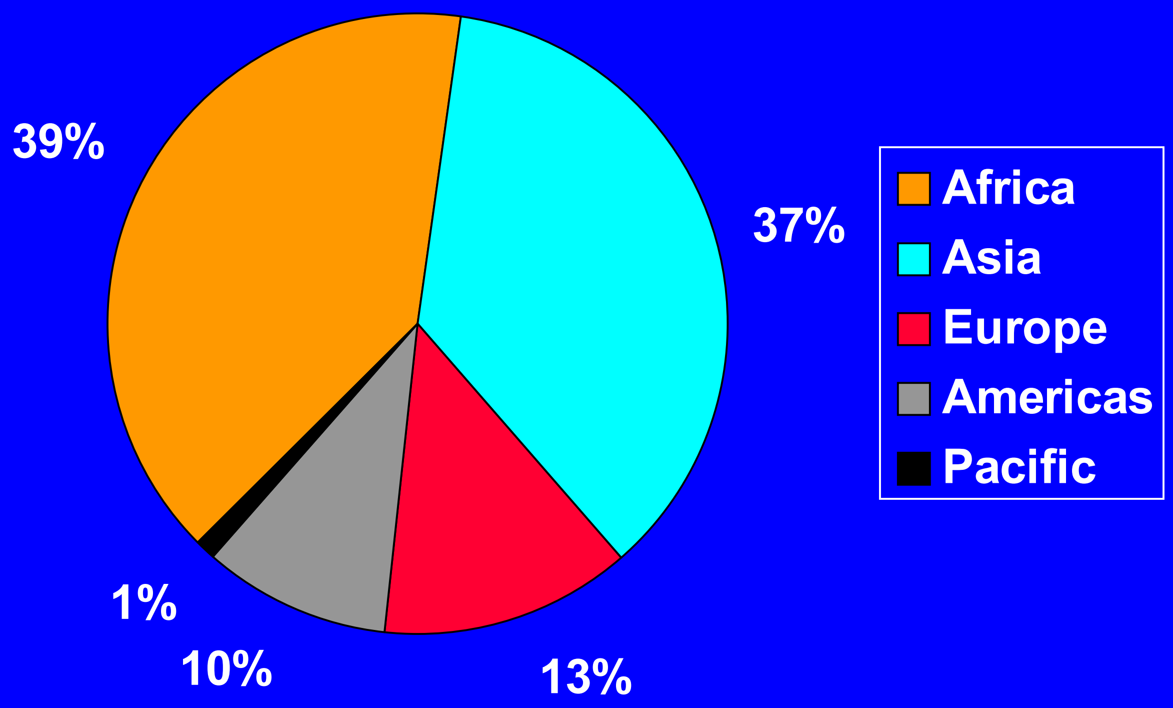
Summary

- What DFID does
- Recent energy activities
- The new agenda
- The future for energy in DFID

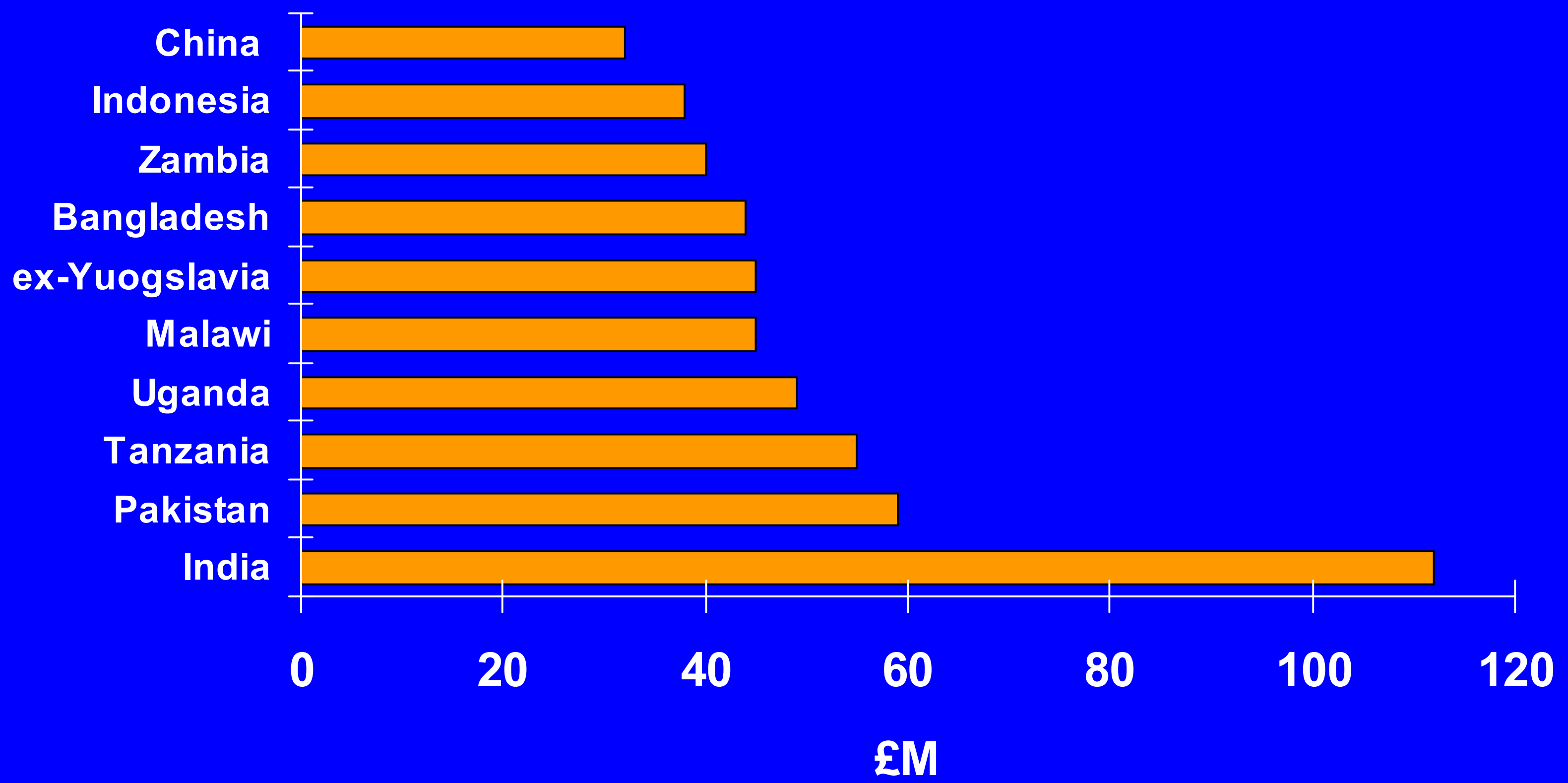
DFID

- Created May 1997 - formerly ODA
- More than 160 countries
- 1998 budget £2.3bn
- Growing proportion of GNP

Aid by region -1997



Largest recipients



DFID organisation

- Nearly half spent through multi-laterals
- Geographic desks
  - Bi-lateral country programmes
- Specialist advisory divisions
  - Knowledge and Research
- Support to NGOs

Energy Efficiency strategy

(ODA - 1994)

- Improve the efficiency of power production and distribution
- Improve the energy efficiency of end users
- Promote the introduction of appropriate renewable energy

Strategy Implementation

- through multi-lateral agencies
  - e.g. ESMAP
- within UK bi-lateral programmes
  - e.g. India, China
- centrally funded research
  - engineering TDR

Research Themes

- E1: power supply efficiency
- E2: renewables
- E3: end-use efficiency
- E4: access to energy in rural areas and by poorer households
- E5: institutional issues

DFID White Paper - 1997

POVERTY ELIMINATION

through :

- enabling sustainable livelihoods
- providing better services
- protecting the environment

Energy in the White Paper

- Basic Infrastructure
  - stoves, alternatives, buildings
- Income and Employment Opportunities
  - for women, economic services
- Climate Change
  - Kyoto, GEF

Developing Country Priorities

- Development through economic growth
- Reliable and adequate energy supplies
- Air pollution - local (esp. urban) and regional
- Climate change - not a priority over basic services and economic survival
- Need to find win-win initiatives addressing local concerns and global interests

The Problem

- Rising energy demand - inevitable
- Unmet demand will limit development, trapping billions in poverty and dependency
- Must resolve the conflict between energy supply/use and damage to the world

Renewable Energy

- Can renewable energy resources really make a difference?
- Energy services for off-grid communities
- Capacity building - not product dumping

Future DFID energy work

- Need for greater poverty focus
- Less technology - more knowledge
- Horizontal integrated themes instead of the sector approach?

Wednesday, October 7, 1998

09:00-11:00 **Promoting Productive Uses and Small Businesses for Rural Development**

- *Chair, Khalid Siraj,World Bank*

•Promoting Productive Uses through Rural Enterprise Development - *Jim Finucane, Indonesia SHS Project Support Group*

•Energy's Role in Rural Income Generation: The Grameen Strategy- *Dipal Barua,Grameen Bank*

•Productive Uses of Electricity: Country Experiences - *David Kittelson, NRECA*

•Small Scale Village Electrification; an NGO Perspective - *Donella Bryce, Appropriate Technologies for Community and Environment*

•Capacity Building for Small Scale Rural Development - *John Kadyszewski, Winrock*

•Gender Poverty and Rural Electrification – *Elizabeth Cecelski, Consultant*

Promotion of Productive Uses of Rural Electrification in Indonesia

Jim Finucane

SHS Project Support Group, Indonesia

October 7, 1998

prepared with information and assistance of PLN's Rural Business Services team, especially Mr Marnoto and Mr Basri Hasan

Rural Business Services (RBS) is a marketing activity of Indonesia’s national electricity utility (PLN) to increase kWh sales to rural businesses for productive uses (PU)

Background

- 1986 IBRD sector report identifies low productive use of RE as a problem
- 1989-93 Rural Electrification I project includes a pilot Small Business Services component
- 1994-98 Rural Electrification II project includes expanded Rural Business Services component

The Problem

Low productive uses

- reduces the financial viability of RE investments
    - low load factor
    - low revenue
- reduces the economic benefits of RE investments

Causes of Low Productive Uses which PLN can address

- Rural businesses have limited information about PU possibilities and competitiveness of PLN services
- Poor PLN service for initial connections and increased kVa, negotiated tariff classifications
- Service interruptions lead to captive power

Solutions

- Better PLN marketing
  - Better information to customers
  - Better customer service
  - Assistance to link customers with banks, equipment suppliers
- Better technical performance

Approach

- Use local NGOs as PLN’s marketing outreach to rural businesses to provide information on PU possibilities and PLN services and to link with banks, suppliers
- Reorganize PLN internally to improve customer service and technical performance

Criteria for area selection

- Grid supplied
- Local NGO available
- Local support from PLN
- Low productive uses - high electrification ratio, low ratio of industry customers to households connected, high va connected and per capita kwh sales to households, secondary data indicates significant number of enterprises in area

Initial pilot - 1989-94

- Five NGOs promote PLN services to existing and potential entrepreneurs
- NGOs use community meetings, door to door surveys, demonstrations, cost comparisons of PLN vs manual and diesel alternatives, contacts with banks, suppliers
- PLN has central unit with international advisor to strengthen, guide local NGOs

Changes for 1995 -98

- Expand to 26 areas (26 local NGOs)
- Target better
  - existing businesses, not startups
  - larger as well as smaller businesses
  - changeovers (new connections, increase kVA)
- Operate better - standardize materials, centralize local NGO training, conduct 11 month campaigns, use two local advisers
- Mainstream - involve local PLN staff more

Results

- 1991 - 94
  - 15,800 entrepreneurs guided
  - 8,409 (53%) increase productive uses
- 1996 - 98
  - 42,339 enterprises guided
  - 33,143 (78%) increase productive uses
  - average monthly increase of 170 kWh

Key indicators

	firms	employment		delta
		before	after	kWh
SBS	8,409	2.48	3.28	
RBS	33,143	3.42	3.63	170

Source: PLN - RBS database

PLN cost benefit study conclusions

- Net benefit compensates the cost of the program incurred by PLN
  - Benefit cost ratio is 1.296
  - Payback period is 5.72 years
- Profits and employment of businesses increased compared with their “before RBS” status and compared with a control group of enterprises

Lessons

- PLN can increase productive uses by targeted marketing interventions which address information constraints of small enterprises
- Rural businesses have limited information on changeover options and costs and weak capacity to deal with PLN, banks
- Local NGO's can be viable rural marketing partners for PLN, but they require capacity building assistance themselves

Energy's Role in the Rural Income Generation:
The Grameen Strategy

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Dipal Chandra Barua
Managing Director
Grameen Shakti

Background:

Electricity is considered to be one of the essential inputs for improved quality of life. As a matter of fact, the per capita consumption of electricity is taken as a development indicator of a country or a community. Growths of population and industries have resulted in greater demand for energy worldwide. In Bangladesh per capita annual fuel consumption is only 56 litres of oil, which is one of the lowest in the world. Most of this energy derived from fossil fuel (coal, gas, oil and nuclear) which will soon be depleted. With the predominantly agro-based population of Bangladesh, bio-fuel is mostly used for cooking in the rural sector. On the other hand the lighting needs are met with use of kerosene. Expenditure of lighting is minimized by short evening hours and limited night activities. At the current time 85% of the total people, mostly in rural areas of Bangladesh are without access to electricity from centralized grid. Electrification by solar photovoltaics has emerged as a viable technical option for meeting lighting and other small energy needs of the millions of people living in remote areas of Bangladesh. In this context the need for developing renewable sources of energy was taken on a greater sense of urgency. Over the years significant technological advances have been made in the area of renewable energies, especially in the field of solar photovoltaics (PV), wind energy and bio-gas technology. In addition, for remote rural areas where there exits no infrastructure for conventional energy supply, these forms of decentralized alternative energy system will be far more adaptable and well suited. In addition, it can bring multiple positive results in terms of women's welfare, children's education, employment and income generation. Renewable energy can also bring considerable improvement in rural life through income generation and thus alleviating poverty.

2.0 Introduction to Grameen Shakti

The obstacle of non-electrification prevents Grameen Bank members as well as rural people from earning to their full potential. By having electricity many micro-enterprises can become more lucrative through:

- extending working hours,
- extending selling & shopping hours in the rural areas,
- increasing income from women-led micro-enterprises include basket making, electronics repair, carpentry workshops, tailoring, stores, fish net weaving, and many other activities,
- growing the local technical retailers include local expertise in selling, maintaining, and repairing,

- helping to become productive households,
- extension of housing plan,
- facilitates children's education, women's welfare, recreational activities, income generation of the rural households,
- Extending education, health benefits to end the cycle of poverty.

In the above background a company named **"Grameen Shakti" (GS)** came into existence in June 1996 to translate the ideals of Grameen Bank into reality so far as renewable energy is concerned. The Grameen Shakti aims at:

- Popularizing and delivering renewable energy to the rural households.
- Marketing solar, biogas and wind energy on commercial basis, focusing on rural areas, particularly the clientele of Grameen Bank.
- Providing services that alleviate poverty and protect environment through applied research and development of renewable energy based technologies.
- Undertaking a project to progressively manufacture and market efficient and affordable household based photovoltaic systems.
- Implementing projects to generate electricity from wind in the coastal belts and offshore islands; operate mini and micro hydro-plants in the hilly areas.
- Developing and implementing special credit, savings and investment programs for generation, storage, and utilization of renewable energy for benefit of the rural people.
- Testing the new and appropriate technologies to provide more cost effective energy services at affordable price to the non-electrified areas.
- Providing capital, technology and management services to energy enterprises, including individuals, communities, businesses, non-government organizations (NGOs), private voluntary organizations (PVOs) which promote, produce and finance enterprises based on renewable energy sources.

Programs of GS

Grameen Shakti is a specialised and leading organisation in renewable energy sector in Bangladesh. It is currently implementing projects in renewable technologies: PV Program, Wind Energy Program, and Biomass Program. Besides, training of rural people as well as dissemination of these technologies among the common people is the core activity of each program. In addition, Grameen Shakti works with other entrepreneurs in the private sector.

PV program of Shakti:

Grameen Shakti has installed 430 Solar Home Systems up to August 1998 with installed capacity of 18.174 KWp. It has a plan to install 5000 systems within next 3 years. For this purpose Shakti will open 8 more branch offices (total of 20) in rural Bangladesh. It also plans to open some special branches through which Shakti will research on marketing policy. This network allows Shakti to quickly disseminate and commercialize any improvement in the technology. Since the systems are expensive for the rural people Grameen Shakti has introduced a soft financing process.

Credit Policy of GS:

A PV system buyer pays 25% of the system cost as down payment and the remaining 75% can be paid within 2 years time in equal monthly installments with 8% service charge on the outstanding amount. But Grameen Bank members can get financing from the Bank where the payments are made in weekly installments instead of monthly installments.

But there remains a group, which can not respond to this financing system. Therefore, Grameen Shakti has developed small systems (one lamp system & two-lamp system) in order to reach the technology within the capability of the lowest income group.

Besides, GS has bridged this technology to some income generating activities, so that the Grameen Bank members can easily adopt the system without exceeding the economic capability.

PV system is also directed to build up some micro-entrepreneurs. The idea of micro-entrepreneur is such that one will buy the system and sell the power from it to the nearby consumers.

The sales of SHS up to August 1998 are given below:

Table: System sold by Grameen Shakti

Area	System sold upto December'97			System sold during Jan-August' 98			System sold upto August 1998		
	No. of Customers	No. of Panels	Watts	No. of Customers	No. of Panels	Watts	No. of Customers	No. of Panels	Watts
Tangail	64	95	2602	39	45	2042	103	140	4644
Mymenshingh	60	92	2980	94	99	4970	154	191	7950
Comilla	18	20	1085	13	13	675	31	33	1760
Shatkhira	0	0	0	30	30	1825	30	30	1825
Khulna	0	0	0	9	9	500	9	9	500
Dhaka	2	9	435	18	18	1060	20	27	1495
Total	**144**	**216**	**7102**	**203**	**214**	**11072**	**347**	**430**	**18174**

Wind Energy Program:

Grameen Shakti has installed two wind turbines in coastal areas. It will install four (4) hybrid power (Wind, PV and diesel engine) stations in October 1998. Grameen Shakti is pioneer in wind energy sector in Bangladesh. It is expected that coastal population will be benefited from this project and it will be a basis for utilisation of wind energy at commercial scale. This wind energy project will be carried out on micro-enterprise zone basis.

Micro-enterprise zone concept: We decided to electrify one main building where micro-entrepreneurs could come and use electricity for their businesses, We expect this center becomes a commercial one, which we call a micro-enterprise zone. The Grameen Bank has many cyclone shelters along the coast, which turned out to be the perfect places to house the micro-enterprise zone. These buildings are two or three storied concrete buildings that often house a Grameen

Bank Branch office. Thus they are frequented by the Grameen micro-entrepreneurs, and enjoy the presence of trustworthy staff. The targeted options of this micro-enterprise are battery charging station, workshops, rice husker, ice making etc.

Bio-mass program:

Grameen Shakti has constructed 30 brick bio-digesters to produce cooking fuel (biogas) and organic fertilizer. Shakti is planning to conduct research to promote bio-digester as an avenue to increase family income in rural areas.

Training Program:

GS gives training to the technician in order to create employment for the local people. It has several dimensions: (a) improving the technical and managerial skills of the professionals of GS for effective implementation of the programs of GS, (ii) transferring and developing skilled technician-cum retailer in the rural areas who will be able to provide after sale services to SHS buyers, provide the accessories and retail SHS as well; (iii) educating the rural people in renewable energy and popularizing the use of renewable energy.

Research and Development Program:

The research programs have three distinct areas: (i) exploring ways to develop appropriate technologies and their uses, (ii) developing ways to popularize and making the renewable energy systems that will be easily accessible to large number of households and institutions, (iii) innovating financial services for the customers to facilitate rapid expansion of use of renewable energies, (v) developing and fabricating the solar accessories (charge controller, lamps, dc to dc converters etc.) locally in order to reduce the total system cost.

Income Generating Activities through Photovoltaics:

Grameen Shakti encourages entrepreneurs to apply PV systems for generation of income. Few examples of application of PV systems for income generation are cited below:

- One customer of Grameen Shakti is using PV system for heating soldering iron for repairing radio, TV etc.
- One carpenter extended his working hours after the sunset using solar system by enabling him earn more than before.
- One saw mill owner has extended his working hours as well by installing solar system.
- Another buyer has installed a system in the rural market and he is selling power to the shop owners who buy power to light their shops. It is an example of micro utility company.
- By operating solar powered computer, some institutions in the remote area have improved their working ability.

There are other opportunities yet to be tested. Some examples are, operating sewing machine, pumping for irrigation, battery charging stations to charge batteries for household use, charging cellular phones in rural areas (Grameen Bank members provide telephone services to villagers), operating drill machines (for the carpenters), operating blending machines to make juice in market places etc. However, rural entrepreneurs may come up with other innovative ideas.

Few case studies of photovoltaic applications are being cited here.

Case –1

Mr. Hanif is a saw mill owner. The mill is located in the rural area named Dhalapara and is operated by diesel. The villagers bring their timbers to the sawmill for sizing. Before using the solar system the mill owner failed to deliver the timbers in right time. But by working at night with the help of solar light, the working capacity of the mill has increased and the villagers are getting their timbers delivered at right time, which has increased the number of customers.

Type of use	: For lighting a diesel operated saw mill.
Project location	: Village-Baromedor, District-Tangail
System description	: One 17W solar module Two 7W fluorescent lamp
Total system cost	: US$ 270
Mode of payment	: 25% down payment 75% by instalment with 8% service charge per annum Repayment period is 2 years
Daily hours of use	: 4 hours
Impact of solar system	: **Direct impact** - Extending working hour (4 hours/day) - 20 US$ extra income per day (100 cft/day @0.20US$/cft) - Better quality of work - Better working environment **Indirect impact** - Increasing income of the workers - Increasing employment opportunity - Increasing social status

Case-2

Mr. Manik, husband of a Grameen Bank member operates a repairing shop of the electronic/electrical appliances. The main obstacle of his business before using the solar system was, heating up the soldering iron. Now by the help of solar system he is using the DC soldering iron operated by solar power to test the appliances and using solar light for his shop that enables him to work even at night.

Type of use	: Using solar power for repairing the electronic appliances (e.g. TV, radio, cassette, emergency light etc.) in an electronic repairing shop.

Project location	: Village-Dhalapara, District-Tangail
System description	: One 34W solar module Two 7W fluorescent lamp One outlet for powering TV, radio etc. One DC soldering iron
Total system cost	: US$ 354
Mode of payment	: 25% down payment 75% by instalment with 8% service charge per annum Repayment period is 2 years
Daily hours of use	: 4 hours/day (for lamps) & 6 hours (for iron)
Impact of solar system	: **Direct impact** - Increasing income by efficient repairing of appliances by electrical iron. - Extending working hour at night time - 25 US$ more income per day than before - Increased efficiency of work - Better working environment : **Indirect impact** - Increasing income of the workers - The villagers feel easy to use entertaining appliances. -Increasing the standard of living of the villagers.

Case-3

Mr. Umor has a grocery shop at of kornel bazar. He has bought a solar system with six lamps. He uses one lamp for his shop and has rented other five lamps to the nearby shops. He collects the rent @2.5 US$ per lamp per month from those shops. Not only Mr. Umor getting more money with the help of this system but also the other users are selling more at the night. This is an example of micro-utility model.

Type of use	: Earning by selling solar power to the shopkeepers.
Project location	: Village-Kormel Bazar, District-Brahmanbaria
System description	: One 50W solar module Six 7W fluorescent lamp
Total system cost	: US$ 520
Mode of payment	: 25% down payment 75% by instalment with 8% service charge per annum

	Repayment period is 2 years
Daily hours of use	: 4 hours
Impact of solar system	: **Direct impact**
	- Running a business by providing solar lights to the shopkeepers on rental basis.
	- 12.50 US$ income per month (@2.5US$ /lamp per month)
	- Explored an additional way of income
	- Earning more from his shop by attracting more customers at night by brighter light.
	: **Indirect impact**
	- The income of the other shopkeepers has also increased due to the use of solar light.
	- The customers are feeling easy to market at night.
	- Making easy the living status of the villagers.
	- Increasing social status

Case-4

Use of solar system has given Mr. Shah Alam a new dimension of business. He has taken a cellular phone connection to his shop by which he provides telephone service to the customer in a rural area named Nabinagar where no other telephone facility exists. The villagers have got a tremendous communication network with all over the world by the phone service operated by solar system.

Type of use	: Operating cellular phone powered by solar system.
Project location	: Village-Nabinagar, District-Brahmanbaria
System description	: One 50W solar module
	Two 6W fluorescent lamp
	One socket for charging cellular phones battery.
Total system cost	: US$ 450
Mode of payment	: 25% down payment
	75% by instalment with 8% service charge per annum
	Repayment period is 2 years
Daily hours of use	: 4 hours (for lamp) & 8 hours (for phone)

Impact of solar system	: **Direct impact** - Running a business by private telephone service. - 30.00 US$ income per day [30 calls/day @1.00US$(average)/Call] - Better quality of work - Better working environment : **Indirect impact** - Established a good network between the rural and the urban areas. - Villagers are happy to getting the way to communicate with their relatives living abroad. - Increasing the business position of the locality by the communication system.

Case-5

Mr. Uttam kumar is operating a barbershop in the market place of Sagordighi. In past it was not possible for him to work after evening. Now he has rented a lamp from a solar system owner (from a micro-utility model) to light up his shop at he night. Therefore he is able to work at night and thus earning more.

Type of use	: For lighting up a barbershop.
Project location	: Village-Sagordighi, District-Tangail
System description	: One 8W solar lamp on rental basis.
Rent per month	: US$ 2.5
Daily hours of use	: 4 hours
Impact of solar system	: **Direct impact** - Increase of working hour (4 hours/day) - 5.00 US$ extra income per day - Better quality of work at night - Better working environment - Attracting more customers : **Indirect impact** - Increasing income of the workers - Providing better service to the villagers - Busy villagers are happy to make their hair cut at the off time (i.e. at night).

Impact of Photovoltaic on Women:

Electrification by solar systems have directed the housewives to some income generating activities (e.g basket making at night, net weaving, tailoring etc). The solar light has eliminated the health hazard kerosene lamp thus providing a better environment. Women need not to bother for lighting up their houses at every night. It is also helping in improvement of the children's education. The bright lights have ensured the women's security. The areas where the wind turbines will be installed will be developed as a micro-enterprize zone. The targeted options of this micro - enterprize are electric sewing machine, ice-making, rice-husking etc, where women will be encouraged to participate.

Conclusion:

Solar photovoltaic systems are most suitable for electrification of isolated remote areas in developing countries like Bangladesh. But people living in such backward area can hardly meet the high cost of solar PV system due the poverty. By introducing a soft loan procedure Grameen Shakti has already sold 430 numbers of Solar Home Systems.

From the examples, it is seen that solar electricity has helped a lot the rural people who are involved in business and other activities. Having access to electricity they can work at night and can earn extra money. Electricity has improved children's education, women's security as well as the social status of the villagers. Grameen Shakti's effort helps rural people to achieve better quality of life. GS cannot change the whole scenario but at least it can demonstrate a way that creates an opportunity and hope for the rural people to alleviate their poverty and improve the life style.

Energy's Role in Rural Income Generation:
The Grameen Strategy

Dipal C. Barua
Managing Director

Grameen Shakti

Grameen Shakti

Activities of Grameen Shakti

Dipal C. Barua

Managing Director

Grameen Shakti

Grameen Shakti

September'1998

Grameen Shakti (GS)

- An affiliated company of Grameen Bank.
- A company “Not for Profit.”
- Established in June 1996.
- Operates through unit offices in rural areas to popularizing and delivering renewable energy to households.

Renewable Energy Program of Grameen Shakti

- Solar Energy Program
- Wind Energy Program
- Biogas program
- Technician Training Program
- Research Program

Solar Energy Program

- Marketing solar home system in remote areas.
- Awareness development of potential customers.
- Developed financial packages for different customer groups.
- Offer credit program.
- Provide after sales maintenance.

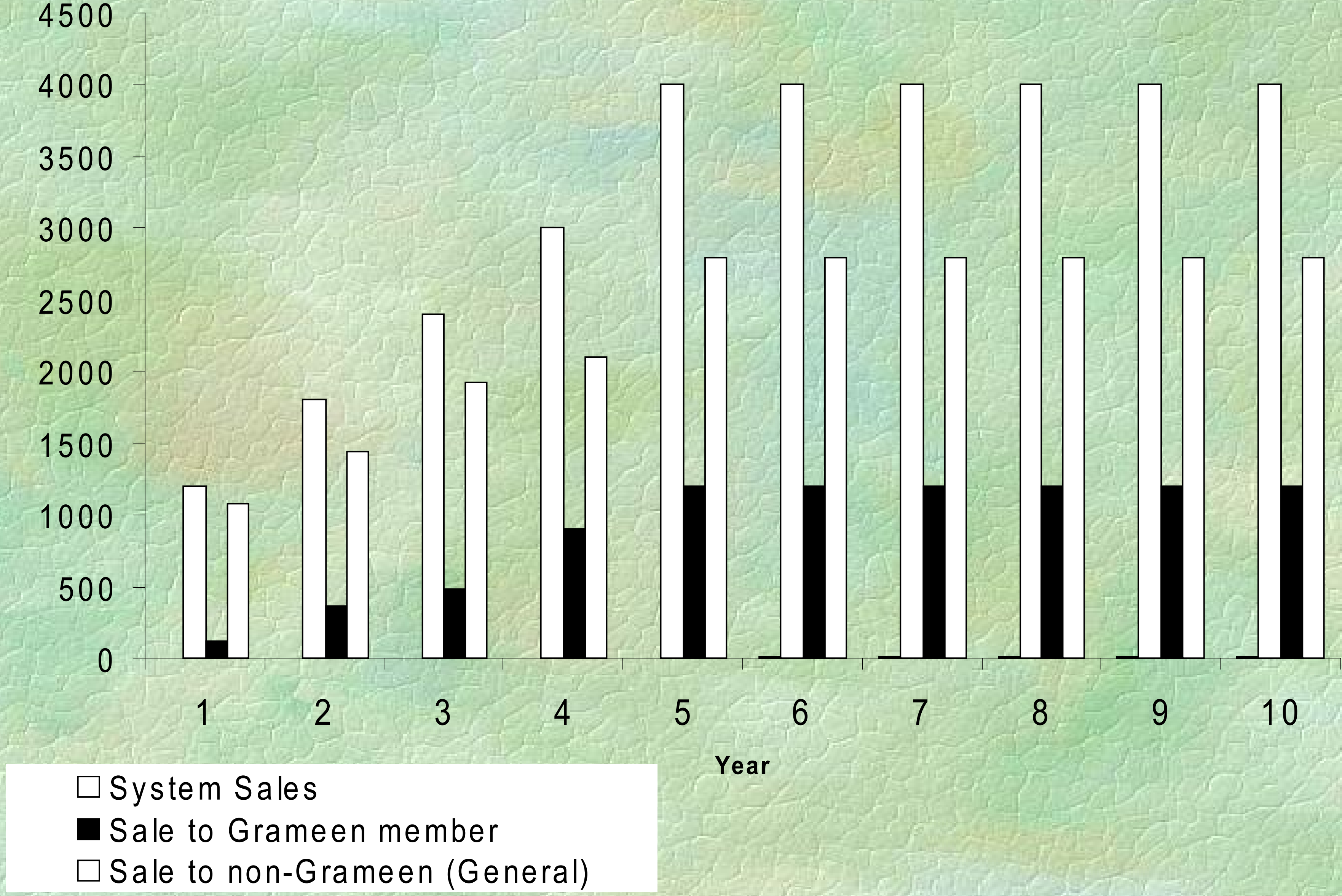
Credit Policies of GS

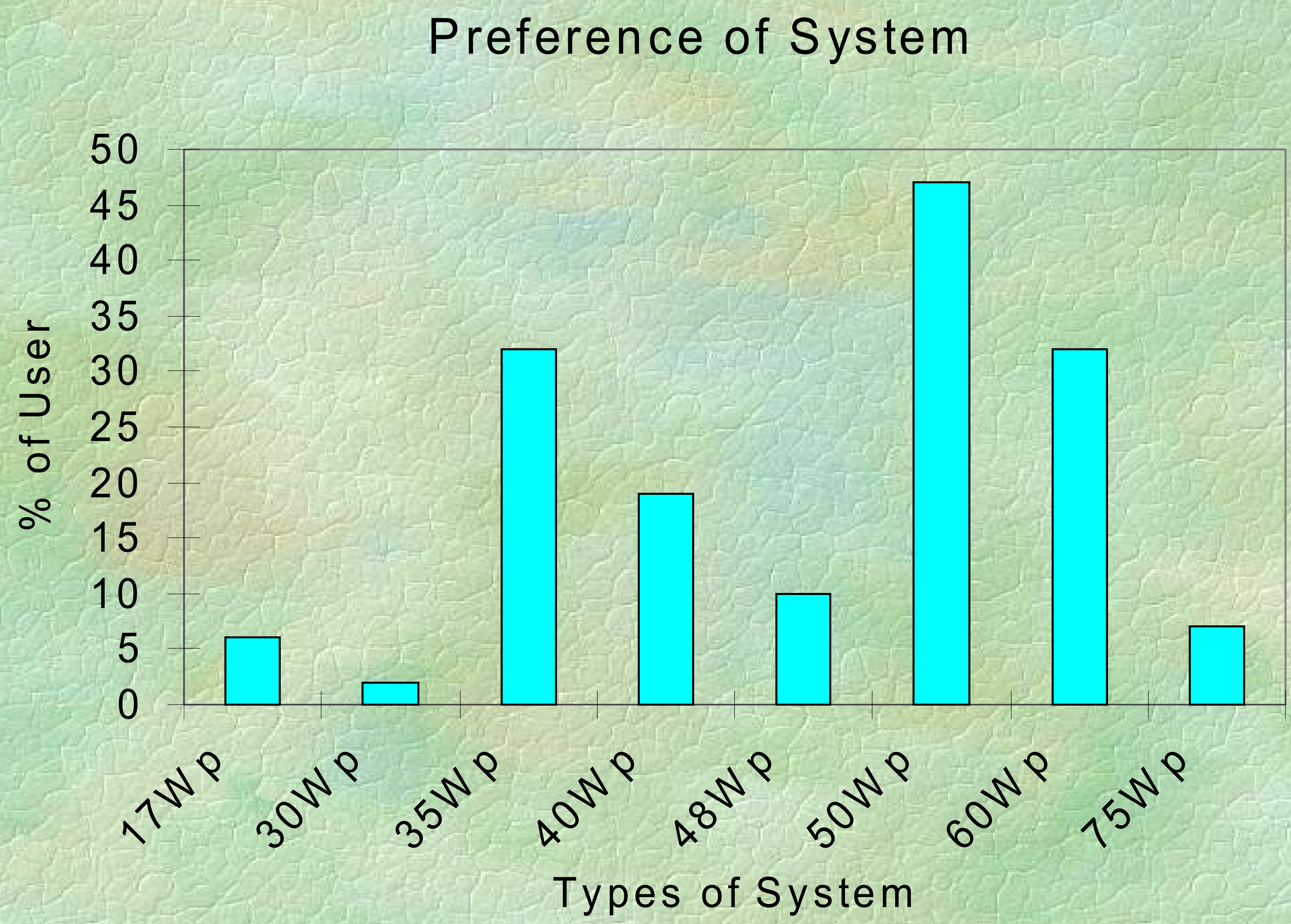
- 25% down Payment.
- The remaining 75% of the cost must be repaid within 24 months with 8% service charge.
- To encourage the customers to pay 100% cash, Shakti offer 3% discount on the sales price.

System Sold by Grameen Shakti Upto August'98

Area	System sold up to August'98		
	No. of Customer	No.of Panels	Watts
Tangail	103	140	4644
Mymenshing	154	191	7950
Comilla	31	33	1760
Shatkhira	30	30	1825
Khulna	9	9	500
Dhaka	20	27	1495
Total	347	430	18174

Future Plan Of Grameen Shakti




Preference of System
% of User
50
45
40
35
30
25
20
15
10
5
0
17W p
30W p
35W p
40W p
48W p
50W p
60W p
75W p
Types of System

Wind Energy Program

- Shakti put two anemometer in two sites for measuring wind speed.
- Installed two wind turbine at Chokoria in Cox's Bazar.
    - 300W Turbine
    - 1kW Turbine
- Shakti installed four turbine for setting up the Micro-enterprize zone.
    - One 10 kW
    - Three 1.5 kW

Biomass Program

Bio-digester Project

- Cooking purpose
  - Shakti installed and supervise 28 brick Bio-digester at
    - » Sirajgang
    - » Pabna
    - » Rangpur
    - » Dinajpur
    - » Panchagar
    - » Thakurgaon
- Fish & Land Cultivation Purpose
  - The residue of the biogas plant is used in the ponds for fish cultivation.
  - These residues of the biogas plant also used in the field as fertilizer.

Case Study: 1

Saw Mill Owner

- Project Location:
  - Village: Baromedor , District: Tangail
- System Description
  - One 17W module
  - 2 Lights
- Total System Cost: US$ 270
- Payments:
  - 25% Down Payments
  - 75% loan, with 8% Service Charge
  - Repayment period: 1 Year

Case-1

Impact of Photovoltaics

Direct Impact

- Extending working time: 4 Hours/day
- 5.20 US$ Extra Income per hour (25cft /hr@ 0.20US$/cft)
- Increase quality of working.
- Better working environment

Indirect Impact

- Increase income of the workers.
- Create employment's
- Increase social status.

Case Study-2
Electronics repair Shop

- Project Location:
  - Village: Dhalapara, District: Tangail
- System Description
  - One 34 W module
  - 2 Lights
  - 1 plug outlets
- Total System Cost: US$ 354
- Payments:
  - 25% Down Payments
  - 75% loan, with 8% Service Charge
  - Repayment period: 1 Year

Case-2

Impact of Photovoltaics

Direct Impact

- Extending working time: 4 Hours/day
- 0.52 US$ Extra Income per hour
- Provide Better quality of work to the Customer by using DC Soldering Iron
- Increase Business

Indirect Impact

- Use one lamp to his house which increased his social status.
- Healthier Environment
- Attract more customer.
- Get better entertainment by operating radio, TV, Cassette etc.

Case Study-3
Cellular Phone Shop

- Project Location:
  - Village:Nabinagari, District: Brahamanbaria
- System Description

  One 50 W module, 4 Lights, 1 plug outlets for TV
- Total System Cost: US$ 520
- Payments:
  - 25% Down Payments
  - 75% loan, with 8% Service Charge
  - Repayment period: 1 Year
- The owners rent two lamps to other two shops.

Case-3

Impact of Photovoltaics

Direct Impact

- Creating a new business.
- 30.0 US$ Extra Income per day (30 calls per day@1.0 US$)
- Enjoy Better quality of Light.
- Better working environment.

Indirect Impact

- Established a good network.
- Villagers are happy to getting the way to communicate with their relatives living abroad.
- Increase the business position of the locality by the communication system.

Case Study-4
Micro-utility Model

- Project Location:
  - Village: Kormel Bazar District: Comilla
- System Description
  - One 50 W module, Six 7W Light
  - Total Cost: US$ 520
- Payments:
  - 25% Down Payments
  - 75% loan, with 8% Service Charge
  - Repayment period: 1 Year
- The owners rent the lamps to other shops.

Case-4

Impact of Photovoltaics

Direct Impact

- Creating a new business.
- 12.500 US$ Income per month @2.5 US$/lamp per month)
- Explored an additional way of income
- Earning more from his shop by attracting more customer by brighter light.

Indirect Impact

- The income of other shopkeepers has also increased due to the use of solar light.
- More customer is coming.
- Increased social status
- Villagers can marketing even at night time.

Case Study-5
Barber Shop

- Project Location:
  - Village: Sagordighi
  - District: Tangail
- System Description
  - One 8 W solar lamp on rental basis
- Rent per month:
  - 2.5US$ Repayment
- Daily hours of use: 4 Hours.

Case-5

Impact of Photovoltaics

Direct Impact

- Increase of working hours.
- 5.00 US$ extra income per day
- Enjoy Better quality of Light.
- Better working environment.
- Attract more customer.

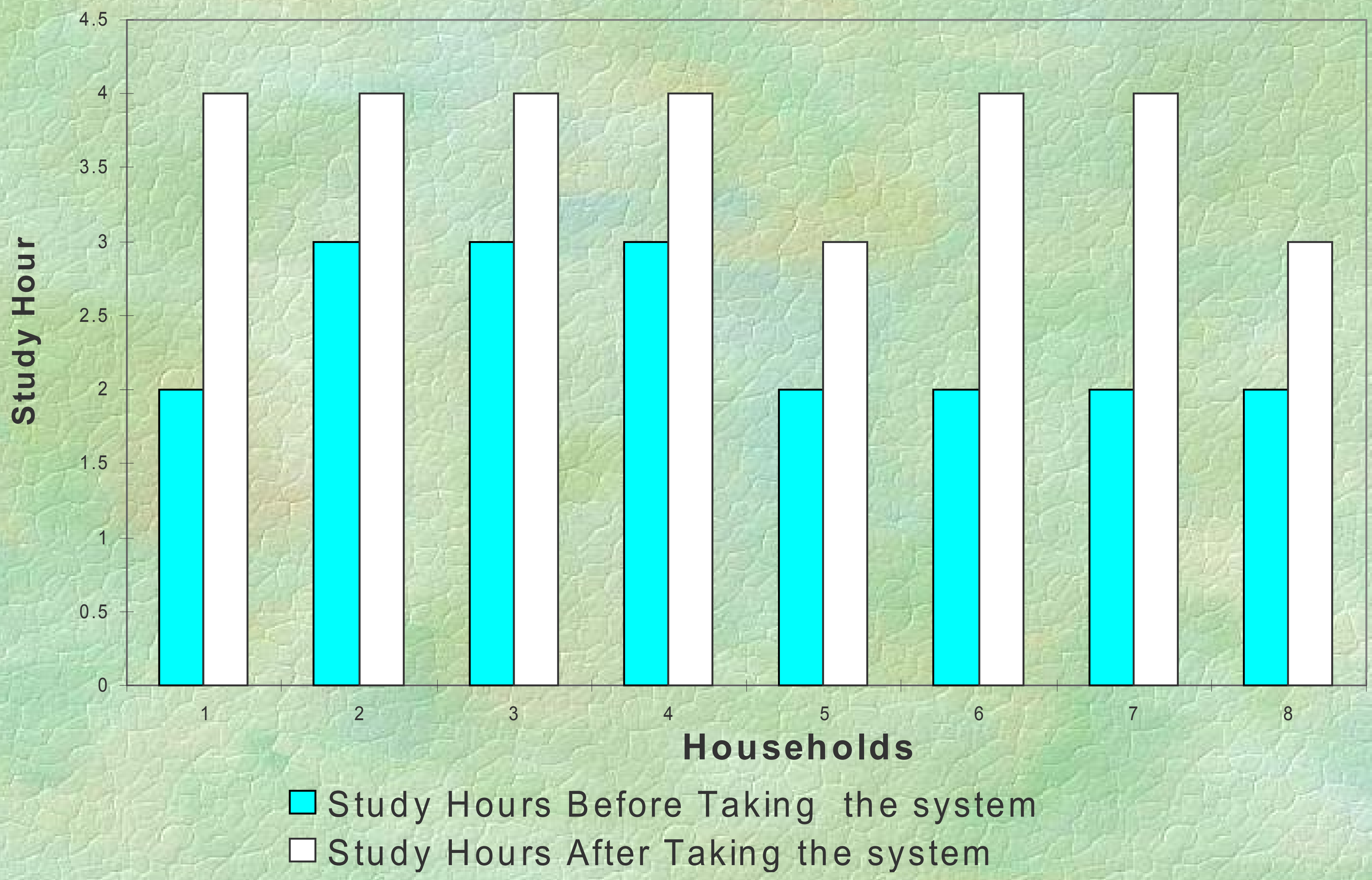
Indirect Impact

- Increase income of the customers.
- Providing better service to the villagers.
- Increase the business position of the locality..

Impact of Photovoltaic on Household Specially on Women

- Eliminated the health hazard due to kerosene lamp.
- Providing better environment.
- Improving their children's education.
- Ensured the women's security.
- Able to work at night.
- Helped women to create income generating activities like sewing at night, basket making etc.

Impact of Photovoltaics on Households



PRODUCTIVE USES OF ELECTRICITY:

COUNTRY EXPERIENCES

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Prepared for:

Village Power '98
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Washington, D.C.
October 6 – 98, 1998

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PRODUCTIVE USES OF ELECTRICITY:

COUNTRY EXPERIENCES

1.0 INTRODUCTION

This paper was prepared for the Village Power ’98 conference held in Washington, DC October 6-8, 1998. The author provides an overview of the productive uses work done by the National Rural Electric Cooperative Association (NRECA) in various countries with special emphasis on projects in Bolivia. A simple definition of the term “a productive use of electricity” is, “Any use of electricity that helps generate income for the end-user.” The author describes both successes and failures and concludes with a section describing the five factors that he considers to be the most important for implementing successful productive uses programs.

2.0 BACKGROUND

Since its founding nearly 55 years ago, the National Rural Electric Cooperative Association (NRECA) has championed rural electrification (RE) in the USA. And, during the last 35 years it has played an active role in RE internationally. Though it does not create miracles, invariably, rural electrification has improved the quality of life for rural peoples around the world. Nevertheless, a line of reasoning exists that argues that most RE end-users simply consume electricity rather than use it productively. That line of reasoning assumes that if end-users would employ electricity productively it could benefit them much more. In conclusion, the reasoning goes, when productive uses proliferate everybody wins. The end user takes advantage of the electricity to generate income for himself and employment for others. The utility sells more electricity making the investment in electric generation, transmission, and distribution infrastructure more profitable.

As mentioned in the introduction, a simple definition of a productive use of electricity is, “Any use of electricity that helps generate income for the end-user.” Some prefer a broader definition that can encompass the use of electricity for such things as schools and community water-pumping systems. Those applications do not directly generate income for the end-user, but they can obviously contribute to quality of life and development. An expanded definition would be: "Any use of electricity which improves the financial situation of the end-user and/or contributes to the development of the community and the nation." Though this paper will concentrate on examples of the former, applications that fit the latter definition will also be included.

Some people tend to consider only micro-enterprises when thinking of productive uses. By definition, however, large industries also qualify and can sometimes be the key to financial viability for a project. Perhaps some have felt that the large investors have sufficient capital to invest in hiring experts of their own and that productive uses programs should limit their help to the poor and disadvantaged. In the experience of the author, however, it is important to address the entire range of productive uses. Large factories and mines, for example, also generate income and create jobs.

A discussion of the key components in a productive uses program is included after the "Country Experiences".

3.0 COUNTRY EXPERIENCES

NRECA has actively promoted productive uses for over 15 years. In Bangladesh, for example, literature on productive uses dates back to at least 1982 when a conference on productive uses was held there. In Guatemala under the Central America Rural Electrification Support program (CARES), managed by NRECA, productive uses were promoted with international seminars and specific interventions in the field. NRECA personnel worked with micro-credit organizations to get productive uses loan programs started and to enlist their help for training.

In El Salvador NRECA worked with the national utility, CEL, promoting productive uses with a demonstration trailer and later a van. These demo units were filled with all kinds of electric tools and equipment. The units were taken around El Salvador and served both to inform the villagers of the existence of certain tools and equipment and to demonstrate how the equipment was used and what it could do.

In the USA, NRECA-affiliated cooperatives have promoted economic growth in their communities by sponsoring "incubators". The concept of an incubator is to provide a setting with the appropriate support where a business can "incubate" before it launches out completely on its own. The support often includes physical space in which the business can operate and access to central office equipment and a secretary offered at affordable rates. Readers interested in more information regarding incubators may contact Brian Crutchfield at BREMCO, the electric cooperative that serves the Blue Ridge area of North Carolina.

The efforts mentioned above have been documented in NRECA reports and other literature and will not be further elaborated on in this paper.

The author worked as the Productive Uses Specialist in Bolivia for five years and he continues to be stationed there as the Deputy Director. Therefore, the bulk of the country experiences and supporting data will be gleaned from selected Bolivia projects described below.

3.1 Vinto

The Vinto Densification Project was implemented as a pilot project to promote productive uses in the lower Cochabamba valley in the area in an around the town of Vinto. NRECA set aside $237,000 for the project. Of the total, $100,000 was to be used in conjunction with ELFEC, the local utility, to install productive uses service drops that the end users could pay for over time. The remaining $137,000 was to be granted to PRODEM a micro-credit organization. Under the terms of the contract, PRODEM was to use $100,000 to provide loans to at least 50 productive uses and $37,000 were to cover administration and operation costs.

At the conclusion of the project, $95,166 had been invested in service drops and line extensions with 73% of that amount used in the Vinto area and 23% used to electrify the community of K'aspi Kancha Alta in another province of Cocabamba. A total of 217 service drops were installed: 183 in the Vinto project area and the other 34 in K'aspi Kancha Alta. Of the 183 in the Vinto area, only 28 were for productive uses.

Because of problems with disbursement of Bolivia governments funds, PRODEM received only $112,000: $75,000 for loans and $37,000 for administration and operation. PRODEM used some of its own money to complete the loan portfolio and made 101 loans worth $103,026. In all, 83 productive uses were benefited since 14 of them qualified for two loans and 2 qualified for 3 loans. Loan amounts varied from $66 to $6,500 and 77 of the loans were for less than $1,000. Of the 101 loans, 63 were used to purchase raw materials and 38 for electric equipment.

When PRODEM had fulfilled its contractual obligations with NRECA it sold its entire loan portfolio in the project area to Banco Sol and unexpectedly returned all the loan portfolio money, plus 6% interest, to NRECA. Therefore, Banco Sol continued providing loans throughout the project area and NRECA had additional money to invest in another productive uses project.

A financial analysis projected out to 20 years for the service drop component of the project showed a loss. The main reasons for the deficit were: 1) the low consumption of the end-user of only 36 kWh/month as an average per end-user, and 2) the high administrative costs (nearly 50% of the total) that ELFEC charged to the densification project.

Of the 83 productive uses that benefited from loans, 18 were surveyed in a final evaluation of the loan component of the project. All but one showed an increase in production. Similarly, all but one showed an increase in profit, though, paradoxically, it was not the one that had reduced production. A majority also showed an increase in the number of employees. Most of the participating productive uses were tiny shops or businesses with only 4 to 7 employees. Nevertheless, the 18 productive uses surveyed generated a total of 25 new jobs.

In the three tables below, one can see a summary of the loan program results. Of special interest is the effect on the production and profits of the 18 productive uses that were surveyed.

Table 1. Changes in production and profit or productive uses benefited with loans

	Production Level			Profit/Month (Bs)		
	Without	With		Without	With	
Production	Loan	Loan	Change	Loan	Loan	Change
Unit	Program	Program	%	Program	Program	%
Dresses, hats	1104	264	-76%	8549	13619	59%
Trousers	384	480	25%	3719	2291	-38%
Women's shoes (pair)	96	144	50%	2060	2830	37%
Tables and chests	30	60	100%	915	2175	138%
Shoes (pair)	18	36	100%	628	1857	196%
Bedspread	24	48	100%	2555	4570	79%
Tables, chairs, doors,	72	148	106%	167	3191	1811%
windows, beds						
Guitars, charangos	21	44	110%	2353	4224	80%
Clothes chest	50	120	140%	496	2522	408%
Trousers	480	1200	150%	2291	8225	259%
Trousers	250	700	180%	2225	6896	210%
Traditional skirt	72	216	200%	-149	367	346%
Bedspread	12	48	300%	271	2809	937%
Doors, windows	36	144	300%	1520	8242	442%
Closet, showcase,	30	186	520%	1880	3062	63%
dining set, nightstand						
Meat and vegetable pastry	6000	45000	650%	1485	5262	254%
Exchange Rate: approx. Bs 4.80 to US$ 1.00 during 1995						

Table 2. Number of loans listed by ranges of amount of loan

Amount (US$)	Qty of Loans
4,001 - 6,500	3
3,501 - 4,000	2
3,001 - 3,500	3
2,501 - 3,000	1
2,001 - 2,500	2
1,501 - 2,000	5
1,001 - 1,500	8
501 - 1,000	32
66 - 500	45
Total	101

Table 3. Quantity of loans given listed by activity of the productive use

Productive Use Activity	Quantity
Potato Chip Makers	2
Market sales stalls	2
Juice Stands	2
Blacksmiths	5
Metal-working Shops	5
Shoemakers	7
Carpenter Shops	16
Clothing Makers	21
Others	23
Total	83

3.2 Valles Cruceños

Using USAID funds, NRECA helped to finance the Valles Cruceños project in conjunction with the regional government and CRE, the rural electric cooperative that has the concession for the city of Santa Cruz. The project cost about $5.5 million and connected approximately 5,500 end-users in over 40 villages and small towns. NRECA provided technical assistance to CRE for launching and promoting a productive uses program. Based on the positive experience with stores opened by electric cooperatives in Chile, CRE opened a productive uses store called CREAGRO in the project area. Certain electric cooperatives in Chile began by selling goods directly related with electricity then expanded to the point of selling everything from toothpaste to automobiles.

Obviously, it is no small task to launch into a new activity. It required significant investment on the part of CRE to buy a house in the town of Mairana, outfit it as a store, stock the store, hire and train personnel, and cover the losses associated with start-up. At the end of September 1998, the author learned that CRE had decided to close the productive uses store in the Valles Cruceños (and the other stores that CRE had opened elsewhere). Subsequently, in a conversation with the General Manager of CRE, the author was informed that CRE decided to shut down the stores for legal reasons. A clause in the New Electricity Law states that utilities can use the electric bill to charge only things directly related with providing electricity and garbage collection services. The productive uses stores had been successful, but the law undermined the best leverage they had for having people pay back their loans – cutting off their electricity if they did not pay.

Another component of the productive uses work in the Valles Cruceños consisted of electrifying sugar cane crushing machinery. There were at least 50 small cane-crushing operations in an area known as El Chilon. They depended on internal combustion engines for to move the crushing equipment and on firewood to boil the cane juice to transform it into dense brown sugar blocks. The internal combustion engines were obvious sources of pollution and the use of the firewood was an even more sensitive ecological issue. The cane crushers bought firewood that was coming from a unique protected rain forest area. Therefore, a project was designed to have the internal combustion engines converted to electricity and to take advantage of the natural gas pipeline that came through the area for boiling the juice.

For the project, NRECA granted the productive uses money (about $85,000) that PRODEM had returned from the successful Vinto loan program. That money permitted CRE to build the line extensions and service drops that would allow the cane crushers to convert from internal combustion engines to electric motors. To the author's knowledge, the component of substituting gas for firewood has not been concluded yet.

3.3 Chapare

The Chapare has become infamous because of it reputation as a coca growing and drug processing area. The United Stated Agency for International Development (USAID) in collaboration with the Government of Bolivia has designed a program intended to create an alternative economy in the region. NRECA success in rural electrification projects has been tapped to carry out three stages of identifying and connecting area industries and communities to the grid.

Under Chapare I, NRECA built over 19 km of line and installed service drops with transformers ranging from 10 to 250 kVA to connect 41 industries. Under Chapare II 21 connections were made including both industries and communities. Transformers ranged from 5 to 50 kVA. The Chapare II project included technical assistance to small dairy farmers. NRECA personnel met with the farmers on various occasions and visited some of their small farms, their milk collection and cooling facilities, and the dairy processing plant to which they sell their milk. An experimental extension farm in the area was also visited. Based on the information obtained, detailed spreadsheets of costs and potential profits were prepared and explained to the farmers. Based on priorities identified by the farmers, NRECA also supplied cost information for tractors and electric milking equipment with ideas regarding how they could contact suppliers and purchase the equipment on credit. Chapare III is now in progress and is scheduled to conclude by the end of 1998.

3.4 Licoma – Mina Chilaya

The Licoma – Mina Chilaya project is an example of how one large productive use made an entire project financially viable. The productive use was a gold and antimony mine, Mina Chilaya. NRECA did the prefeasibility study for the project to determine the viability of electrifying three remote rural villages and the mine (Kittelson, et al, 1995). The results made it obvious that it was not financially viable to electrify only the villages. The mine, however, used diesel generators and a least cost useful life cycle analysis showed that the mine was much better off paying for a line extension from the grid. The mine and the electric utility reached an agreement on how much the mine would contribute and NRECA contributed the money that made it possible to tap into the three phase line to the mine to connect the villages.

3.5 Renewable Energy Projects

NRECA has implemented various renewables projects around the world. One of the most recent examples is the work in Chile under contract with NREL to implement hybrid wind projects that have benefited schools and health posts, besides the village households. In Bolivia, projects have included solar, wind and biomass technologies. The biomass plant in Riberalta, which is a 1 MW unit fueled by brazil nut shells and waste wood, has permitted the greatest productive activities. The electric cooperative in Riberalta has a significant industrial and micro-enterprise load. The wind project was exclusively for pumping water for a village water supply system. Solar energy has been used for village water systems, powering a satellite TV dish (the owners of which charge an entrance fee to viewers), school systems for lighting, audio-visuals, and learning-at-a-distance programs. Though there are many who will argue for the long-term benefits of renewable energy, the fact is that its current cost per kW installed drives large productive users to find alternative energy sources with lower initial capital costs.

4.0 KEY FACTORS FOR PRODUCTIVE USES PROGRAMS

In this section the author summarizes the lessons learned from the productive uses programs described above. An effort is made to make the conclusions internationally applicable.

Successful productive uses of electricity programs depend on a combination of key factors. If any particular factor is weak or missing the program will either fail or be significantly less successful. Those factors are: 1) reliable and affordable electricity, 2) available and reliable electric tools and equipment, 3) available and affordable financing, 4) available and qualified human resources, and 5) sufficient demand for the product or service. Obviously, other factors such as the legal framework, government stability, and the national economy affect the success of these programs, but those issues are more country-specific and will not be addressed in this section.

1) Because the tendency has been to emphasize the end-user in productive uses programs, the author also wishes to point out the importance of considering the utilities. Bear in mind that reliable and affordable electricity is a key element. Yes, the profit of utilities must be kept within reasonable limits, but they also have a right to make a profit and one must remember that if the utility is not financially healthy, sooner or later there will be problems with the reliability of the service. Moreover, it does not take much imagination to think about how extended outages impact on productive uses that have frozen chicken or ice cream in storage.

NRECA has worked extensively with electric cooperatives and utilities to help them provide reliable service to productive uses. In general, the utilities like to attract and retain large, stable industries that consume thousands of kilowatt-hours monthly. They can also be convinced to participate in productive uses programs where end-users have smaller consumption, as discussed below. Nevertheless, they have to keep the bottom line in mind. Utilities cannot be philanthropic beyond their means and still stay in business to provide reliable power.

2) Reliable electric equipment is not always readily available in remote areas. Equipment can be brought in to jump-start a productive uses program, but that does not solve the ongoing need for adequate maintenance and repair services with readily available spare parts.

3) In many cases credit exists, but there have been annoying and discouraging obstacles to actually having access to it. Large enterprises with the proper clout and assets for guarantees have more alternatives available to them. In recent years, micro-credit programs have been widely implemented with varying degrees of success. In Bo-

livia, PRODEM has been one of the most successful, but even it has not gotten out into remote rural areas.

4) The author considers the need for qualified human resources to be the paramount factor in the success of a productive uses program.

5) One of the most difficult things to address is demand for the products and services of the productive uses. It is impossible to control, much less guarantee, a market. Nevertheless, one can at least avoid making overly optimistic projections. It usually does not take much market research to determine if projections are reasonable.

5.0 CONCLUSIONS

A productive use is any use of electricity that generates income for the end-user. It may be a huge cement factory or a tiny juice stand with an electric blender. Electric cooperatives and utilities must watch their bottom line. They are obviously interested in attracting and retaining those productive uses that consume thousands of kWh per month. While they can be convinced to participate in programs that cater to micro-enterprises, their philanthropic efforts must remain within reasonable limits if they are to continue to provide reliable electric service.

Five key factors must exist in order for productive use programs to be successful: 1) reliable and affordable electricity, 2) available and reliable electric tools and equipment, 3) available and affordable financing, 4) available and qualified human resources, and 5) sufficient demand for the product or service. Many productive uses programs have concentrated on only one of the five factors mentioned above, but for the program to succeed the other four have to exist. It does not mean that a program must build all five from scratch, but program implementers must ensure that the other components already exist in the target area or that the appropriate linkages can be forged with other actors that can make them available. The author considers that of the five, qualified human resources is the most important.

Finally, no matter how carefully something has been planned, there are inevitably unforeseen issues that arise. One must learn to be flexible and be prepared to make timely adjustments in order for the program to generate the greatest benefits.

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Small-scale village electrification; an NGO perspective

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

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This paper examines traditional mechanisms for Overseas Development Assistance (ODA) in the sector of rural village electrification, and the preconceptions that underlay these mechanisms. Some specific consequences 'on-the-ground' are examined. The reticence of many donors to commit further investment in the sector is understandable and may be explained by these results, but an understanding of the mechanisms may lead to an alternative approach.

Electricity is the most versatile of energy forms; indeed there is arguably no route to sustainable development in its absence. It does not automatically provide development paths, a fact that is implied later in this paper. Nevertheless electricity does represent a tool capable of economic, educational, health and other sectoral enhancements that are ingredients for controlling one's developmental destiny. In rural areas in particular, electricity has an important additional role as a vehicle for information flow, enabling a community to take part in affairs beyond its village confines, and making national political and social cohesion a meaningful concept.

Notwithstanding the need and benefits, electricity is not available for the vast majority of rural communities, and access is not improving at any significant rate. More people are without electricity with each passing year. Its highly uneven distribution represents a significant divide within and between nations.[ii]

The UNDP's Initiative for Sustainable Energy (UNDP, 1997) concludes that 'current approaches to energy are thus not sustainable and will, in fact, make energy a barrier to socio-economic development'. The document also notes that the 'conventional approach to developmental assistance, based on significant use of ex-patriots, is becoming increasingly more expensive. A new, more cost-effective approach… is needed."

Planned redirections towards new and renewable technologies and local capacity building (for example, UNDP,1997) have general merit, but some of the disappointing results of past efforts will remain unless a change in underlying presumptions is also included in new strategies. A new field-tested paradigm addressing past disappointments is presented here for the specific context of Melanesia, but may also be relevant in other similar contexts.

The challenges for rural energy supply:

The energy sector as a whole is in crisis. Whereas much can be attempted on the demand side in nations with adequate supply, nearly half the world's population have no affordable access to commercial energy services. Conservation and efficiency are academic notions in most rural settings of developing nations. Less than 20% of such villages have nominal access to electricity and perhaps no more than a few percent have actual and consistent access (Reddy and Goldemberg, 1990).

Recently, some donors and other stakeholders have looked to new renewable technologies, and new financial arrangements involving the private sector, as a way around the dilemma. The notion that renewable technologies alone have an answer to rural needs, through their decentralised character, leads usually to debate on relative costs of some of these technological 'solutions'. The debate diverts serious attention from the managerial and institutional frameworks that remain central to any effort in this area.

Encouraging the use of private capital, in credit schemes, loan guarantees and B.O.O.T. and B.O.T. arrangements, may have application in urban and peri-urban areas in nations enjoying a moderately developed market base and middle class. It is seldom a solution for rural village contexts, particularly in contexts for which poverty-directed ODA is most relevant. In short, such arrangements become increasingly less attractive as the poverty-alleviation need increases.

'Natural' urban population drift has also become a reason for procrastination on the difficulties of rural energy supply. The serious side-effects of rapid urbanisation has diverted attention from the rural sector, although rural populations do continue to increase in absolute terms. As well, the institutional frameworks that exist in urban areas, at least in some form, tend to encourage urban-based ODA. Economic restructuring focuses further attention to urban institutions, and may be said to reduce the importance of the rural, informal sector. Nevertheless in many regions, and notably many of the small island developing nations of the Pacific, there is little prospect of a sustainable physical, social and political environment for economic restructuring without attention to the rural sector. Of the 90% of PNG citizens dwelling in rural areas, 3 out of 4 live in absolute poverty compared to 1 in 10 within urban areas (Flanaghan, 1997). In the Solomon Islands, the rural dweller accounts for 86% of the population. No more than 500 jobs are created each year in the formal urban sector, for an annual cohort of 6000-7500 school leavers (Bank of Hawaii, 1994). In such situations rural and urban problems are inseparable. A suitable approach to affordable electricity, that can enable a meaningful social, political and economic participation of rural citizenry, needs to be adopted.

The traditional paradigm:

There are a number of presumptions built into technical development assistance projects, and in particular village electrification projects. They are listed below, as generalities that apply in varying degrees to different programs and different national contexts. These are set out as caricatures, rather than judgements of any particular program in the sector.

Presumption 1: 'Village development is a technical matter':

Investment of ODA in the sector is increasingly recognised in the literature as serving a people-centred developmental objective, since financial analysis seldom finds such investment justified. Paradoxically, the developmental objective, at least at village level, remains unacknowledged in detailed project design. The indicators chosen for appraising, managing, implementing and evaluating and reporting on specific programs or projects are technical in nature, rarely concerned with the translation process to people-centred development outcomes.

Initial assessment of a rural village electrification program, for example, is generally conducted by a team chosen for their technical training. Given a positive prognosis from this appraisal, prefeasibility studies often proceed to rank preferred sites for village electrification, using a weighted function of quantifiable technical and financial parameters. If decentralised renewable technologies are considered, the parameters would involve the potential of the energy source, such as the head and flow of water from available rivers, or the insolation available. If existing and projected demand for electricity at the site is estimated, the figures will normally derive from quantitative models presuming a formal economy, and will accordingly be very small or difficult to estimate. [These small figures are often self-fulfilling prophesies, for reasons discussed under Presumption 3.] If on-site estimates are considered, the field team will again be chosen for their technical measurement abilities.

Following these studies, projects proceed through detailed design, specification, tendering and construction in a similar technical vein. Accordingly, reporting in the literature of completed projects will often focus upon machinery choices and technical performance. Training aspects may be mentioned, focussing on the nature and extent of technical training associated with post-project requirements only. Such training is normally conducted for, and within, an institution remote from the village; in accordance with Presumption 3. In contrast, most failures of rural power schemes are attributed to local non-technical factors. The operation can be a (technical) success while the patient dies.

During each of these project phases, there is seldom meaningful contact with the target recipients, nor the context of their needs. The institutional strengthening that must accompany any infrastructural project is seen to be focussed elsewhere, in accordance with Presumption 2. A process of rural participatory appraisal, if considered, does not include village recipients in technical or management roles that may enable local strengthening.

In short the power supply industry, and its management methods, are based on specialised technology and support structures; the rural developing world is not.

Presumption 2: 'Village development is a First-World matter'

Developing nations generally find themselves particularly short of the technical expertise perceived in Presumption 1 as central to this developmental exercise. Technical expertise in the electricity sector is already over-extended by the challenges of maintaining the existing urban infrastructure. Trained people have an urban career path that follows their University engineering training, in which electricity system design and equipment choices are tied closely to the contexts of First-World institutional management and social structures.

Almost by definition, those regions in which ODA is most justified will be the most deficient in such technical expertise. Accordingly, overseas consultants are often relied upon to make assessments of a program, and here the mismatch of background and training with a rural people-centred objective is perhaps even more acute. The overseas technical consultant is generally chosen to have the maximum level of preconceived knowledge of power system construction and management learnt and applied in a foreign social, cultural and economic context. If such consultants also have exposure to developing country situations, their experiences are likely to be in previous appraisal and design roles where the Presumption 1 has already been formed and reinforced.

Later feasibility and design stages are often provided by ODA-subsidised energy advisers, and dependence upon such overseas expertise will intensify as new and renewable technology projects become more frequent.

The tendering process (of Presumption 1) favours implementation by overseas-affiliated contractors. They bring experience gained in a context where equipment, technical infrastructure and educational structures are quite different to those found in local villages. A 'First World' methodology is 'planted' within an exotic physical, cultural and economic environment.

These methodologies have not 'taken root', with the response that the UNDP, for example, sees building indigenous capacities as a clear priority (UNDP, 1997). Nevertheless, such capacity building is still seen to involve translating and strengthening the first-world model of well-trained expertise within central institutions, a model that we argue will not directly address the challenge of sustainable rural village electrification.

The most important 'institution' to be strengthened must relate to local development, centred on the consuming community. Such an institution has most need, most motivation to focus on the underlying project objective, and is least distracted by competing contractual agreements and career paths.

Presumption 3: 'Village development is an urban matter'

Presumption 2 notes that the choice of expertise for appraisal, and indeed for program design, draws on a small selection of urban-based individuals, commonly with a lifetime of experience concentrated on technical and economic decisions as they pertain to a formal economy. In-country expertise may possibly be found within the Governmental Ministry or private sector of a major city, where the few technically-trained graduates have found rapid career advancement outside their rural origins.

Their training and experience of decision-making within the electricity 'industry' in urban centres reinforces assumptions that are not optimal for a rural village setting. Some are cited below:

- Decisions for urban electricity supply are adequately conducted without reference to specific consumer groups; their requirements are statistically predictable. The social context does not significantly impinge upon design and management; it is a delivery system only.
- Existing and projected demand can be quantified, operation and maintenance costs can be estimated, and competing energy technologies can be compared 'on paper'.
- The consumer, the designer and constructor, and the system operator are separate entities.
- The environment potentially affected by the power system, and the environment most relevant to beneficiaries, are separate.
- A power scheme ends with the generation system, or at most the transmission line. Existing cash-flow and power demand will support connection fees and a usage-based tariff system.

- Dwelling and building construction conforms to presumptions in electricity wiring standards developed in the First World.
- The cultural beliefs, the skills base and the local physical resources of clients are generally not a consideration.
- The land for power station and transmission facilities is either Government-owned or available for title purchase.
- There is no need for consumer training nor awareness programs, since separate mechanisms are available for safety licensing, operation and maintenance of the system, and for awareness of the developmental potential of electricity usage.

In short the power supply industry, and its thinking patterns, are centralised; rural people are not. None of the above assumptions were valid in rural energy projects conducted by the authors.

The consequences:

There are a range of endemic factors that lead to the Presumptions 1,2 and 3, not least of which is the isolation of recipients. Indeed, the very needs of rural village residents for poverty-alleviation and developmental programs stem largely from their position at the far end of a well-meaning but imperfect institutional pipeline of information and capacity-building. Their aspirations and their capacities are difficult to reach within cultural and organisational frameworks developed rationally from the opposite, donor-based end. The preconceptions of value-free technology, centralised management and context-free development that underlay these 3 Presumptions tend to be a natural result of ODA processes.

In short, it may be that the goal of sustainable human development at rural village level becomes, in practical application, divorced from the process of implementing village electrification programs. It may be this process that underlies shortcomings in results of rural village electrification programs, that have led to such persistent criticism in the literature.

Specific effects that the author has observed, particularly within the context of the Pacific Island developing states, may be summarised as follows:

1. Local communities are left with
    - a “Catch 22” of initially unaffordable costs for connection fees and usage tariffs;
    - rules that preclude connection to most forms of customary dwelling, based on wiring practices suitable for urban areas;
    - few, if any, skills derived from the project;
    - few, if any, direct employment opportunities;
    - little understanding of locally-appropriate possibilities for electricity-based development, since local involvement and discussion has been minimised by the management process, and the developmental objective has been largely lost in technical challenges of providing infrastructure for a harsh, remote site;
    - a lack of community cohesion to pool skills and capital for applications of the power, exacerbated by outside environmental and social disruptions from the construction phase;
    - internal social strains arising from the impact of an exotic technology, and in all probability the alienation of traditional land and resource holdings.

2. The host Government or Electricity Authority is left with

- legal disputes arising from land alienation, and possibly displaced persons;
- recurrent maintenance, repair and security costs at a remote site;
- minimal revenue from tariffs, as the subsistence economy is presented with no obvious means to exploit the available electricity;
- low plant utilisation factor, leading to reduced motivation for expansion or replication;
- disappointing lack of local cooperation and communication regarding minor operation and maintenance tasks, and possibly security problems, arising from many of the above factors;
- no development of local infrastructure to support service personnel;
- imported machinery fabricated by exotic production techniques that cannot been replicated in-country;
- minimal employment generation, even in urban areas, given the imported machinery;
- added social costs, arising from continuing population drift to urban areas, perhaps exacerbated by the displacement of people and deterioration of local community cohesion.

An alternative paradigm:

There are long-standing examples of successful village electrification projects in the Solomon Islands, in which the debilitating residual characteristics listed above have not arisen (Bygrave, 1997). Indeed, remarkable social and economic development has followed such projects (Krajenbrink, 1984; Holden and Gammage, 1991; Offord,1995, Waddell, 1997). In essence, their common characteristic is a 'Village First' project management cycle. Institutional support runs through several levels, but major effort must occur at local level, and begins with day 1 of the appraisal process in which village recipients begin attaining ownership of the development process that is the objective of rural energy supply. The process may be separated into phases as follows:

1. A village request precedes a process of self-appraisal, based upon indicators of social cohesion, community goals, managerial and other capabilities and an information sharing regarding costs and responsibilities.
   Lesson 1: The developmental objective must be formulated and owned at village level.
2. An awareness workshop builds upon initial appraisal information, focussing upon appreciation of the technology, its implications and potential uses, and local resource investments necessary for a process where project effort is locally-focussed. A local technical appraisal, mirroring that found in conventional approaches, accompanies the workshop allowing preliminary feasibility results to be shared and possible difficulties discussed relative to local capacities.
   Lesson 2: Institutional strengthening begins early, and locally.
3. Feasibility design draws upon the results of the above processes, in which costs are weighed against (qualitative) indicators concerned with the likelihood of sustainable human development. Technical parameters influence potential costs and become a limiting factor in the magnitude of developmental potential. These parameters are influenced by social, environmental conditions as well as local resources, and are subservient to the major

questions of likely linkages between energy supply and human development.
Lesson 3: The technical design is within a local developmental context.

4. Project funding is based upon contribution-sharing, in which village communities are a significant stakeholder. A contract is drawn up to delineate respective responsibilities of donor, implementing agency and village community.
5. Implementation follows a design-and-construct methodology that allows some local decision-making and avoids costly processes of remote specification, tendering, contractual management and cost-over runs from unanticipated local difficulties.
   Lesson 4: Local objectives are matched by local responsibilities.
6. On-site local training-by-doing, encouraged by previous phases. Off-site training for key women and men in operation, maintenance, project management, load utilisation, electricity safety.
7. A participatory follow-up phase of evaluation, based upon developmental indicators set by local priorities in phases 1 and 2.
   Lesson 5: Evaluation is concerned with objectives and outcomes, rather than time-bound outputs.

The 'village first' model requires patiently-developed partnerships, but it is not a speculative, academic model. The approach has been adopted and proven in the field in differing technical and social contexts, over many years. Results are 'on-the-ground', with higher levels of local cohesion leading to endogenous maintenance and indeed improvements to infrastructure as well as locally-initiated developmental effects. There have been reductions in population drift to urban areas, schools locally constructed and increased attendance rates, improved health facilities and several local industries established.

Summary:

UNDP's Initiative for Sustainable Energy (UNDP, 1997), while observing the lack of sustainability of present mechanisms for energy supply, also proffers four planks to activity programmes in the future:

- capacity building
- encouragement of institutional and legal frameworks
- encouraging a leapfrogging to new and renewable technologies
- linkages between energy and developmental goals.

- The alternative 'Village First' project cycle for rural electrification discussed above addresses each of these facets in a fashion that provides the means for its appropriation to specific cultures, and has been demonstrated to be cost-effective.

The challenge may be seen in the words of a past achiever, quoted here out of context:

"The world that we have created, as a result of the thinking we have done so far, creates problems that cannot be solved at the same level at which we created them."
.... Albert Einstein

Acknowledgments

We acknowledge the kind support of the National Renewable Energy Laboratory and World Bank in making this presentation possible. The paper draws on 20 years of design, management and field implementation of small renewable-energy systems in the Pacific and SE Asia, made possible and greatly assisted by the competence of staff and supporting members of APACE and the University of Technology, Sydney.

Part of the content presented here first appeared in Development Bulletin, Volume 43, page 13, 1997.

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[i] APACE is an NGO specialising in rural village electrification in the Pacific and parts of SE Asia. It can be contacted at APACE@UTS.edu.au; c/o University of Technology Sydney, PO Box 123, Broadway 2007, Sydney, Australia.

[ii] This corrosive effect on North/South relations, from the general failure to address energy needs at the poorest levels of global society, was evident from personal discussions and observations at the recent Rio + 5 Earth Summit.

Capacity Building for Small-Scale Rural Development

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October 7, 1998

Summary

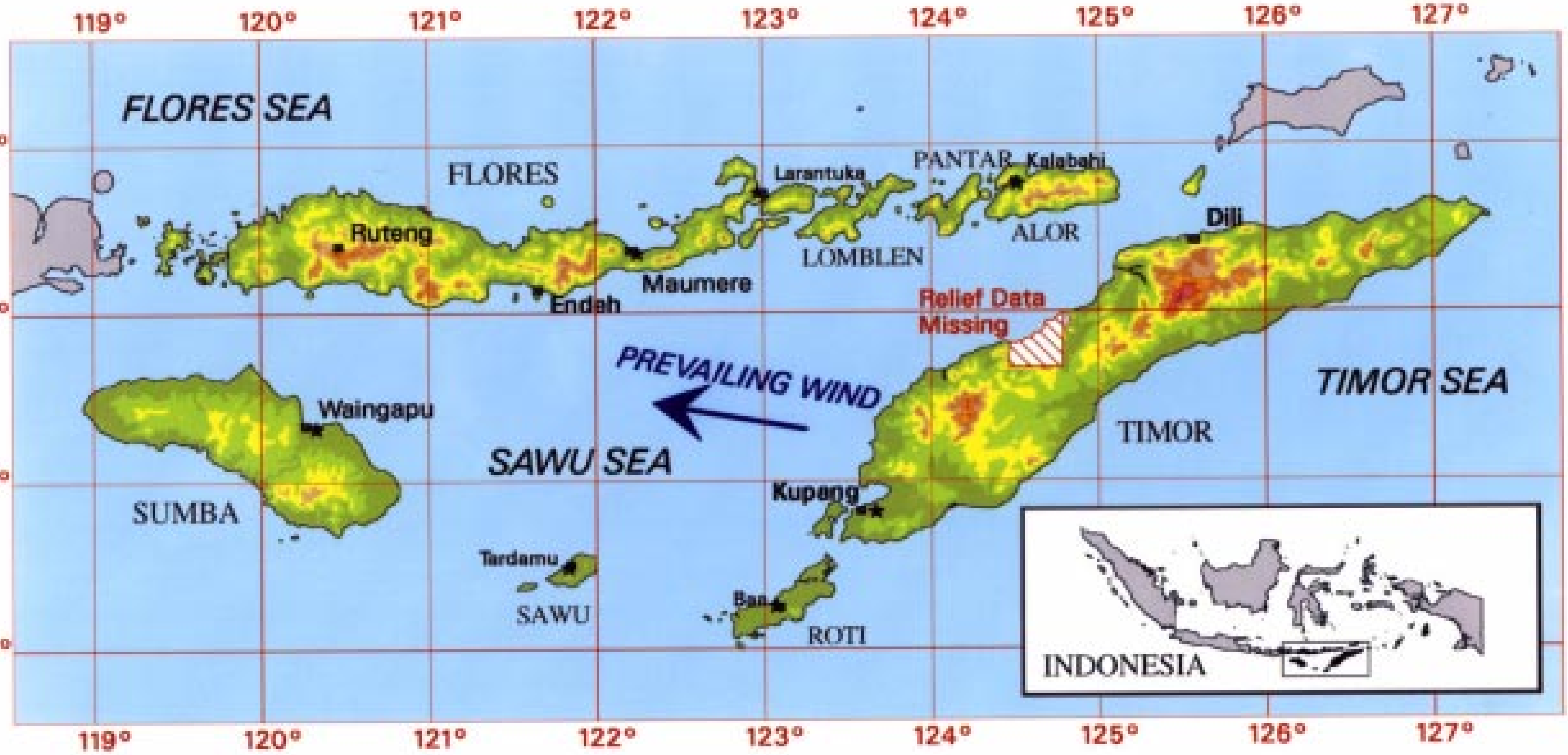
- An onion farmer in Indonesia
- To grow the market, we must expand the ability to pay
- Stories from Indonesia and India

An Onion Farm in Indonesia

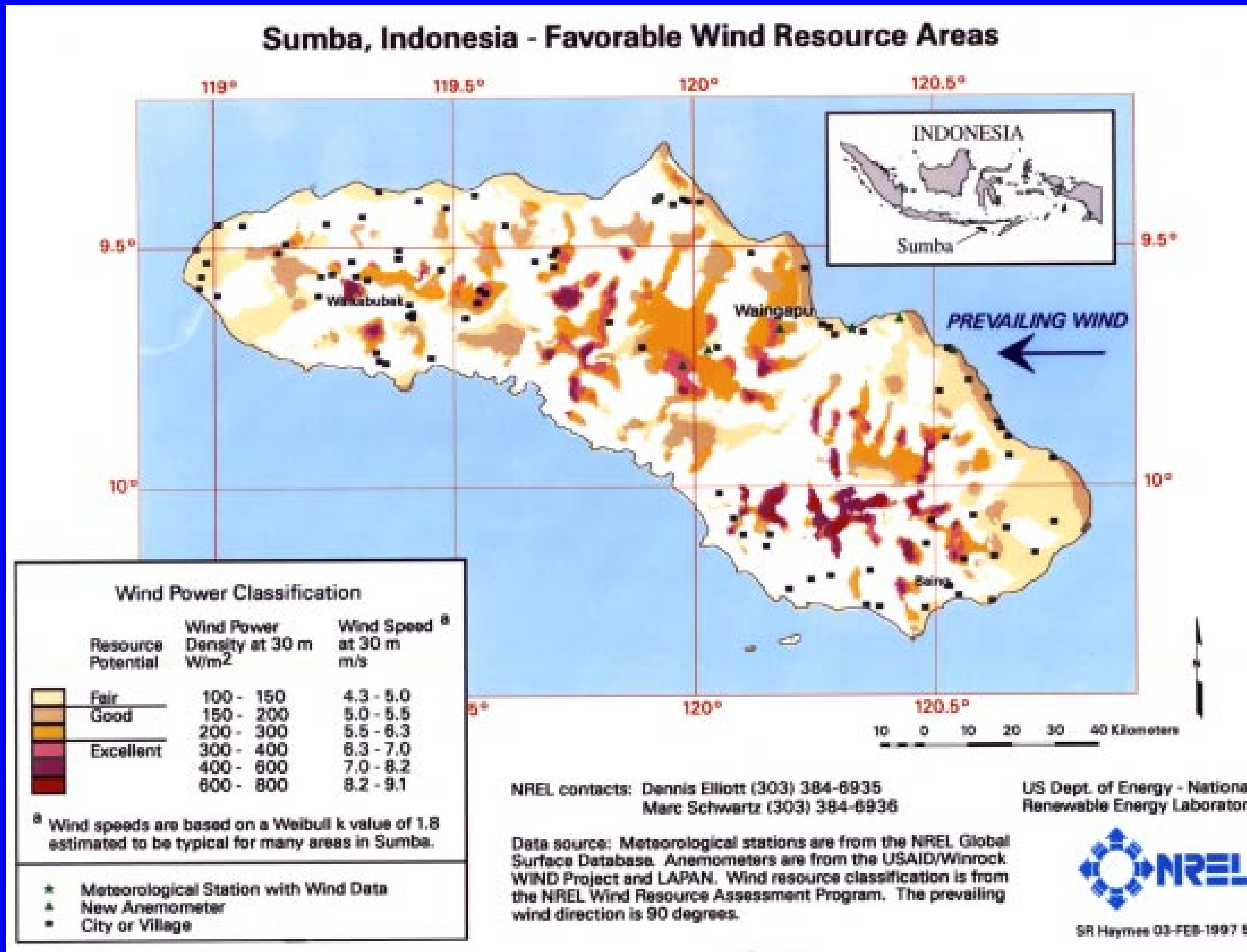
- Area—0.065 hectares (7000 square feet)
- Labor required—
  1040 hours per season hauling water to bring crop to harvest
- Value of crop—
  US$ 550

An onion farmer displays his crop.

Selected Islands Of Southeast Indonesia - Elevation Map



Source: NREL


Sumba, Indonesia - Favorable Wind Resource Areas
119°
119.5°
120°
120.5°
9.5°
10°
INDONESIA
Sumba
Waikabubak
Waingapu
Baing
PREVAILING WIND
Wind Power Classification
Resource Potential
Wind Power Density at 30 m W/m2
Wind Speed [a] at 30 m m/s
Fair 100 - 150 4.3 - 5.0
Good 150 - 200 5.0 - 5.5
200 - 300 5.5 - 6.3
Excellent 300 - 400 6.3 - 7.0
400 - 600 7.0 - 8.2
600 - 800 8.2 - 9.1
[a] Wind speeds are based on a Weibull k value of 1.8 estimated to be typical for many areas in Sumba.
Meteorological Station with Wind Data
New Anemometer
City or Village
10 0 10 20 30 40 Kilometers
NREL contacts: Dennis Elliott (303) 384-6935
Marc Schwartz (303) 384-6936
Data source: Meteorological stations are from the NREL Global Surface Database. Anemometers are from the USAID/Winrock WIND Project and LAPAN. Wind resource classification is from the NREL Wind Resource Assessment Program. The prevailing wind direction is 90 degrees.
US Dept. of Energy - National Renewable Energy Laboratory
NREL

Pumping Water with a Windmill

- Labor required—100 hours per season
- Value of crop—US$ 2200

The onion field and wind tower.

Children of onion farmer now attend school.

Who are the 2 billion people in the world without electricity?

Winrock Perspectives

- Insufficient funds to subsidize everyone
- Subsidies difficult to manage and can lead to corruption
- Private capital essential for renewable energy market development
- Surveys of willingness to pay show demand
- Fastest way to grow market is by expanding the ability to pay

Expanding the Ability to Pay

- Identify regional comparative advantage
- Introduce more efficient production techniques
- Assist with marketing and quality control
- Improve access to credit
- Build local capacity and infrastructure

Building Local Capacity

- Use and strengthen existing institutions and companies
- Engage local organizations to improve policy environment
- Attract companies to new markets and provide continuing business support
- Support local NGOs to help develop markets

Reduce Transaction Costs

- Establish viable enterprise models
- Build market to stimulate demand for local distributors
- Enlist local NGOs and community leaders in training and skills development

Create Models at Two Levels

- Individual enterprises
- Market for products

Fishing in Indonesia

- Location—
  Eastern Islands
- Individual enterprise—
  fisherman
- Infrastructure needed to
  transport fish to market

An Indonesian fisherman
with his catch.

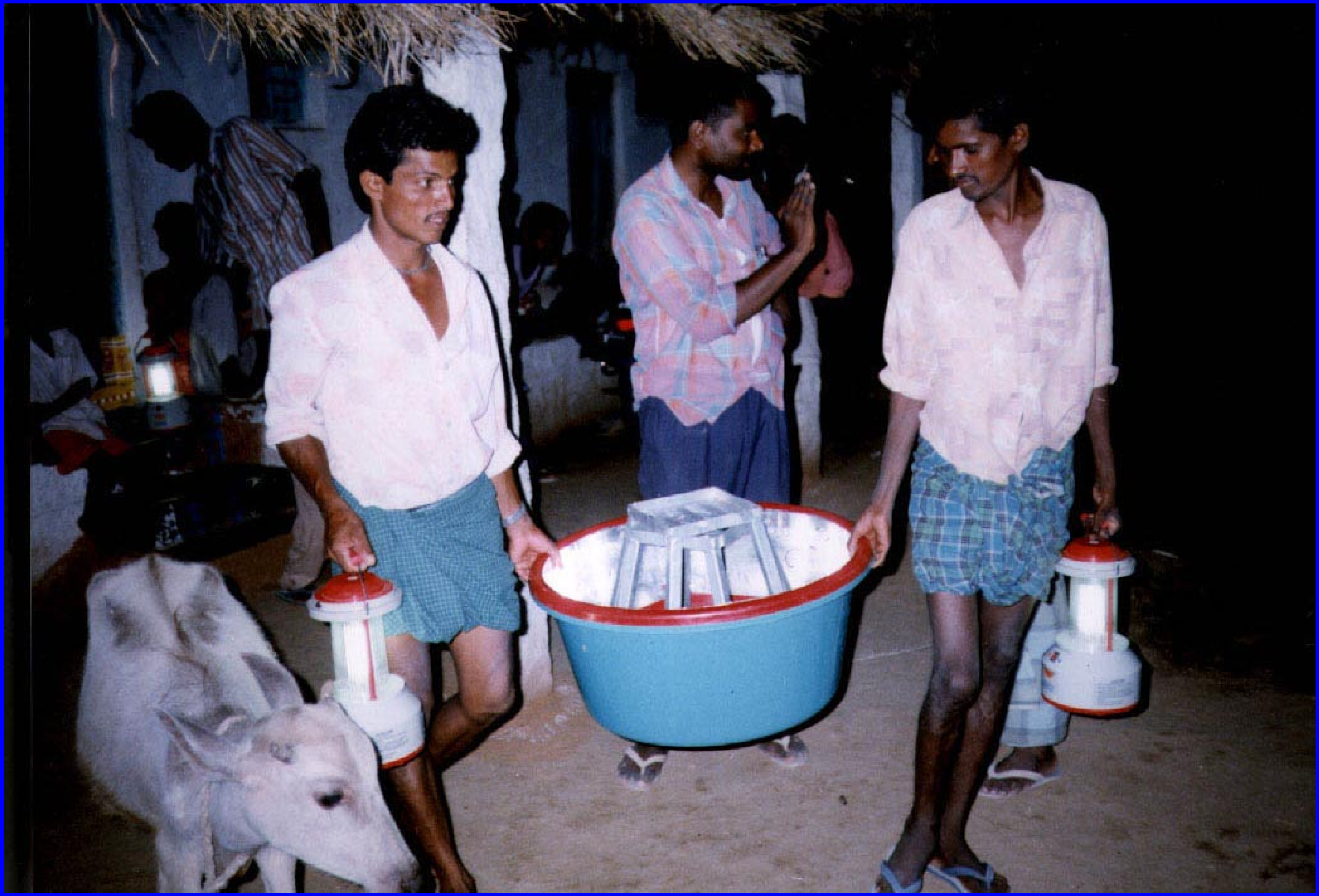
Program Concept

- Increase value of fisherman's catch
- Produce ice for fish preservation
- Organize transportation to market

Pest Control in India

- Location—Southern India
- Enterprise—farmer
- Farmers need more effective methods for pest control

Villagers with lanterns.



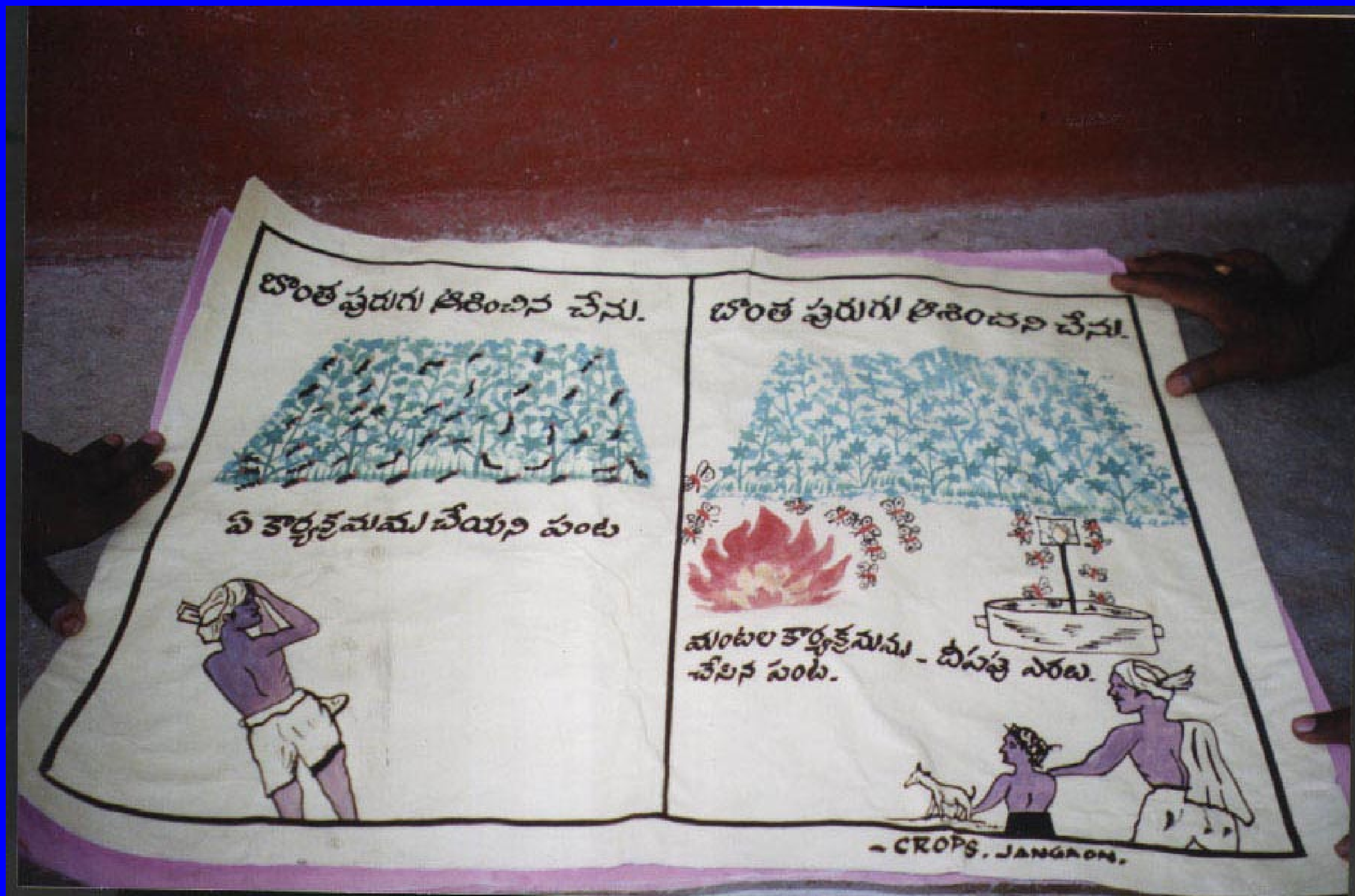
Farmers prepare to set the solar lanterns.

Program Concept

- Increase agricultural productivity and profitability
- Reduce crop losses
- Replace pesticides with solar lanterns

Trial Results

- Lanterns tested in 40 hectare trial area
- Reduced losses from 50% to 4%



The old and the new methods of moth control shown in art.

Fruit Production in Indonesia

Location—
Eastern Islands

Individual enterprise—
fruit production

Infrastructure needed to access market and transport fruit to market

Timorese fruit farmer cutting his second harvest of mandarin oranges.

Program Concept

- Regional conditions optimal for fruit production
- Identify fruit buyers in premium market
- Select fruit varieties and develop local production infrastructure
- Develop credit mechanisms with local banks
- Provide training in packaging and quality control
- Develop transportation infrastructure

Most orange trees are planted in villagers' garden or yard.

Timor's mandarin oranges command premium prices.

Mandarin oranges packed to be shipped to buyers in Java or Bali.

Fruit distributors attending a training session.

Boxes of fruit being lifted up onto the deck of the passenger ship Dobonsolo.

20-foot refrigerator container on the Dobonsolo.

Energy Inputs

- Water pumping for drip irrigation
- Cooling for fruit preservation

Summary—Winrock Program Concept

- Target markets where small amounts of energy will increase income
- Reduce transaction costs by developing local capacity
- Technical assistance to assure income growth

Provide Continuing Enterprise Support

- Business planning
- Marketing
- Quality control

New Role for Public Institutions

- Set development priorities
- Create enabling environment
- Reduce credit risk

Local boys help with irrigation.

Gender and Poverty Challenges in Scaling Up Rural Electricity Access*

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

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* Based on a paper under preparation for the National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, CO 80401 USA (contact: Barbara Farhar).

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When I was first asked to give this presentation on gender and poverty in scaling up rural electricity access, I went back to the Village Power '97 Proceedings from last year and looked for what had been discussed on poverty and on gender last year. I found very little. Out of maybe 50 or 60 projects that were presented in the course of the meeting, for example, there were only two (2) that even mentioned women; and there was very little discussion of poverty issues. This was very different in the presentations yesterday and this morning at Village Power '98, and in the workshop on Women and Energy Sustainability on Monday. I want to take this opportunity to thank the organizers of this year's meeting and yesterday's speakers, and of course the speakers in this session, for putting poverty alleviation and gender squarely on the international agenda for scaling up rural electricity access at VILLAGE POWER '98. That makes my job this morning much easier.

Sustainable rural energy development and the 1990s global energy agenda

Sustainable (energy) development has been defined as (deLucia, 1990):

(1) Equitable growth - betterment for *all* people but *with particular concern for the poor*;
(2) Avoidance of natural resource degradation or depletion; and
(3 Self-sufficiency with respect to organizational, fiscal and managerial inputs.

Decentralized power clearly meets the second criteria above; considerable attention is presently being given to the third; to the first, in light of current international development priorities, "particular concern for the poor *and women*" should probably be added.

For example, sustainable human development goals are currently defined by UNDP as: (1) eradicating poverty; (2) increasing women's role in development; (3) providing people with income-earning opportunities and livelihoods; and (4) protecting and regenerating the environment.

Most renewable energy activities have in fact been justified largely on environmental and global climate change grounds in the 1990s. The Kyoto targets on carbon dioxide emissions have given these efforts a renewed urgency. The global energy agenda today recognizes that the energy-environment link is often a negative one, yet more energy is needed for growing populations and for increasing energy demands with higher incomes. Energy efficiency, fuel switching and renewable energy are possible solutions that are technically mature and commercial. These activities are to be promoted through "sustainable" market processes, but are still hoped to be affordable for the poor. Hence "market barriers" need to be overcome to reach their primary target group of poor, rural households.

What about the poor?

We spoke a lot yesterday about poverty alleviation, while at the same time talking in terms of market approaches to promoting renewable energy. At a time of global economic crisis, when rather than poverty alleviation, we are seeing tens of millions of people likely to be pushed below the poverty line, it seems especially important to clarify what our approaches to scaling up can be here.

What about the poor? There are three approaches to access by the poor that have been followed in scaling up rural electricity access. First, access by the poor has been ensured through targeted measures, such as subsidies or community/NGO approaches. These has been justified by the fact that access to adequate energy supplies is critical to livelihood strategies of the poor. The poor, with irregular and unreliable incomes, cannot afford to invest in more efficient appliances or to buy in bulk, and thus end up paying more per unit for energy.

The problem with this approach is that subsidies may not be sustainable; and the community/NGO approach is risky, time-consuming, and input-intensive, and may not be replicable everywhere.

A second approach that is being experimented with a lot lately, is to make credit available to purchase renewable energy technologies, in order to overcome the market constraint of high capital costs and limited credit for renewables. However, the most optimistic credit scenarios for e.g. solar home systems (SHS) assume that 50 to 75 per cent of rural households will be able to afford SHS, even with liberal credit programs in place. That still leaves 25 to 50 per cent of rural households without electricity!

And offering credit to poor households can even have perverse effects: Total household energy expenditures of poor households typically increase following rural electrification, likely decreasing expenditures on food; debt payments may not be sustainable, given irregular incomes; and poor households even risk losing their original investment through repossession.

The third approach to expanding access is simply to ignore the poor. They can't afford rural electrification anyway. Marketing should aim at higher income households who can not only afford the initial costs, but can afford to take on the risk of trying out new technologies. Some poor households will still be able to finance and benefit from renewable energy technologies through cash purchase (gifts, remittances, savings societies).

However this approach not only contributes little to poverty alleviation; it runs the risk of even intensifying inequalities between rich and poor, as happened with the introduction of improved agricultural technologies during the Green Revolution in Asia.

All of these strategies have some role to play in increasing access to electricity in rural areas. But as we see above, none of them is entirely satisfactory. So if we want to link rural electrification to poverty alleviation - and I think that we do, especially those of us working in development organizations - then we need to be coming up here with some more innovative solutions to access. Leasing, and micro-credit through solidarity groups, for example, are promising new approaches we have heard about this week.

How are gender and poverty related?

How are gender and poverty related? Poverty means, among other things, limited access to energy sources. Poverty influences and determines energy choices of households. It is also one element that can enhance or detract from survival strategies of the poor.

The main source of energy in poor rural households is not biomass. It is women's labour. The real energy crisis in rural areas is women's time.

This graph shows the allocation of time to survival activities by gender for a few selected activities in several countries where time use data is available. [1] As Mieko Nishimizu [World Bank Vice President, South Asia] so eloquently described to us yesterday morning, clearly this burden falls disproportionately on women. Cooking, firewood collection, food processing, water hauling - this is productive work, this is necessary work, but it is unpaid work, it does not enter the market. It is not recorded either in national accounts or in energy balances.

So energy poverty has a gender bias in rural areas.

Another gender-poverty linkage: women-headed households. This table shows the high percentage of households headed by women throughout the world. The figures are regional averages; in some countries they are much higher. In Botswana, for example, 46% of households are female-headed. Women-headed households are poorer than male households, and they are more vulnerable to energy scarcity. Certainly if we look at that 25-50% of households who cannot afford solar home systems, even with credit, a disproportionate number are likely to be households headed by women.

Market demographics of renewable energy

Now that we have talked about some of the ways that the market can fail to provide access to energy for the poor and for women, let's talk about what the market can do. What are the market demographics of renewable energy and women? Some of you may have noticed that women are different from men (I refer here of course to their energy consumption!). *Women use energy differently than men.* They have different energy needs, too.

For example, this overhead shows the different home lighting and connection point preferences of women and men in a biogas village power project in Ghana. I would like to make a couple of points here. First, women want to use home lighting to make their work easier and more productive - both their domestic work and their income-earning work. Remember, many of women's income-generating micro-enterprises are home-based. The income from these small-scale, part-time activities is often absolutely critical for their families' survival. But like women's domestic work, these income activities are not highly visible -

[1] Thanks to Barbara Farhar of NREL for this overhead, using some of my data but presenting it in a much "sexier" way.

women often don't go to a workplace, they are weaving while taking care of children, or preparing foods to sell at the same time that they cook the family meal and so on. Women work at home in spurts when they have time, often after the children are in bed. They need light where they work. One bulb in the living room may not meet those needs.

Men on the other hand, in this case at least, are mainly interested in the entertainment value of electricity. We see this too in unelectrified areas. Have you ever seen a woman taking a car battery used to run a television to be recharged? Men do this. Men also are - not always but usually - the purchasers of batteries for radios, and batteries are often a major household energy expenditure.

Of course these electricity needs could be different in other areas (in another example I have from a South African township, men are also interested in income-generating uses of electricity), but I think this example is interesting to illustrate that there can be real differences between women's and men's energy needs.

What about cooking?

What about cooking? This is women's energy need *par excellence*. Cooking is time- and effort-consuming. We worry a lot about the burden of fuel *collection* on women, but fuel collection, even in very fuel-scarce areas, takes maybe 1-2 hours per household per day. And at that level of scarcity, men are probably also participating in fuel collection, as well as women.

But *cooking*, and food preparation, and cleaning up - remember, cooking with biomass fuels is *dirty*, too - the cooking activity takes 5 or 6 hours/day, and this is virtually all done by women in every culture. Of course, there are the negative health impacts on women and children, too.

Cooking is also, I would like to point out, a very large share of household energy consumption, and *the largest single rural energy use in low-income countries*. It is even larger if we include women's micro-enterprises, where food processing and other energy-intensive activities make up a considerable proportion of informal sector energy consumption.

This means that, *unless cooking needs are addressed, positive impacts on carbon dioxide emissions, on deforestation, and on women's health and time will be fairly marginal.*

And *electricity provision does not address rural cooking needs* in most cases. In particular, most decentralized electricity systems cannot address cooking needs at reasonable cost. Now I wanted actually to talk a little about the potential for electric cooking, but not wanting to be responsible for any engineers having heart attacks so early in the day (yes, electric cooking is thermodynamically inefficient and expensive to use, but even rural women in developing countries like it and in some cases, use it), let me just mention one point here. A few people are working on low wattage and low-cost electric irons, burners, kettles, someone yesterday brought up DC appliances: How about focusing *more* technology research on these end-use appliances that women are interested in?

What high priority needs of rural women could be met by electricity?

There are however other energy needs that rural women have, that can be met by electricity, such as:

- saving labour in water collection by energizing water pumping;

- saving labour and time in cooking where feasible, e.g. with excess output from small hydro, perhaps with low-wattage, low-cost appliances;

- saving women's time and labour in agricultural processing such as grain grinding, rice hulling and oil extraction.

- improving security and women's ability to participate in community and school activities at night, with street lighting;

- making women's domestic work easier and improving the productivity of women's income-earning work through home and commercial lighting, refrigeration and key appliances like blenders and irons - with connection points, naturally, in the places around the house where women work; and

- improving women's and family health, through water purification, and perhaps in innovative ways like solar-operated fans to remove smoke from kitchens.

Of course there can be many others, but those mentioned above are certainly among the priorities for many rural women. There are many elements to meeting these needs: technology research and adaptation aimed at women's needs; targeting women in marketing and extension; ensuring complementary infrastructure to enable energy to increase productivity; and empowering women to use energy to improve their status and confidence, among others. One of the most important, though, is undoubtedly guaranteeing women's equal access to credit.

Women need credit

One of the key areas for enabling women's participation in renewable energy is credit and finance. We are hearing a lot at this meeting about measures to ensure affordability of renewable energy, including credit. Women need credit for renewable energy: first as end-users, to be able to afford labour-saving technologies and appliances; secondly to improve energy efficiency and profitability and save labour in their micro-enterprises; and thirdly, perhaps as energy entrepreneurs who could sell and maintain renewable energy technologies. The latter two are especially important, because we know that women use additional income from their enterprises for food, for school fees, for clothes for their households.

There are several arguments, summarized recently by Amulya Reddy in ***ENERGIA News***,[2] for women logically being appropriate renewable energy entrepreneurs for household and small-scale industry:

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[2] The quarterly newsletter of ENERGIA, the International Network on Women & Sustainable Energy, c/o TDG, P.O. Box 217, NL-7500 AE Enschede, The Netherlands, <www.energia.org>.

- women are users of these devices, so they may be more sensitive to customers' desires, e.g. women potters produce and market 11,000 stoves annually in West Kenya;

- women are effective entrepreneurs with a good credit record, e.g. in 1996, 94% of Grameen Bank borrowers were women, with a 98% repayment rate;

- women can more effectively market to women, e.g., the Vietnam Women's Union is promoting solar home systems and collects payments.

To this we should add too the important point that Ambassador Spearman made yesterday, that women are often more effective in maintenance and repair than men are. There is a long and well-documented successful experience of involving women in hand pump maintenance in the water sector, and we are starting to have some positive anecdotal evidence on women being effective in maintenance of solar home systems and biogas plants too. As Ambassador Spearman pointed out, one reason is because women are less mobile than men, they tend to stay in the rural area where they receive training, and not to take those skills off to urban areas.

What kinds of financing programs have been successful in providing micro-credit to women? This overhead gives information assembled by Women's World Banking on business credit for women. Poverty-focused programs within commercial banks; poverty lending banks; non-governmental organizations; and affiliate network institutions have been most effective. As you can see, some of the portfolios are quite substantial, in the multi-millions of US dollars. Some of these programs have quite a high proportion of women participating, and some target only women. The average loan size is in some cases in the right order of magnitude for solar home systems, for example. And the repayment rates are quite high, mostly in the high 90s percentiles, much better we might note than figures we have been hearing lately from some major commercial banks with more conventional portfolios. We should note too that these repayment rates refer not only to women, but to the total portfolio of low-income borrowers in these micro-credit programs.

What are some of the factors that make these credit programs accessible to women?

Frequent and flexible repayment schedules, alternative collateral requirements, low transaction costs (in money and time), an informal banking atmosphere where women are respected, simple loan application procedures to accommodate illiteracy, and the use of information channels accessible to women, are all factors that have been found to favor access by women to credit programs (UN, 1995). Many of these factors favor low-income borrowers as well.

For example, conventional credit programs require land or property as collateral, which women often don't have; frequently they require a male member of the household to co-sign a loan. Alternative collateral like jewelry, that women have, or solidarity groups that guarantee repayment through social intermediation (as just described by Grameen Shakti), can facilitate women's access to credit.

Other design characteristics that contribute to women's access to credit have been identified in South Asia as (Bennett and Goldberg, 1993):

- Training services that recognize the economic constraints and cultural barriers faced by women clients;

- Incorporation of women staff members in both promotion and delivery of project services; and

- Use of community networks and self-help groups.

Some recommendations on gender and village power

First, there is so much that we don't know because we do not have information by gender. If you take one message home from this presentation, please take this one: disaggregate by gender. I think you will discover some very interesting and useful findings when you look separately at the differential activities, roles, preferences, constraints, participation, and access by women and by men. Though we often focus on women's needs because these have been neglected in the past, probably there are gender issues that relate specifically to men's roles and needs, too, that should be explored.[3]

In addition to analysing separately what women and men do, it is important to look at the ways they work together in energy activities such as construction and maintenance and household decisionmaking. The interrelationships between men and women in community and other organizations also bear examination.

We talk about the market demographics of renewable energy: how are we going to provide rural energy products if we don't know who our customer, who our client is, and how to best target HER? I would like to issue a challenge right now to each and every presenter that follows, to disaggregate by gender in their presentation.

We need to know for example, in market surveys, are women or men the customers? I was interested to see in Richard Hansen's talk yesterday that all the SHS customers he showed in the slides were women. If the customers are women, do they have access to cash income that will allow them to purchase the energy system? Who controls the income and who makes the decision in the household to purchase energy appliances? We have to think of how to structure credit programs so they will be accessible to women.

We have a session on financing. Tell us, what share of your loan portfolio is made up of women and what share is men? What are the repayment rates for women and for men? We know that women have an excellent credit record in micro-credit schemes generally; is the same true for renewable energy financing?[4]

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[3] For example, in some areas men are more interested than women in street lighting, because they go out more at night and are victims of violence more; men often put a high priority on children's studies; men tend to use electricity for small tools operation in income-generating activities and therefore need higher wattages; and the common initial PV application of lighting and entertainment uses in drinking establishments in remote villages could encourage an increase in male alcohol consumption and absence from the household.

[4] One of the few renewable energy credit programs to target women is in the Indian Renewable Energy Development Agency (IREDA). Although in operation just over a year, preliminary evidence suggests high repayment rates by women.

Later today we are talking about the role of electric utilities in rural electrification, power supply options, and service models. What have been the impacts of these approaches on women and on men, what have been the benefits? I would like to see disaggregated data on benefits, not just on the number of installations or amount of loan disbursements.

Second, renewable energy projects and technology research need to specifically address women's needs for labour-saving, for time-saving, for improved health, for security, and for income. Women use energy differently than men, and they have different energy needs. Electricity can meet some, but not all of these needs. Cooking is women's most critical energy need. It is also the *only* household energy use whose replacement is going to have any *significant* impact on carbon dioxide emissions and global climate change. Please, with all due respect, stop telling me that solar home systems are going to decrease deforestation or reduce global warming. It just ain't so.

Thirdly, we need to ensure women's equal access to credit and training in village power projects. Larry Flowers [International Programs, NREL] put up a list yesterday of institutional factors that are constraints to renewable energy promotion - credit, training, cultural factors, and so on. All of these constraints are exacerbated for women. Women are less literate than men, they have less access to credit, less access to information, etc., etc. So we need specific approaches to reach women.

There has not been much time today to talk further about access by the poor to renewable energy. We may notice however that the poor (in addition to more often being women) generally share many characteristics with women: a lack of disaggregation of access and benefits of energy technologies targeted to them; a high proportion of total energy used in cooking and meeting basic needs; inequitable access to credit and education; and so on. Hence many of the approaches required to reach women will also facilitate access by marginalized groups generally to renewable energy.

Fourth and finally, we have been talking a lot about partnerships. We need to build alliances and create a dialog between renewable energy and gender, at the research level, at the planning and programming level, and at the political level. There are some interesting recent initiatives to do this, such as ENERGIA, the International Network on Women and Energy, where a quarter of the 1000 members are men. Energy programs, such as UNDP/SEED and NREL, are also initiating activities on gender and energy.

The political element was mentioned several times yesterday. Women are a powerful force for social change, and renewable energy is about social change. Women have been highly commited and politically astute, at the forefront of the anti-nuclear movement, the peace movement, the ecology movement globally: there is an obvious congruence of interests around renewable energy. We need to build these partnerships.

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GENDER AND POVERTY CHALLENGES

IN SCALING UP RURAL ELECTRICITY ACCESS

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Paper Presented at
VILLAGE POWER '98
Scaling Up Electricity Access for Sustainable Rural Development
6-8 October, 1998
World Bank, Washington, DC

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SUSTAINABLE RURAL ENERGY DEVELOPMENT:

1. EQUITABLE GROWTH - FOR *ALL* BUT ESPECIALLY FOR *POOR AND WOMEN*

2. ENVIRONMENTAL PROTECTION/REGENERATION

3. SELF-SUFFICIENCY (INSTITUTIONAL AND FINANCIAL

1990S GLOBAL ENERGY AGENDA

OBJECTIVES:

1. Reduce carbon dioxide emissions to meet Kyoto targets.

2. Increase energy for growing populations and higher incomes.

SOLUTIONS ARE TECHNICALLY MATURE & COMMERCIAL:

1. Energy efficiency

2. Renewable energy

HOW?

Commercial, market approaches.

Overcome market barriers

WHAT ABOUT THE POOR? THREE APPROACHES:

- ♦ ENSURE ACCESS BY POOR THRU SUBSIDY OR COMMUNITY APPROACH?

  - energy key to livelihood strategies

  - equity: with irregular/unreliable incomes, poor can't invest in more efficient appliances or buy in bulk = poor pay more for energy

  Problems:

  - subsidies may not be sustainable

  - community/NGO approach is risky, time-consuming, input-intensive

- ♦ OFFER CREDIT, OVERCOME MARKET CONSTRAINTS?

  - most optimistic credit scenario for SHS: 50-75% of rural households (still leaves 25-50% without electricity)

  - possible perverse effects: debt, increased household energy expenditures, loss of investment

- ♦ IGNORE THE POOR - THEY CAN'T AFFORD RURAL ELECTRIFICATION?

  - let rich take risk of new technologies

  - some poor will finance thru gifts, remittances, savings societies

Time allocation to survival activities among women and men (hours per day)

Activity	Indonesia	Burkina Faso	India	Nepal
Firewood collection				
Women	0.09	0.10	0.65	2.37[a]
Men	0.21	0.03	0.57	0.83[a]
Water hauling				
Women	0	0.63	1.23	0.67
Men	0	0	0.04	0.07
Food processing				
Women	2.72[b]	2.02	1.42	0.70
Men	0.10[b]	0.17	0.27	0.20
Cooking				
Women	-	2.35	3.65	2.10
Men	-	0.01	0.03	0.38
Average total work time				
Women	11.02	9.08	9.07	11.88
Men	8.07	7.05	5.07	6.53

[a]Includes grass and leaf fodder collection.
[b]Includes cooking.

Sources: Tinker, 1990 and Hotchkiss, 1988, in Cecelski, 1995.

Women-headed households, 1990 census (%)

Developed regions	**24**
Africa	
Northern Africa	13
Sub-Saharan Africa	20
Latin America and Caribbean	
Latin America	21
Caribbean	35
Asia and Pacific	
Eastern Asia	21
South-eastern Asia	18
Western Asia	12
Oceania	17

Source: UNDP, 1995

Home Lighting/Connection Point Preferences of Women & Men, Biogas Village Power Project, Ghana

Women	Men
Kitchen (for preparing food)	In front of house (for entertaining friends, cards)
Work room (for working on income-generating activities at night)	Music/TV
Back of house by bathroom (for bathing children at night)	

Source: W. Ahiataku-Togobo, Ministry of Mines & Energy, Accra.

WHAT ABOUT COOKING?

- Women's largest single energy use
- Time-consuming (5-6 hours/day compared to 1-2 for fuel collection)
- Negative health effects (respiratory & eye diseases)
- 80% of household energy consumption and largest single rural energy use in low-income countries.
- Unless cooking needs are addressed, positive impacts on deforestation, women's health & time will be minimal.
- Electricity does not address rural cooking needs.

Options for meeting cooking needs in rural electrification programs:

- Encourage electric cooking with excess hydropower (China, Nepal)
- Develop low-wattage and low-cost appliances (cookers in Nepal, irons and kettles in South Africa)
- Promote non-electric options along with electricity (SHS/improved stoves in Guatemala, gas burners/cylinders by ESKOM in South Africa)
- Adequately resource now-marginalized household energy programs as part of integrated rural energy planning

High priority needs for rural women that could be met by electricity:

- Drinking water pumping and purification
- Cooking where feasible e.g. small hydro, low-wattage appliances
- Food/agricultural processing e.g. grain grinding, oil extraction
- Security - street & home lighting
- Home lighting in work and study areas

WOMEN NEED CREDIT

- Access to credit: A barrier to renewable energy technologies, exacerbated for women.

- Women receive only about 10 per cent of credit from formal institutions.

- Women need credit for renewable energy:
  - as end-users
  - in micro-enterprises
  - as energy entrepreneurs

- Women use additional income for food, school fees, clothes for the household.

- Women have an excellent repayment record (90-100% in micro-credit programs).

Women may logically be appropriate renewable energy entrepreneurs for household and small-scale industry because:

- Women are users of these devices so may be more sensitive to customers' desires e.g. women potters produce & market 11,000 stoves annually in West Kenya

- Women are effective entrepreneurs with a good credit record e.g. in Grameen Bank 94% of borrowers are women, with 98% repayment rate (1996)

- Women can more effectively market to women, e.g. Vietnam Women's Union promotes solar home systems, collects payments

Business credit for women, 1993 data

	Portfolio (million US$)	Women clients: Per cent of total	Women clients: Per cent of portfolio	Average loan size (US$)	Repayment rate (%)
Commercial bank programmes					
BRI/KUPEDES Programme, Indonesia	1122.5	23	21.9	720	98
BPD/BKK Programme, Indonesia	-	60	-	60	80
Poverty lending banks					
Grameen Bank, Bangladesh	311.08	94	90	158	87
Self-Employed Women's Ass'n (SEWA), India	0.462	100	100	263	97
BancoSol, Bolivia					
Non-governmental organizations					
ADOPEM, Dominican Republic	1.590	100	100	750	95
Kenya Rural Enterprise Programme	1.872	63	61	254	95
Credit Union Association, Ghana	0.254	30	-	-	-
Affiliate network institutions					
FINCA International, Washington, DC	13	96	-	100	97
ACCION International, Washington, DC	200	54	-	489	95
Women's World Banking global, New York	-	97	-	300	96

Source: Women's World Banking in UN, 1995.

Credit programmes accessible to women have:

- Frequent & flexible repayment schedules
- Alternative collateral requirements
- Low transaction costs, in money and time
- An informal banking atmosphere where women are respected
- Simple loan application procedures to accomodate illiteracy

Design characteristics that contribute to women's access to credit:

- Training services that recognize the economic constraints and cultural barriers faced by women clients.
- Incorporation of women staff members in both promotion and delivery of project services.
- Use of community networks and self-help groups.

RECOMMENDATIONS FOR VILLAGE POWER

1. Disaggregate & analyse by women and men, e.g.

    * market surveys
    * loan portfolios
    * impact evaluations
    * stakeholders

2. Address women's needs for labour- and time-saving, security & income, especially:

    * cooking
    * water pumping & purification
    * street lighting
    * home lighting where women work
    * agricultural processing

3. Ensure women's equal access to credit & training in village power projects.

4. Build alliances between renewable energy organizations & women's organizations.

11:30-13:00 **Panel Discussion: Role of Electric Utilities in Rural Electrification**
- *Chair, Allan Hoffman, U.S. Department of Energy*
•Good Practices in Grid-Based Rural Electrification - *Doug Barnes,World Bank*
•Decentralized Rural Electrification - *Wolfgang Mostert, Consultant*
•Utility Challenge for Distributed Generation - *Carl Weinberg,Consultant*
•Utility Response:.
- Edison Technology Solutions - *Jim Reilly*
- EJSEDSA in Argentina - *Daniel Angel Sandoval*
- South Africa ESKOM - *Thulani Gcbashe*
- Arizona Public Service (APS) - *Peter Johnston*
- NRECA - *Pete Smith*

Best Practices and Grid Rural Electrification

Preliminary Evidence from Selected Case Studies

Doug Barnes

The World Bank

Reason for Examining RE

- Failures have been highly publicized
- Successful programs provide lessons that often are not replicated by new programs
- Pace of reaching 2 billion people remains painfully slow
- Presentation: Focus on dealing with problems faced in expanding service, not on benefits
- Renewables face many of same problems

RE ProblemsTo Be Solved

- Rural areas involve dispersed populations and difficult terrain
  - High capital costs (requires capital subsidy/cross subsidy?)
  - High operating costs (bill collection, line maintenance, etc.)
- Customers are often poor
  - Customers cannot afford full upfront lump sum connection costs
  - Low load and poor load profiles (evening only, low load)
- Political interference in operation of rural distribution company
  - Distortion of electrication extension plan
  - Interference with pricing, bill collection, disconnection policy

RE ProblemsTo Be Solved

- Main power companies have institutional difficulty meeting special demands of rural distribution
- Local community level problems often are not addressed (right of way problems, potential theft, lack of bill payment, lack of knowledge of potential uses, etc.)
- Power sector reform poses unique problems for rural electrification--potential for skimming the cream and leaving rural people without service

Draft Case Studies Completed

- Thailand--Gov initiated. WB Supported
  - 80-85% of rural HH have electricity
  - Regional distribution company financially viable
- Costa Rica--USAID/NRECA assistance
  - 85% of rural HH have electricity
  - Coops developed when private sector would not enter.
- Ireland--Some of same problems as Dev. C.
- Philippines--Initial USAID assistance
  - Successful cooperatives out of 119 cooperatives

High Capital Cost of RE

- Cost Rica--Concessional borrowing, low cost system design (single phase), and consumer connection fees
- Ireland--Capital grants, fixed charged on bill rather than connection charge, low cost design (three Phase backbone with single phase distribution)
- Thailand--Concesional borrowing, cross-subsidies from bulk power rate, standardized procurement

High Operating Cost of RE

- Philippines--actively minimize losses, high tariff, barangay bill collection (meter banks), urban areas are in service territory, cross bulk power subsidy for isolated island systems
- Thailand--actively minimize losses (especially theft), high bill collection rate through village leaders, cross subsdidy from urban to rural due to nationwide tariff, also bulk tariff cross subsidy
- Ireland--After initial capital grant subsidy for system expansion, system required to be financially viable

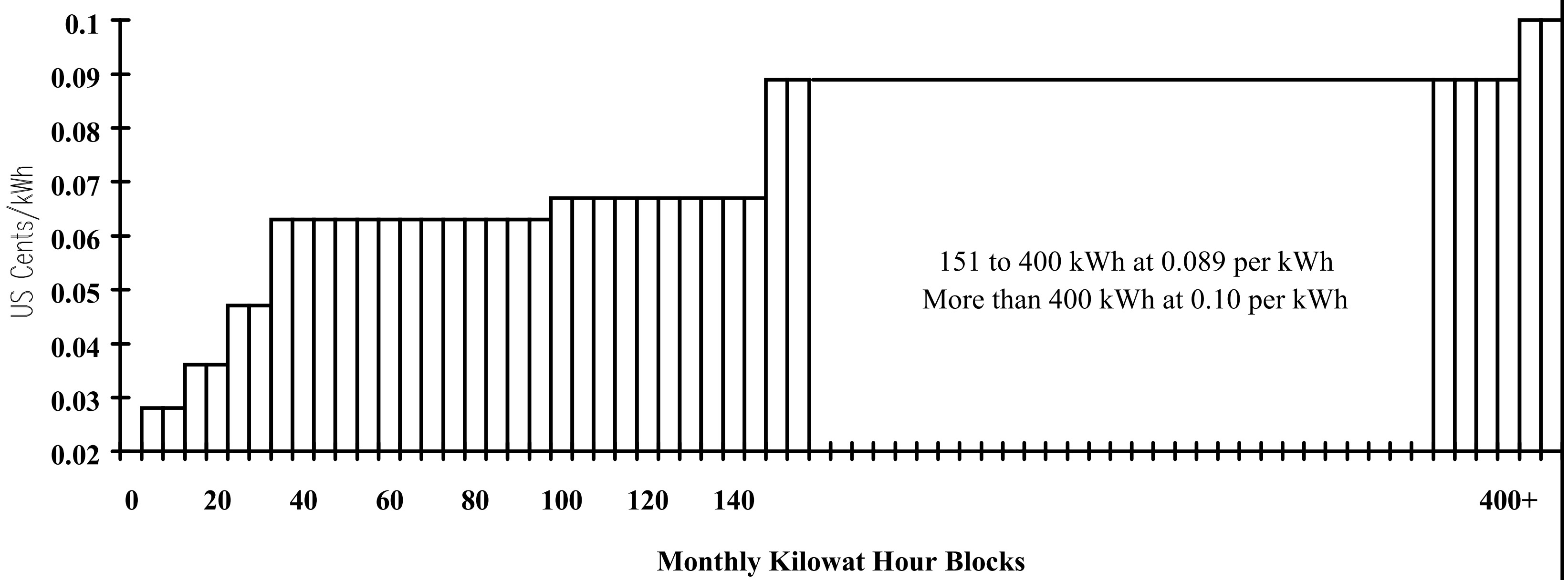
Customers Are Poor

- Rural people cannot pay full upfront costs
  - Ireland--No upfront costs for rural customers but fixed charge on regular bill (interest on capital, loan repayments, depreciation and administrative costs)
  - Costa Rica--Require up-front payments for service drops, but charge was same for group; tariffs contain capital charges
  - People can afford greater upfront costs than normally assumed
- Low load and poor load profiles
  - Thailand--careful system extension planning prioritized high consumption areas, encouraged productive loads, load promotion, lifeline rates based on load profile (ie less than 25 kWh)
  - Philippines--Accepted low load and charged high tariff

Example: Thailand's Rate Structure

Figure 6-1 Residential Tariff Schedule (in US Cents)

Tariff schedule includes a fixed charge and the increasing block rate:
< 150 kWh a fixed charge of US Cents 20 for first 5 kWh or less;
> 150 kWh a fixed charge of US$3.56 for the first 35 kWh or less



Political Interference

Distortion of electricity connection plan

- Thailand--Developed objective selection criteria to rank villages, allowed communities to jump to higher rank if they paid for part of village connection charges, village selection plan was included in national economic development plan
- Costa Rica--Standard procedures for least cost expansion overseen by regulatory agency, customers have to pay for extension cost if too far away from system
- Ireland--Priortized the parishes based on system proximity and the proportion of households willing to take a connection, little political interference

Institutional Issues: Focus on Solving Problems

Main power companies have difficulty with special demands of RE: Special institutions focused on problem solving

- All case studies countries had special institution for RE
- Thailand--Office of Rural Electrification in PEA which dealt only with distribution. It also had its own budget and could raise grants and loans for distribution
- Costa Rica--Development of rural cooperatives specializing in distribution. They could raise their own funds through loans and grants.
- Ireland--Rural Electrification Office for implementation with separate accounts budget (including 50 percent capital subsidy). There was a career structure for RE Office. Once system was built Rural Electrification Office turn the system over to ESB for serving the customers

Community Level Problems

Local community ownership to avoid right of way problems, theft, vandalism, low load development, etc.

- Thailand--Community meetings concerning electricity plan well before electricity came to community, local leaders to collect bills and report problems, had community agree to provide right of way and settle disputes internally
- Ireland--Rural electrification committee formed in advance of electricity (Parish priest, school teachers, etc.) to do preparatory work and problem resolution.
- Costa Rica--Cooperatives used rural electrification committees for community laison. People are automatically members of the cooperative when they pay for their service initiation. Programs to explain service options, meeting on time schedule, construction issues, etc.

Power Sector Reform and RE

- No experience yet from case studies
- Eliminates the possibility of cross-subsidies unless service territories contain both urban and rural areas
- Limits coverage to regions that will be profitable?
- Protection needed for poorest households? (low access charges, lifeline rates, low cost wiring, etc.)

Conclusion

- ??????

Scaling-up Micro-Hydro, Lessons from Nepal and a few Notes on Solar Home Systems

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Wolfgang Mostert [1]

1. Introduction- Definitions

Small-scale hydropower in Nepal is divided into *micro-hydro* (<100 kW), *mini-hydro* (0.1-1 MW), and *small hydropower* plants (1-10 MW).

The *small hydropower plants* are usually connected to the national grid and are often privately financed and owned. Scaling-up small hydropower means to develop proper regulatory frameworks for independent power producers (IPPs) and to streamline the licensing and concessions systems for the use of water rights for power production and other competing purposes (irrigation, agricultural uses, potable water).

Mini-hydro plants are connected to the national or to an isolated grid. They can be developed and owned by the national power company, the community or by private investors. Scaling-up the use of mini-hydro for connection to the national grid is similar to the small hydropower, scaling up its use for isolated grid is similar to micro-hydro, which is discussed below.

Micro-hydro comprises not only "grid-connected plants for village electrification [2]", but also "mechanical-purposes only" plants and "mechanical cum electricity add-on [3]" systems.

2. Micro-Hydropower in Nepal

In Nepal, 85 percent of the population lives in rural areas. The *national electrification rate* is 13 percent, but above 80 percent in the cities. The low electrification rate provides a large market to se served by micro-and mini-hydros and by solar home systems (SHS). The power forecasts prepared by NEA (Nepal Electricity Authority) foresee that 30 percent of national households will be connected to the grid by the year 2020. Urbanisation is one causal factor. *Rural electrification* develops mainly via the extension of the national grid in the Southern Lowlands, the Terai, where

[1] The paper is based on insights gained by the author working as consultant to DANIDA for the preparation of the first five-year "Nepal Energy Sector Assistance Programme 1999-2003".
[2] The term "pico-hydro" has also been used for the very smallest of plants, which are currently being standardised and marketed under the term "peltric sets". These are produced in the range of 0.5 to 3 kW to cover the demand for electricity of a few households.
[3] The term "Add-on" is used for the case that a generator is connected to the turbine of an agro-processing unit, normally by a belt drive. The turbine is then used for agro-processing during the day, and for electric light generation during the evening/night.

40 percent of the national population will live around 2005. In the more inaccessible Hill and Mountain regions rural electrification takes place primarily via isolated grids.

Nepal has a feasible hydropower potential of around 80 GW. The political and expert opinion concerning the best strategy for the exploitation of this potential and the promotion of national electrification is divided into two camps. One side argues for the development of large-scale hydropower destined for exports to India with attached national grid electrification. Others argue that the primary focus of hydropower policy should be on the development of micro-hydro power. The latter technology is said to be relatively low cost, to rely on nationally manufactured technology and be well suited to provide power to the population in the isolated hills and mountain regions.

With regard to the preconditions for a successful promotion of micro-hydro, Nepal has potentially a lot going for it on the sides of supply and demand. 63 of Nepal's 75 districts have potential for hydropower. With the help of INGOs since the 1970s, Nepal has succeeded in building up an interesting manufacturing base capable of manufacturing or assembling all micro-hydropower components except the generators for micro-turbines up to 300 kW. The Government supported the development of micro-hydro on a stop-go basis through various technical and financial support programmes ever since the 1980s. At present, the Government budget provides a 75 percent subsidy to the electrical equipment parts of investments to micro-hydro projects in districts defined as being very remote, and 50% of electric equipment costs in other districts. This amounts to 20-30 percent of the total investment. Turbines, penstocks, waterways etc. are not subsidised under the budget line, but village electrification schemes have squeezed additional subsidies out of donors and development funds. The subsidy rates are now being reviewed by HMG, following a proposal to increase subsidies to 50% of total plant cost.

Originally, NEA was entrusted with the task of planning and implementing small isolated grid projects. The public sector has set up 35 of the *36 mini-hydro plants* mainly to supply district head quarters and market centres; five plants are connected to the national grid. Most of the mini-hydro plants connected to isolated grids are owned and managed by NEA. But NEA has realised that its cost structure and approach is too expensive for mini-hydro projects, and has withdrawn from mini-hydro. NEA has leased five of its isolated grids to private operators, and the development of new isolated grid projects is left to local private / municipal initiative. However, the ideal organisational model for local ownership and operation of isolated grid systems has not been identified yet. The installed capacity of micro-and mini hydropower can be seen below, which shows the modest use of micro-hydro for electricity generation.

Installed Micro-and Mini Hydropower in Nepal

Technology	Total number	Mechanical purposes	Add-on electricity	Electricity only	Installed capacity
Ghatta [1)]	25,000(350[5])	25,000	1	0	12 MW
Peltric sets [2)]	250			250	0.25 MW
Micro-turbine[3)]	950-1000	800	150	30	9-10 MW
Mini-turbine [4)]	36			36	8.5 MW

1) Traditional water mill. 2) 0.5 to 3 kW integrated turbine and generator sets, 3) >100 kW, 4) 100-1000 kW; the number of mini-turbines mentioned in the literature ranges from 20-36. 5) "Improved ghattas" that are installed.

Nepalese legal Provisions on hydro-power development provide a number of fiscal and administrative incentives for plants with a capacity less than 1000 kW:

- No licence is required for conducting surveys or for building and operating plants. For plants between 100 kW and 1000 kW, a notice shall be given to the concerned agency before commencing work on the project.
- No royalty shall be imposed on the electric power generated.
- Exemption of income tax is granted.
- The private producer may itself fix the selling price of electricity.
- In case a licensee is going to distribute electricity in an area where a plant smaller than 1000 kW is already generating and distributing electricity, the licensee is obliged to purchase the existing plant and distribution system, if the owner wishes.

Although NEA has withdrawn from providing support to micro-and mini-hydro development, there are still a number of important *institutions that support initiatives in the sector:*

Public institutions:

- *WECS*, the Water and Energy Commission Secretariat, under the Ministry of Water Resources, has provided an inventory of approximately 200 potential sites for MH, meant as assistance to developers [4]. The objective is to identify the 10-15 most viable micro-hydro power sites in each of the 63 districts having potential.
- The Alternative Energy Promotion Centre, *AEPC*, was formed late 1997 as an institution to promote development and monitor activities within the alternative energy sector, including Micro Hydropower [5].
- The Remote Area Development Committee, *RADC*, has been given the task of establishing MH plants at selected sites in certain districts at or near the border of Tibet, designated Very Remote Areas, under the "Integrated Rural Community Development through Village Electrification Program" [6].

[4] The practical usefulness of the inventory appears to be limited.

[5] AEPC is not yet fully operational. Danida provides institutional strengthening support to AEPC by special funding.

[6] Faced with feasibility studies that showed the projects to be neither economically nor financially viable, the reaction of the government has typically been "we do it anyhow in order to maintain a regional balance of service for reasons of equity".

INGOs and NGOs

- United Mission of Nepal, *UMN*, has promoted the build-up of manufacturing capabilities in micro- and mini hydro-turbines by founding local manufacturing firms and by providing technical assistance to users and manufacturers through the company DCS-Development Consultant Services, founded by UMN.
- *ICIMOD* - International Centre for Integrated Mountain Development and ITDG, Intermediate Technology Development Group, (active in Nepal since 1979) provide conceptual and policy-making contributions.

International donors

- *Swiss* bilateral aid - through Swiss Association for Technical Assistance (SATA), Swiss Development Corporation (SDC) and the Swiss Foundation for Technical Cooperation (Swisscontact) - has been involved in developing village-based isolated grid schemes.
- *German* bilateral through GTZ (Gesellschaft fur Technische Zusammenarbeit) and German Development Service (DED) has identified options for private financed mini-hydro power projects for production to the national grid. DED supports the RADC programme. The result is published in the form of a "Master Plan".
- *Danish bilateral aid*, Danida has included support to micro-hydro development as one of five components in its 1999-2003 Nepal Energy Sector Assistance Program.
- *UNDP* is involved in mini- and micro hydro through the Rural Energy Development Programme (REDP). The REDP is active in ten rural districts. It encourages the individual District Development Committees (DDCs) to establish a district level authoritative office for promoting decentralised bottom-up rural energy planning and to create a District Energy Fund. At the village level, the REDP promotes the establishment of community organisations (COs) of male and female separately. The REDP has conducted technical feasibility surveys of more than 80 micro-hydro sites in the first five districts it was active in, and found 42 sites technically feasible.

Yet despite all support, progress is not satisfactory. Investments in new micro-hydro plants are stagnating or falling and existing plants experience operational and institutional problems. A study on the functional status of MH demonstrated that:

- 75%-80% of the plants had loans overdue
- Some 30% were not operating for a variety of reasons
- Poor site selection, inadequate/inaccurate surveys, wrong size, poor installation, faulty equipment.
- Plants affected by floods and slides.
- Poor estimation of hydrology. Surveys conducted in the rainy season is one reason.
- Uneconomic canal length, bad canal design
- Civil works usually neglected.
- After breakdown of generator, many owners had not been able to replace it.
- Wrong estimation of raw materials, of demand, of end use possibilities, oversized plants, over-estimation of tariff collection, inappropriate rates, ignorance of competition with diesel

- The plant factor of micro- and mini plants is 0.2 on average. Lighting for 4-5 hours can theoretically give maximum plant factors in the order of 0.15 to 0.20. The use of one mill for some hours per day can theoretically double the plant factor, but in practice most micro-plants have plant factors lower than 0.25.

Some 11 manufacturers produce turbines, which is an impressive achievement. Anecdotal evidence, however, suggests that the quality of the equipment has declined during the last 10 years. And the cost of the equipment seems to have increased faster than the rate of inflation, a fact, which has reduced the impact of the subsidies.

During the 8th Five Year Plan (1993-98), the Government hoped that 5 MW of hydropower would be developed. The result was far below. It is obvious, that the present strategy of the Government does not lead to "scaling-up". In order to find out what can be done, it is necessary first to look at the technological characteristics of micro-hydro and next at the socio-economic characteristics of the village community.

3. Technical Characteristics of Micro-hydro

Compared to the level of development in the isolated communities, where it is introduced, hydropower represents a very advanced technology in terms of hardware and in terms of operational requirements. The three available technologies are the peltric units for single ownership, the micros for smaller communities and the minis for larger communities (or group of smaller communities). As one moves from one to other, the technical sophistication of the technology, including the demand for highly skilled manpower increases.

The civil technology of micro-hydropower plants is simpler and cheaper in terms of initial investment than in the case of mini-hydro. Dams and intakes are made of concrete in the case of mini-hydro plants, and of earth/stones in the case of micro-hydro. The civil technology allows making intensive use of "free" labour by the local community for construction and annual maintenance. This reduces the cost of initial investment, ranging from US$1200 to 2500 per installed kW in micro-hydro projects [7]. But it adds to annual O&M costs, which can vary from 3 to 50 percent of original investment - and leads to the shutdown of the plant and loss of electricity production during15-40 days per year, when intakes and canals have to be rebuild following destruction by monsoons and landslides. And although the cost of investment per kW compares favourably with large plants, the low plant factor implies that energy costs will be comparatively high for micro hydro [8].

The organisational requirements are substantial during all phases of project identification, preparation, investment and operation, and not sufficiently satisfied:

- *Site surveys and feasibility studies*. It is normal practice in Nepal that micro-turbine manufacturers perform the survey and project assessment in which the turbine and generator

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[7] More often than not there are no roads to the site - several days by foot may be the only way to reach the nearest road. Transport cost will be a be a significant part of total plant cost, up to 30% - 40% are reported.

[8] Reported costs for Nepalese mini-hydropower plants are in the range of USD 2,800 - 7,600 per kW.

capacities are decided. The manufacturer receives a nominal fee for his survey, and has to recover the actual costs in the turbine price. A manufacturer should ideally produce equipment from specifications given by others - he cannot be expected to be technically capable of performing total project assessment, nor can he be expected to be totally unbiased in his selection of turbine size. Stream flow assessment is particularly unreliable. There is a lack of data on water resources for micro-hydropower resources. Measurement technique is a problem by itself, and if made outside the dry season leads to overestimation of flow. Socio-economic aspects are not covered in detail. A too optimistic demand forecast is a frequent cause of financial problems. In village electrification projects, the assumption is often made that even the poorest of the population will at least afford one light bulb as a minimum, since they are expected to make savings on kerosene. In agro-processing projects, competition for services is underestimated.

- *Project survey*. The Agricultural Development Bank, ADB/N, in charge of financing arrangements on behalf of the government, does not possess sufficient expertise or resources to assess the projects technically.

- *Investment*. The civil works during construction (in particular intake and canal construction, but also poles and distribution lines) require to organise local labour on a "volunteer non-paid" basis in order save on the monetary cost of construction.

- *O&*M. Routine maintenance requires a dedicated and reliable daily operator:
  - Intakes for micro-hydro are nearly always of the "temporary" type, meaning that continuous (daily) maintenance and yearly (or more often) cleaning out of sand and stones in the intake pond will be necessary.
  - Sediment will enter the intake and may cause rapid erosion of the turbine runner. Chambers for sedimentation of pebbles and sand (sediment traps) are necessary. The correct design of these requires knowledge, and for successful operation they need to be inspected and cleaned regularly.
  - The design, slope and alignment of the headrace, be it a canal or a closed conduit, requires some skill in hydraulic design and an eye for topographical or geological conditions that may cause maintenance problems.
  - The forebay and/or the peaking reservoir must be be cleared periodically for sedimentation.

- *Repairs*
  - The distance from the villages to repair facilities and competent experts, who can offer inspection services, repair, advice and training is a problem.
  - The major annual repairs following landslides and monsoons demand village mobilisation.

Thus, although micro-hydro technology may be relatively simple in terms of hardware, its soft-organisational requirements are anything but simple.

4. Characteristics of the potential target group for micro-hydro

Micro-mini-hydro projects are located in rural areas at considerable distance from electric transmission lines and distribution network. Access from nearest road will be by foot or mule, with a duration of a few hours to several days. The economic conditions in the settlements vary from very poor at subsistence level to relatively well off communities at or close to popular tourist routes or trade centres. The communities can differ considerably with regard to the degree of caste homogeneity and ethnic diversity of the population.

The *household demand for electricity* in the isolated communities and *the ability and willingness-to-pay* for electricity is low. Household metering equipment is not installed in micro-hydro projects. Households pay according to the number of light bulbs they use or according to their demand for capacity - a fuse / cut-off device will typically limit the maximum demand of a household to 100 W. Monthly household charges are NRS 0.5-2 per W capacity, or NRS50-200 per month (US$0.74-2.94, or roughly US$0.05-0.20 per kWh of consumption) [9]. This is far from enough to cover the cost of supply; and although projects receive substantial investment subsidies, the revenue is often insufficient to cover the cost of O&M and repairs and to repay loans received from ADB/N. In several projects, households refused to pay agreed monthly charges, once the investment had been made. The project promoters then felt forced to accept lower and loss-making monthly rates rather than no revenues.

Lack of knowledge in *book-keeping and accounting* is a problem, which is encountered in almost all micro-hydro projects, whether the plant is for agro-processing only or is used for household electrification. Revenue above the cost of O&M is regarded as profit and treated so.

Four types of *ownership-developer models* for micro-hydro electricification were tested in Nepal:
1. Promotion, development, ownership and management by national power company NEA
2. Promotion and development by outside (I)NGO (sometimes assisted by the local district development committee), ownership and management by local community
3. Local entrepreneur builds, owns and manages the micro-hydro plant primarily for agro-processing purposes and sells electricity to community households
4. Outside (I)NGO promotes and develops the micro/mini-hydro power plant, a jointly INGO / local Government / local community owned limited liability company owns and manages the plant

No ownership model has come out as a clear winner. A clear lesson is that *power companies such as NEA* are not geared to handle micro-hydro projects. They think to big and too quality standard conscious during the design stage and their staff is too costly during the operation phase. *Individual entrepreneur* ownership has the advantage of providing a productive demand for

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[9] The 400 kW Salleri Chialsa power plant, supported by Swiss bilateral aid has a more sophisticated billing system, consisting of three components. (i) The initial connection fee increases with the amount of power allowed from NRS250 for a 100W. connection to NRS1500 for loads higher than 4 kW. This Connection fee is automatically transformed into company shares. (ii) The fixed rates for admissible power are subdivided into eight levels, from NRS50/month for the first 100W connection to NRS500 / month for the highest power level. (iii) The energy charge per kWh ranges from NRS0.9 to NRS3.0.

power with household electricity demand being an add-on. But it experiences more problems about water use rights and makes it more difficult to organise "free labour" for civil construction and for major repairs. Furnishing lighting to a larger group of customers must involve the engagement of the community in some manner, and a strong agent must be present to enforce rules. *Community ownership* calls for a long, intensive period of community awareness building (one to two years) before any infrastructure investment is made. The case system of Hindu society, as also NRECA found out during the 1970s in India, is not conducive to the establishment of electricity co-operatives. If, in addition, the community is ethnically heterogeneous, the task becomes "impossible". Only one experience with the *corporate* model exists - a mini-hydro project, which received massive Swiss bilateral support to succeed.

The agricultural development bank ADB/N provides 5 to 7 years loans at a 16 percent rate of interest to until 80 percent of the cost of micro-hydro projects. Even when revenues are sufficient to cover the cost of amortisation ADB/N experiences *problems with overdue loans* in its loan portfolio to micro-hydro projects. The relatively richer and politically best connected farmers have the worst repayment records. ADB/N has a bad image among the rural population. The dual role of ADB/N as rural technology promotion and rural credit agency blurs its role as a professional financial intermediary. The rural population's willingness-to-pay normal credit rates is negatively affected by the Government's use of ADB/N to channel direct investment subsidies and interest rate subsidies to specific materials and technologies. Corruption in the public sector is endemic in Nepal and ADB/N is affected also, helped by its near monopoly position in rural credits. ADB/N has about 670 rural offices, the two most important competing banks have 20-30 each.

It can be concluded that a number of factors on the demand side block a wider penetration of micro-hydro projects.

5. Towards scaling-up

Micro-hydro has two major built-in obstacles for scaling up:

- The technology is rather *demanding in its requirements for organisational back-up and support*. Even the simplest case of a micro-hydro, the small peltric unit, involves technology for which the owner/user may be totally unprepared. Yet, the technology is for use in isolated areas, where supporting infrastructure is expensive to build up and difficult to sustain.

- Micro-hydro is investment intensive, but low in operating energy costs compared to diesel power. Yet, the potential cost savings from low operating costs are not sufficiently compensated in the isolated regions, where lack of a productive demand for power leads to low plant factors. *The cost of production per kWh is expensive*, which, coupled with the low purchasing power of the target population, makes it difficult to identify financially viable micro-hydro projects.

It is easy to say at a general level, what the requirements are for scaling-up:

- *The quality of the* feasibility studies *needs to be improved*
- *Local energy planning* and comm*unity awareness building* must be supported
- The system of *subsidies* must be made more effective
- Official regulations must define guidelines for *tariff setting* in isolated grids
- The mono*poly of ADB/N in rural energy credits* must be broken and guidelines be developed for project appraisal and approval
- The *locally produced equipment* must be subject to standards and to quality control
- *Service centres* for technical backstopping and basic repairs must be established
- *Training* in O&M, fault identification, simple repairs, and book-keeping must be provided to entrepreneurs investing in hydro-power plants and to key staff in community owned plants
- *Productive use enhancement* must be an integrated activity in projects receiving financial support
- The *manager of AEPC*, the Alternative Energy Promotion Centre, should be offered training in the principles of modern management, participatory planning and innovative schemes for financing.

The devil is - as always - in the details and in the large scope of supporting initiatives that is required.

Feasibility studies

There is general agreement among Nepalese experts that the quality of feasibility studies needs to be substantially improved, and that this requires more qualified manpower and more subsidies. Neutral experts, not manufacturers should prepare the feasibility studies, not by manufacturers. If however, a subsidy of 75% is provided to this activity, then procedures must be defined (i) for the selection of consultants (qualification requirements or certification, training), (ii) for setting a maximum amount for the cost of the study (relating it to the number of consumers, or to plant capacity), and (iii) for splitting the remaining 25% of the cost between the local entrepreneurs / communities and the financing institution.

Support to local Energy Planning and Community Awareness Building

It is well known that a top-down approach is unlikely to result in local identification with the project. All so-called experts pay lip service to the mantra that rural projects must be based on bottom-up perceived needs and local financial commitment. The promotional efforts have, so far, been top-down, nevertheless: institutions such as WECS make inventories of potential hydro-sites after which attempts are made to persuade the local community that a micro-hydro electrification project is what it needs. The ongoing UNDP/ REDP project is a valuable exception. That project planning and development must start with resource assessment is obvious. The mistake is that the information is not fed into a local planning process, but into the project identification process of higher placed outsiders – either national institutions, (I)NGOs or donors.

The way forward is to get project proposals identified through local energy planning making use of participatory planning techniques and receiving part-financing from locally available development funds. At present, a structure for local energy planning does not exist. The Government has started on a policy for increased decentralised decision taking and financing. The District Development Committees and Village Development Committees now receive some modest funds for local development financing. But this democratization process must be further intensified, and technical assistance must be provided to the District and Village Development Committees in energy planning and in participatory planning techniques. The latter is a powerful method for awareness raising.

Direct and indirect Subsidies to Investments

Without subsidies, investments in micro-hydro will stagnate. Some micro-hydro turbines for mechanical uses will be installed every year (they are not subsidised now). But use of hydro for electrification purposes will be an exception and be almost exclusively in the form of add-on electricity and peltric units. Progress in rural electrification based on micro-hydro power requires *direct subsidies* for investments and feasibility studies and *indirect subsidies* for supporting the build-up of professional advisory and training services. The direct and indirect subsidies are mutually interdependent. Unless there is a sufficient level of investment in micro-hydro (need for subsidy), there is no economic justification for setting up elaborate supporting services.

The tricky question for subsidy design is to find adequate comprises between (i) efficient allocation of scarce resources, (ii) ease of administration, and (iii) local and regional equity.

The 50%/75% subsidy provided by the state budget to purchases of electric equipment amounts to around 25% of project cost. Communities have been able to draw on other sources of grants to increase subsidy levels to 50-80% of the cost of investment. Such high levels of subsidies are a strong indication of misallocation of resources. If the 25% self-financing share expresses the willingness-to-pay for electricity, then it is likely that villages have other investment priorities than electricity. If they reflect skilful bargaining, they represent wasteful use of scarce subsidies. The Government's subsidy support programs should prevent subsidy shopping by insisting on minimum levels of self-finance (including non-subsidised loan finance), of at least 50%.

The question has been raised whether the target of the subsidy should be extended to include the total cost of investment, that is, also the cost of *civil construction*, of *mechanical* equipment and of the *turbines*. So far these items have been excluded, as there is no commercial need to subsidise micro-hydro plants that are used for agro-processing only (distortion of competition). Due to the existence of multi-purpose plants, it was believed, that such subsidies could not be restricted to electricity generating plants, but would automatically call for including "agro-processing only plants". In fact, it has been proposed already to include these. This is not necessary. One can introduce a scheme, which pro-rates subsidies to the non-electrical parts according to the expected use between agro-processing and household electricity demand.

A much discussed issue is whether the subsidy should be given as a *percentage of total cost* or in terms of a *fixed sum per installed kW capacity* or *per connected household*. A lump sum subsidy has the advantage, in principle, that the lowest cost projects are implemented first (which presumably have the highest rate of return) and offers good transparency. The danger is that it may lead to oversizing of the plant and/or cheating with the stated capacity.

A further equity issue is whether the *extra transport cost associated with remoteness* should be subsidised. The same regions are already disadvantaged in terms of income (ability to pay for electricity). The Government operates with two subsidy rates (50% and 75%) depending on the region. That system can and should be refined, providing lump-sum subsidies to communities on the more objective basis of days of walk from the nearest road to the project site.

In many donor-supported programs, *interest rate subsidies* are provided by revolving funds. That policy should be discontinued or reconsidered. First, because interest rate subsidies introduce distorting signals into the rural credit systems. Second, because it is known from subsidy programs in general, that the incentive impact of an interest rate subsidy is lower dollar for dollar than a direct investment subsidy.

Regulations for Tariff Setting

The Government / AEPC should issue *regulations providing guidelines for tariff setting* for two reasons. To ensure the financial viability of community owned projects (adequate allocations for major repairs and for loan repayments) and to reduce tensions in tariff negotiations between entrepreneur-owners and the customers. It is easy to see from the table on page 2, that "electricity only" plants are seldom, the majority of plants used for electrification are "add-on electricity" and the peltric sets. Typically, electrification thus involves negotiations between a private plant owner-entrepreneur and the community on the tariffs. In principle, this can and should be left to market forces. However, there have been several damaging disputes about tariffs. The guidelines cannot eliminate these, but they may ease their intensity.

New Financial Intermediaries

With its 670 branches in rural areas, the ADB/N has been and is a logical collaborator in rural development programs. The ADB/N, unfortunately, is not only part of the solution it is also part of the problem. Donor programs in rural energy must look beyond the short term and make an intensive effort to develop new rural financial intermediaries. The monopoly of ADB/N must be broken, even though it costs lost time in the short to medium term.

Norms, standards and quality control

Whereas the opinion of manufacturers is divided, other Nepalese experts seem to be convinced of the need for setting up a laboratory for turbine testing and quality control. The tricky question is how such an institute can be made financially sustainable at the end of donor support. It is not likely that the institute can price its services to manufacturers on the basis of full-cost coverage without excessive consequences for the price of turbines.

Service Centres

At present, there are three service centres in Nepal for providing technical backstopping and minor repairs to turbine owners (major repairs require that the turbine is brought back to the manufacturer). Two other attempts have failed for financial reasons. The situation might have been different, if the market for micro-hydro had expanded during the 1990s, instead of contracting. But as it is, the commercial demand is insufficient to justify the creation of more centres. A proposal has been made to finance the creation of 10 more centres under Danida's Nepal ESAP. A more viable approach may be to train existing workshops in rural areas to perform such repairs and technical backstopping.

Training of entrepreneurs and of community operators

Experience has shown that entrepreneurs and operators of community owned plants need to get more training in O&M, identification of technical problems and solutions, and in book-keeping.

Promotion of Productive Uses of Electricity

The active promotion of productive uses of electricity in rural electrification projects is becoming a normal feature in developing countries. The practical results do not quite correspond to the attention, which is given to the theme. But in view of the "free ride" of increasing the plant factor in micro-hydro projects, promotion of productive uses must be an integrated part of micro-hydro projects. The potential for this can be maximised if AEPC succeeds in establishing close collaboration with agricultural irrigation and other extension projects.

Training to AEPC

The Alternative Energy Promotion Centre, AEPC was created late 1996, and became operational in the beginning of 1998. AEPC was originally conceived and supported by (I)NGOs working with rural energy issues in Nepal. The AEPC is set-up under the Ministry of Science and reports to a Board of representatives from several ministries. The original intention of including private sector and NGO representatives on the board was dropped, and the AEPC is already showing characteristics of a traditional red-tape bureaucracy. Staff stability will be a problem, as public sector salaries are very low. Yet, the AEPC was created in response to a perceived need for coordination and should be strengthened as much as possible. Staff training courses will be developed and implemented. Special care will be given to provide AEPC's manager with training in the principles of modern management, in participatory planning techniques and in innovative financing schemes. Far too often, donor provide training in energy related issues – energy economics, planning, technologies. The difficult role of AEPC, however, is to introduce proper management and coordination!

Scope of activities and the time factor

The tasks, as shown above, are very comprehensive and the resulting investment level in terms of MW will be modest. Yet, since the typical demand of the target rural households amounts to 100W at present, each cumulative MW of new capacity represents 10,000 households that have received electricity.

The message is that the promotion of micro-hydro takes time. A donor wishing to provide support to the sector should go in with a minimum perspective of 15 to 20 years, and preferably 30 years. The donor should be aware not to expect early results. The level of investment will not increase substantially until several years after the start of the program.

6. A few Notes on the Promotion of SHS in Nepal

Three local manufacturers produce 35 Watt SHS of reasonable quality, and a 50 percent Government subsidy has attracted around 6,000 applications for SHS, of which only a fraction could be satisfied due to lack of subsidy funds. The rural situation in Nepal in many ways favours the penetration of SHS:

- An important part of the population will for decades remain outside the reach of grid connected electricity.
- The productive demand for energy of this group will be low for many years to come; the low power output of SHS thus has no consequences.
- The technology is financially sustainable, as it permits consumer discrimination – only those who can afford to purchase a system will do so.
- Sustainability depends only on a satisfactory level of after-sales service from the manufacturers.

The establishment of the latter, however, calls for a minimum level of consumer demand to make investments in SHS promotion and maintenance services feasible. At present levels of income, it is believed that demand – at unsubsidised levels will be insufficient to permit an adequate development of such an infrastructure.

Assistance to the promotion of solar home systems (SHS) is another component of Danida's "Nepal 1999-2003 Energy Sector Assistance Program". The specific details of the promotion strategy are still being defined. But at present it looks, as if the component is going to have the following features (subject to change):

- Danida will finance an open-ended subsidy to purchases of SHS during a five year period with annually declining levels of support. *Market based interest rates will be combined with a lump-sum subsidy, irrespective of the size of the system*. 20W, 35W and 55W systems will be marketed. The subsidy sum is pre-fixed for each of the five years and declines every year. During the first year, the level of subsidy for a 35 W system is around 30 percent, declining to 10 percent during the last year.
- Only products of *manufacturers that provide adequate after-sales service* and that fulfil quality norms will benefit of the subsidy. Hit-and-run suppliers are unwanted.

- Technical assistance is provided for the establishment of a *solar test station* that offers technical advisory services to manufacturers of solar heaters and SHS, fixes standards for supported equipment and monitors the quality of local products.
- For equity reasons, community and social institutions will be offered SHS at particularly favourable rates. The build up of promotion and afters-sales in very remote regions may be supported financially.

The programme expects to market 5-6000 SHS per year. At the end of the five year period it is expected that market demand at that level can be maintained without further subsidies. The cost of SHS at that time will be lower, a nation-wide structure for promotion and maintenance will be in pace, and the demonstration effect of SHS in nearby homes will have a powerful motivating demand.

Since Danida's development assistance has a clear poverty focus, and the SHS benefit the relatively richer community, the question was, whether subsidies to solar home PV-systems could be justified? Proponents base the justification of the subsidy on two arguments:

- The first *is cost reduction through "pump-priming"*. The production, marketing and servicing of PV-systems are subject to economies of scale. By expanding the market in an initial phase, a minimum scale of efficiency is reached. This provides cost reductions that stimulate demand and allow the subsidy to be reduced. Pump priming helps establishing the minimum service infrastructure that allows PV-systems to provide a reasonable level of reliability.

- The second justification is *equity*. Rural consumers living in areas, where a grid is constructed, get a higher quality form for electricity and get their electricity subsidised. To give subsidies to PV-consumers puts "isolated consumers" on an equal level. That the subsidy benefits relatively richer consumers is defended with reference to the market build-up argument. Market development has to start somewhere. It must obviously start with the "richer consumers" (who are poor by industrialised world standards). The establishment of a national infrastructure in the form of local manufacturing and region-wide maintenance services leads to cost reductions. The poorer inhabitants benefit from this in the long run as it enables them to get access to the PV-systems at a lower cost and to an established structure for servicing and maintenance.

Both arguments have merits. But the equity argument is relatively weak:

- In grid based electrification, the *poor get access immediately* due to better affordability; in villages, where PV-systems enter, they get a "pie in the sky".
- Subsidies to rural electrification are not given only for social equity reasons, they also serve the purpose of enabling the establishment of a *basic infrastructure*. Going from one village electrification to the next through a gradual extension of the grid, enables the nation-wide penetration of the grid to take place. The build up of a demand for electricity in an isolated grid, generates in the long term sufficient demand to permit connection to the national grid. PV-systems are individual consumer goods. The promotion of the systems does not provide the country with a basic infrastructure apart from the service network.

- A 30% subsidy to a 35 W SHS costing NRS32,000 (US$450) reduces the annual amortisation burden of a seven year ADB/N loan (deducting a NRS5000 down-payment) from NRS6700 to NRS2700. In a grid based rural electrification scheme, a consumer with the same level of demand pays NRS2500 for the connection fee and NRS720 per year for his baseline consumption of 20 kWh/month. Assuming that the monthly bill covers roughly one third of the true cost of production [10], *the grid connected consumer receives an annual subsidy of NRS1500 which is considerably less than the annual NRS4000 given to the beneficiary of a PV-subsidy*.

- Grid based electrification takes place based on *the national least cost power expansion plan*. The reason why the target group of PV-consumers is not connected to a grid is that the cost of connecting other consumers is cheaper. The non-availability of electricity, thus, is the result of *a rational allocation of scarce public financial resources*. To jump-start the electrification process by asking for subsidies to PV-consumers on grounds of social equity can lead to a misallocation of scarce public finance.

The above did not lead Danida to a total rejection of subsidies to PV systems during a short pre-defined period. But it asked for caution with regard to the level of the subsidy and with regard to fixing the length of the period during which the subsidy scheme remains. The objective is to provide consumers with the opportunity to get access to well-serviced SHS made of good quality components and benefiting from cost reductions due to economies of scale. Whether they make use of the opportunity, or have other preferences is up to the consumer.

[10] The cost of production of a small isolated grid supplied by a micro/mini plant is guess-estimated at US$0.15/kWh = NRS8.2/kWh.

Distributed Resources and Village Power a Challenge to Utilities

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

Carl J. Weinberg

We are coming to the end of a remarkable 100 years. A time span which saw major changes in the philosophy of people, their relationship to each other and their relationship with nature. Major changes in concepts of governance and major changes in technology that continues to push, pull and shape our lives.

These changes are occurring with different speeds in different parts of the world. The Utility Industry is also changing for it is not isolated, and the changes are embedded in the major global changes taking place already this century and the major global changes that will continue to take place in the next century. A recent insert in a Fortune cookie expressed this most succinctly " The philosophy of one century is the common sense of the next".

This century was also a time span where we began to doubt that our job on this planet was to conquer nature and began to evaluate our need to live in a symbiotic relationship with nature. There were limitations on what we could do to this earth. The environment will become evermore important as we move into this next century. Hopefully, we will slowly begin to move from conquering nature to living in harmony with nature. We act when the problems are local, but dealing with when they are global is more difficult. Rapid and coordinated action between governments on Global Climate Change will be difficult

The Electrical Utility Industry will increasingly come under environmental scrutiny, as it is a major contributor to atmospheric pollution and that concern will not go away. Nature has provided us with a Faustian bargain; **providing relatively cheap fossil fuels available in some form or other for at least the next hundred years but asking us not use them since the atmosphere cannot absorb the effluents.**

The provision of electrical energy and energy services is also undergoing technological change. These technology changes are calling into question the structure and with it the delivery systems of the traditional utility. The technology is changing from the dominance of large central station constructed energy to the more modular, flexible, manufactured energy. These new technologies provides a means for electrical service to move toward the customer, in many cases to the customer's premise, and be tailored to the customer's needs and ability to pay. The conceptual model of a utility as large central station power plants connected to their customers by wires may well not be the model for the future. This is particularly true for rural populations in developing countries.

These then are the major forces;

Governance - Competition and the increased use of market based approaches.

Environment - Sustainability and increasing emphasis on environmental impacts both local and global.

Technology - shifting from large central station constructed energy to smaller more modular, flexible, manufactured energy.

The development of modular flexible manufactured energy, distributed resources, introduces new factors into the traditional analyses of costs and technology choices. Traditional cost of service is a function of large central generation (+G), transmission (T), distribution (D), and, for some utilities, large central storage (S), like pumped hydro. T and D are costs for getting the product to market. The most variable factor is the cost of central generation. Utilities therefore focused on minimizing busbar energy costs.

This cost of service equation looks like:

$$\text{Cost } (\$) = f(+G, S, T, D)$$

Service can now be provided by minimizing the total cost of service, not just the busbar energy costs. Many options are available to serve a customer. Providing either supply or efficiency close to the customer is, in many cases, the least cost of service solution. These are new factors in the cost of service equation, the distributed systems.

$$\text{Cost } (\$) = f(\pm G, S, T, D, \pm g, s)$$

+G	-	Central station power generation
-G	-	General decrease in energy intensity
S	-	Central station storage
T	-	Transmission
D	-	Distribution
+g	-	Small dispersed or distributed generation (often renewables)
-g	-	Targeted energy efficiency
s	-	Small-scale storage

The least cost of service for each customer provides a means for a broader evaluation of options including those technologies the customer chooses to include in the equation. Cost or price will not be the only values that a customer may consider.

There are three generalized situations for consideration of distributed systems, DR(±gs);

1. \$G+\$T+\$D <<< \$DR(±gs) Centralized operation based on central generation (large load centers). Cost of central generation plus the cost of T&D is much less than the cost of distributed resources (including renewables).

2. $\$G+\$T+\$D \ggg \$DR(\pm gs)$ Distributed operation (islands/villages) based on distributed resources . Cost of distributed resources is less than the cost of generation, transmission, and distribution.

3. $\$G+\$T+\$D \sim\sim\sim \$DR(\pm gs)$ A mix of resources depending on localized costs, conditions and choices (market niches).Cost of distributed resources is approximately equal to the cost of generation, transmission, and distribution.

The wholesale or commodity market is characterized by situation 1.

$$\$G+\$T+\$D \lll \$DR\ (\pm gs)$$

This market is the traditional utility market. It revolves around the development of central station generation and its associated grid. Emerging for this market is a regulated or nationally operated powerpool and open access transmission grid with private companies building the generation systems.

Situation 2 where,

$$\$G+\$T+\$D \ggg \$DR\ (\pm gs)$$

Describes the situation where there usually is no utility structure and the central station concept does not fit. It represents 2 billion people without electricity, the off-grid market, limited grid market, or the Village Power market. In this case there is a relatively unknown demand and an indeterminate ability to pay. Attempt to fit this situation into the classical utility model have not been successful, and the standard project financing models are not appropriate. Attempts to “parachute” in technologies using a standard utility approach have also not been successful.

There is also a subtle difference in approach between these two situations. In Situation 1, the centralized approach, the question is “at a given level of service what is the least cost at which services can be provided using traditional technologies”. In Situation 2, the decentralized approach, the design question is “given a cost (or ability to pay) what are the levels of service that can be provided and then expanded. The starting point of the analysis is quite different. This subtle shift in analysis starting point is difficult for traditional utilities to accept. It appears to be a radical notion. Utilities have no special expertise in this situation.

The most successful development of this market has been by Non-Governmental Organizations (NGO’s), religious and philanthropic organizations. One of the interesting developments is the private sector companies who are beginning to successfully provide energy services in this market. Private companies are beginning to provide energy services, that the rural population can afford to buy, using renewables at the point of use or at the village level.
The development of this market, as an example Village Power, is closer to business development than power project development. There is a need, therefore, that government policies to foster rural electric services deal with business development not project development.

The central focus should be to provide electrical services commensurate with the ability to pay and the capability of being expanded as need and ability to pay increase. This also suggests that the appropriate business model may be a "for profit" Franchise business model. This allows for centralized training, financing and technical backup, but localized ownership and focused products. It is a model that has more in common with McDonalds, Burger King and Kentucky Fried Chicken than large utilities, and requires different financing mechanisms than power project financing. In each of the successes it is private industry tailoring its product to the situation (market) with a profit in mind, and providing a degree of flexibility that national, regulated, or traditional utilities seldom exhibit.

Situation 3,

($G+$T+$D ~~~ $DR (±gs)

May best describe the evolving company of the future. It combines central station generation with a mixture of small storage and generation and energy efficiency programs located at specific distribution or dispersed sites. All of these situations imply a dynamic process that will be in a continual change.

Technology choices therefore feed into distinct markets. The grid connected wholesale market, where slight changes in the present utility model and project financing will continue to exist. The grid and non-grid connected markets where the present utility model and project financing are not appropriate and where the business model and associated financial instruments need to be brought into sharper focus and do not follow the traditional utility operational or decision models.

As distributed resources are challenging the traditional utility model so will the environment. Energy is a major aspect of the quality of life and has a major impact on the environment. It is becoming increasingly evident that renewables coupled with energy efficiency are important components of a sustainable energy future**.**

For a sustainable energy future there are really only three approaches;

1. High efficiency conversion of clean (low carbon) fuels,
2. Renewables and
3. Efficient use.

There are varying opinions on the ratios of the three and the emphasis. But that is all there is.

There is no silver bullet only silver buckshot.

Sustainable energy requires the increased use of the short-term flux of the sun or the heat of the earth, rather than the stored flux of eons represented by fossil fuel. The shorter the flux of the sun the more the electricity generation is dispatched by nature and not by man. The more dispatched by nature the more *radical,or disruptive,* from a central station electrical utility viewpoint, is the technology. The central station system with its associated grid requires an exquisite degree of control. Even the thought of relinquishing that control is radical to utilities

Distributed Technologies, in general, require cleaner fuel or utilize the short-term flux of the sun. Energy efficiency technologies are all self dispatched. Distributed resources are best self-dispatched or under some local control. The more dispatched by nature, self or locally dispatched, the more the technology is *radical or disruptive*.

Distributed technologies in general, are smaller and more modular. They work as well or better distributed rather then centralized. The more modular and the more distributed, the more *radical* is the technology. The more a grid is not required the more *radical or disruptive* the technology becomes. Photovoltaics, as an example, is immediately dispatched by nature, does not require a grid, and is the most modular of the renewable technologies and therefore easily qualifies as a radical innovation.

Numerous studies of technical innovation have shown that *radical or disruptive innovation has never been introduced by market leaders. (Users of traditional technologies)*.[1] *Radical or disruptive* technologies are those that result in worse performance in the short term, but offer other features which a few fringe (and generally new) customers value. *Radical or disruptive* technologies don't seem to make sense because they are usually cheaper, promise lower profits, and they target insignificant markets, and large existing customers don't want them. Sustaining or evolutionary technologies improve product performance along the dimensions of performance that mainstream customers in major markets have historically valued. (Example; Combined cycle gas turbines)

One way to characterize these differences is that sustaining or evolutionary technologies are "better, cheaper, faster" and *radical or disruptive* technologies are " a brave new world" with different characteristics and values. The real question is why did companies fail to move to " a brave new world ". In study after study, good management was the most powerful reason they failed to change. Precisely because these firms listened to their customers, invested aggressively in new technologies that would provide their customers more and better products of the sort they thought they wanted, and because they carefully studies market trends and systematically allocated investment capital to innovations that promised the best returns, they lost their positions of leadership. It was impossible for these well managed firms to allocate resources for technologies that their traditional customers did not want and using technologies that did not provide as good a profit stream, had characteristics that they where not familiar with, and they could not centrally control. [2]

What did the companies have in common? One, the decisions that led to failure were made when the leaders in question were widely regarded as among the best companies in the world. Two, they were good, well-managed firms that " ignored the significance of a new technology. The *radical or disruptive* technologies began as apparently inferior products and then grew to overtake the traditional technologies and brought with them a new set of customers and values. Large traditional companies don't like *radical or disruptive* technologies as they typically supply small markets, which are not enough to satisfy the revenue needs of a large firm. In addition these markets are hard to estimate, so companies who require firm quantitative data, the hallmark of utilities, before making a decision will miss out. It just does not make sense for them to invest. The have developed a "value system" that progresses from the bottom to the top of the organization. This system is geared to the technologies that have made the company a leader. A *disruptive or radical technology* can never make it through such a system. Utilities represent such traditional companies. Distributed, renewable, and energy efficiency technologies represent radical and disruptive technologies. Utilities will not be able to make the transition to the kind of business structure and value system required to make these radical technologies a success.

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[1] Mastering the Dynamics of Innovation, James M. Utterback, HBS Press 1994

[2] Liberally adapted from " The Innovators Dilemma, When New technologies Cause Great Firms to Fail" Clayton M. Christensen, HBS Press 1997

The provision of energy services to the rural populations of the world, in a sustainable manner, will depend as much on innovation in organizational structures as it does on the innovation in technologies. So the challenge to utilities is that the delivery mechanism for energy services using renewables and distributed, new, radical technologies requires them to abandon the culture and the structure of control that made them a success. A metamorphosis that history tells us few, if any, companies have accomplished. And if there are any companies that seem incapable of doing so, it is utilities. ⊗

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Remarkable Century

Major Forces and Utilities

Governance	-	Competition Market Based Approach Individual Choice
Environment	-	Sustainability Impacts - Local/Global
Technology	-	Smaller, Modular, Flexible Information Content Manufactured Energy

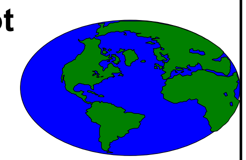
WEINBERG ASSOCIATES

SUSTAINABLE ENERGY

Must Move Closer to the Near Term Flux of the Sun

- **ONLY THREE WAYS TO GO**
  - High Efficiency Conversion of “clean” fuels
  - Renewables
  - Energy Efficiency

- **No Silver Bullet only Silver Buckshot**



Situations for Consideration of Distributed Systems

$G+$T+$D <<	$DU Centralized planning based on central generation (large load centers). Cost of central generation plus the cost of T&D is much less than the cost of distributed resources.
$G+$T+$D > >	$DU Distributed planning based on distributed resources (islands/villages). Cost of distributed resources is less than the cost of generation, transmission, and distribution.
$G+$T+$D -	$DU A mix of resources depending on localized costs and conditions (niches). Cost of distributed resources is approximately equal to the cost of generation, transmission, and distribution.

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Distributed Systems

Radical or Disruptive Technologies

- **Small, Modular**
- **Work as well distributed**
- **Self, locally or naturally dispatched**
- **Not on the grid**

Weinberg Associates

Technologies

Radical or Disruptive - "Brave New World"

New Customers / New Values

Evolutionary - Better ,Cheaper, faster

Traditional Customers/Traditional values

"Radical or Disruptive Technologies never introduced by Market Leader"

Weinberg Associates

Radical or Disruptive Technologies

- Don't satisfy revenue needs of large firms
- Markets hard to estimate
- Lack of quantitative data
- Cannot pass through established decision gates
- Require new organizational structure and culture

Weinberg Associates

The Challenge

- Village Power requires
  - the use of radical technologies
  - business not project financing
  - innovation in organization not just technology

- Utilities cannot change nor deliver systems economically

Weinberg Associates

RADICAL or DISRUPTIVE TECHNOLOGIES

- DISPATCHED BY NATURE, SELF, OR LOCALLY
- MODULAR, GEOGRAPHICALLY DISTRIBUTED

Require New Organizational Structures

Distributed Generation in the New Millennium

James Reilly,Vice President
Edison Technology Solutions
www.edisontec.com
October 7, 1998

EDISON TECHNOLOGY SOLUTIONS[SM]
An EDISON INTERNATIONAL[SM] Company

Distributed Generation

Solar-PV

Wind

Fuel Cells

Micro-Turbines

Distributed Generation is a Disruptive Technology
(Bower & Christensen, HBR, Jan 1995)

- One of the most consistent patterns in business is the failure of leading companies to stay at the top of their industries when technologies or markets change
- Most well managed, established companies are consistently ahead of their industries in developing and commercializing new, next generation technologies

Edison Technology Solutions Intends to Lead Our Industry in Distributed Generation

Edison Technology Solutions (ETS) is the remaining core of Southern California Edison Company's R&D Organization. Over the last decade, ETS employee's have been the drive in implementing the worlds' most diverse utility generation portfolio on behalf of the utility.

- Edison International (EIX), is the parent company
  - 1997 Revenues: $9.2 Billion
  - Net Profit: $0.7 Billion
  - Assets: $25.1 Billion

- Other affiliate companies include:
  - Edison Mission Energy
  - Edison Capital
  - Edison Enterprises
  - Southern California Edison

Edison Technology Solutions

- Vision

  "Develop and commercialize technologies, products and services to meet the needs of emerging competitive energy and electricity markets"

  - Developing distributed resources for enhancing reliability of the grid and creating the "grid of the future"
  - Deploying renewable distributed applications
  - Developing technologies to increase power quality
  - Developing and demonstrating "hybrid" technologies with high efficiencies and low emissions

Why Distributed Generation?

- The evolution of Fuel Cells for stationary power applications, micro-turbines, PV and wind all figure prominently in this emergence of "disruptive technologies"

- The US market is moving towards distributed generation based on emerging technology, time of day pricing and restructuring incentives

- International market is based on high demand and liberalization of the energy markets

Movement to Distributed Generation

- In the developing country markets, Distributed Generation is to the energy sector what the cell phone has been to the telecommunication's sector
- Regulatory reform and technology has made the energy commodity more accessible and less expensive to a large market segment that has previously been poorly served

World Energy Council

- The World Energy Council, on behalf of thirty-five energy ministers and five thousand energy executives from nearly 100 countries, issued on September 18, 1998 their conclusions and recommendations from on the world's energy sources should be used
  - *“The accelerated development and use of renewable energy resources must be given high priority as a means of supplying commercial energy services to people without previous access to energy sources”*

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World Energy Council

"Both traditional and new renewable energy sources have an important place in future energy supply. While fuel, wood and coal will remain the principal energy supply resources for many developing countries, distributed generators -- micro-turbines, diesels, and fuel cells -- and renewable technologies, specifically wind, biomass and solar, may provide a viable option for areas operating independent of power grid and fuel pipeline systems".

Edison Technology Solutions and Solar Photovoltaics (PV's)

- With over twenty years' of experience in the development, demonstration, and implementation of renewable technologies, ETS staff has managed solar-PV installations from 1.5 kW to over 100 kW, at over a dozen sites throughout Southern California.

- ETS has developed a three-tiered approach to help utilities, international organizations, and commercial customers integrate a comprehensive solar program
  - This experience and knowledge will be highly applicable to designing and commercializing solar- PV technology for Village Power

ETS staff managed this PV installation off the California coast on Santa Cruz Island. This 130 kW site validates the cost-effectiveness of renewable technologies in isolated, remote applications.

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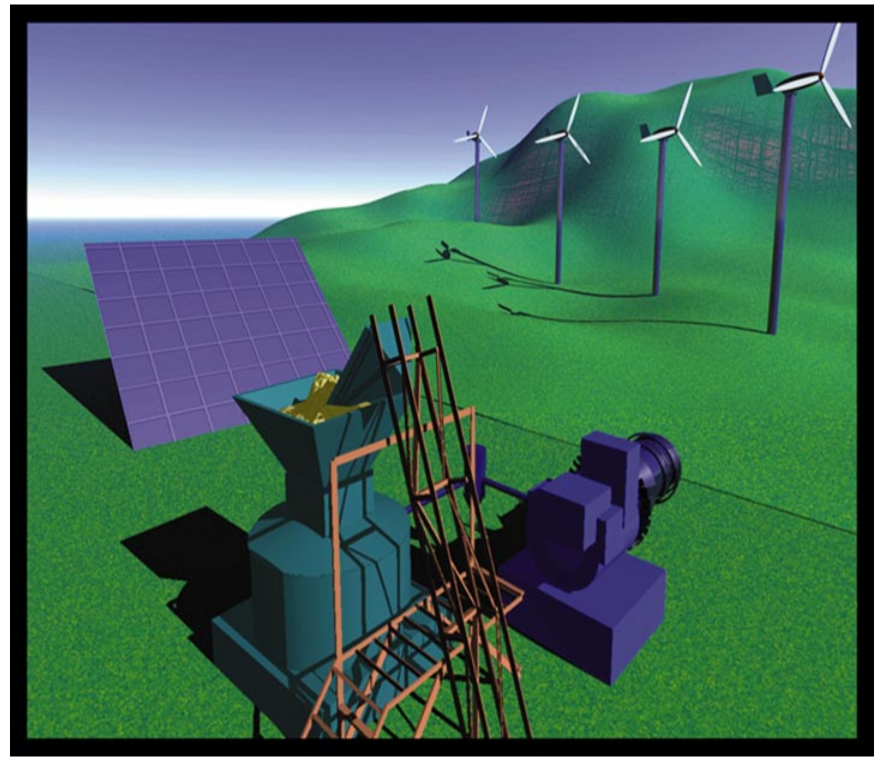
Movement to Renewable/Fossil Hybridization

- Hybridization is essential to renewable energy technologies – lowering their levelized energy costs and increasing system reliability and capacity factor
- Many renewable energy technologies have distributed generation implications/similarities



Edison Technology Solutions and Micro-Turbine Generators (MTG's)

- ETS is managing a $2 million utility/industry/government effort to test, prove, and enhance micro-turbine generators.
- This effort grew out of ETS' early recognition, that a fundamental change in power generation was occurring - the replacement of economies of scale with economies of manufacturing. This insight allowed ETS to take a national leadership role in testing and improving this emerging technology.
- ETS' focus is on increasing efficiency, lower emission levels, and improving machine reliability.

Two micro-turbines under endurance testing at ETS' test facility

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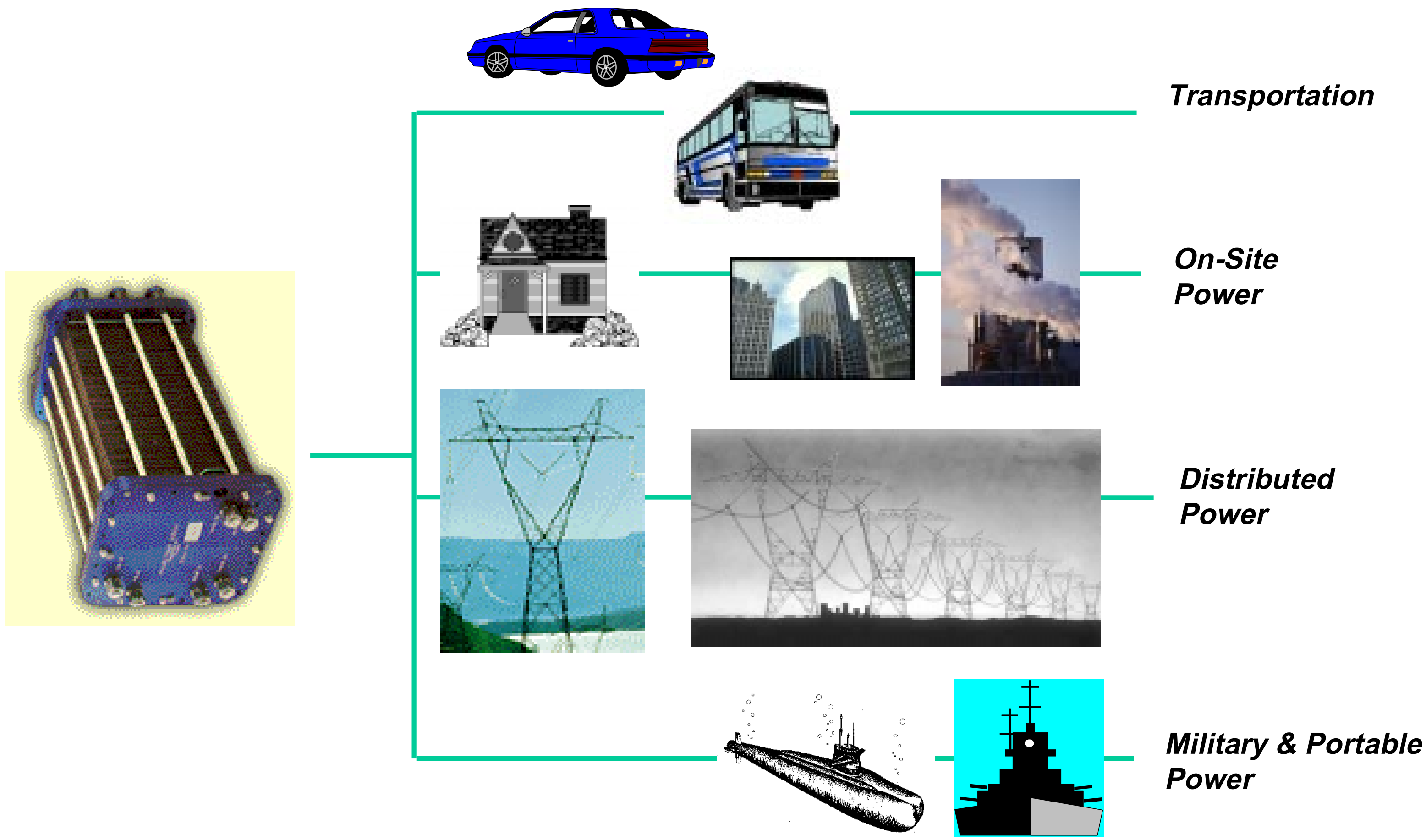
Edison Technology Solutions and Fuel Cells

- With over twenty years' experience in the evaluation, development, and demonstration of distributed generation technologies, ETS has extensive experience with two previous Siemens-Westinghouse 20 kW atmospheric SOFC designs.

- ETS' focus is to pursue initiative enabling technologies that will help foster rapid commercialization and significant deployment of fuel cells
  - Fuel reformation
  - Balance-of-plant (inverters)

Prototype 25 kW SOFC in operation at the National Fuel Cell Research Center at Irvine, California. ETS is a founding member.

Fuel Cells Can Provide a Common Technology Platform for Many Market Sector Applications



Source: AD Little

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Next Wave of Technology Integration

- According to Power Engineering

  "The rapid evolution of gas turbines technology in recent years - achieving higher and higher efficiencies - leads one to wonder how close the thermodynamic ceiling is. The next barrier - 70% - is getting rather tight. To achieve that level, novel cycle designs will be necessary."

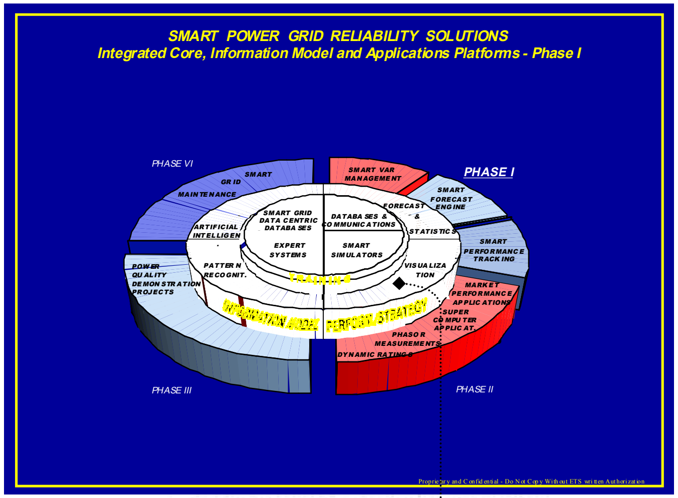
- ETS' Fuel Cell / MTG Hybrid Power Plant has an excellent chance of achieving 60% efficiency and beyond
  - *"Combined cycle"* integrating a fuel cell with a MTG
  - Chemical process - similar to a battery
  - Lower capital cost ($/kW) than a standalone fuel cell
  - Higher efficiency than either a standalone fuel cell or MTG
  - No detectable NO_x emissions
  - Modularity, sized for the less than 1.0 MW market segment

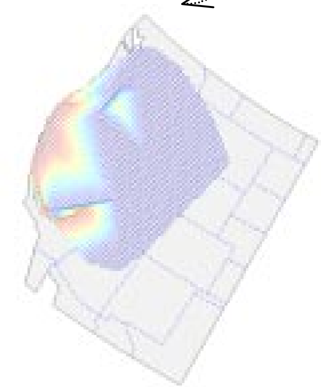
Edison Technology Solutions and "Grid-of-the-Future"

- With over twenty years' of utility policy making, operating, planning and real time control experience, ETS has and is playing a leadership role in the electric industry restructuring, both on a national and regional basis from policy, operational and real-time control perspectives

- The vision of the "Grid-of-the-Future" program is to facilitate creation of new grid infrastructures that will integrate new technologies and tools to maintain and improve reliability and efficiency

- Integration of distributed generation, storage, and power electronics technologies at the transmission, distribution and consumer levels, in addition to development of smart integrated grid management tools make the ETS portfolio to improve grid reliability





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In Summary

- Entrepreneurial subsidiaries within a large, multi-national energy company *do possess* the synergistic characteristics of:
  - Providing the technology push for appropriate technology in the global marketplace
  - Having the market presence and financial strength to collaborate with multi- and bi-lateral organizations
  - Perceiving the de-centralization of energy supply and electrification of the "unplugged"

APS/CFE RENEWABLE ENERGY PROJECT

Peter Johnston

APS/CFE
RENEWABLE ENERGY PROJECT

- Team with CFE to provide a community energy service using renewable energy technologies
- Manage the institutional issues to make a sustainable business model

SITE SELECTION CRITERIA

- Potential for good solar and/or wind resources
- Existing infrastructure and economic activity
- Potential for economic growth
- Low probability of connection to the electric grid in the near future

SAN JUANICO

- Coastal fishing village of ~ 400 people
- World-class surfing, small resort, airstrip
- Diesel power 4 hours/day, existing mini-grid
- Peak load of ~ 50 kW
- Unused fish processing/cold storage facility

PROJECT STATUS

- All major equipment items delivered to Yucca power plant in Yuma
- Delivery to San Juanico awaiting IVA tax issue resolution
- PCU in Phoenix for initial acceptance testing

PROJECT STATUS

- Electric Patronato has been formed
- Tariff structure has been developed - approved by village
- Connection fee being collected
- Civil work has been completed
- Plant in operation by March 31st 1999

SYSTEM CONFIGURATION

- Ten 10 kW wind turbines
- 17 kW photovoltaic modules
- 420 kWh battery storage
- 80 kW backup diesel generator
- 72 kW dc/ac inverter

14:00-16:00 **Power Supply Options for Decentralized Rural Electrification** - *Chair, Judy Siegel,World Bank*
•PV Applications for Sustainable Rural Development - *Peter McKenzie*
•Decentralized Rural Electrification in Zimbabwe - *Alex Makomva, ZESA*
•Lessons Learned in Battery Charging Stations - *Stephen Graham, Consultant*
•Small Wind for Village Power - *Michael Bergey, Bergey Windpower*
•Biomass Gasification for Village Power - *Ralph Overend, NREL*
•Hybrid Power Systems in the Australian Outback - *Stephen Phillips, AES Australia*
•Diesel Retrofits: The Alaskan Experience - *Richard Emerman, Alaskan State Energy Office*
•Micro-hydro Mini-Grids - *Andrew Barnett, Intermediate Technology Development Group*

ZIMBABWE ELECTRICITY SUPPLY AUTHORITY (ZESA)

COUNTRY PERSPECTIVE ON RURAL ELECTRIFICATION

Presented at Village Power '98 : ***SCALING UP ELECTRICITY ACCESS FOR SUSTAINABLE RURAL DEVELOPMENT***: 6 – 8 October 1998 Washington DC, USA

By Alex C.B. Makomva – MARKETING AND ELECTRIFICATION MANAGER (ZESA)

COUNTRY PERSPECTIVE ON RURAL ELECTRIFICATION

ALEX C.B. MAKOMVA – MARKETING AND ELECTRIFICATION MANAGER

ZIMBABWE ELECTRICITY SUPPLY AUTHORITY

Paper presented at Village Power '98 SCALING UP ELECTRICITY ACCESS FOR SUSTAINABLE RURAL DEVELOPMENT : 6 – 8 October 1998 Washington DC – USA

Synopsis: ***Zimbabwe's final energy consumption is in nearly equal halves commercial energy and fuelwood. Rural electrification in Zimbabwe aims at addressing the energy problems of the rural population and thereby stimulate new and diversified economic growth in rural areas, create employment and reduce rural urban migration. ZESA's mission statement states "We are committed to the total electrification of Zimbabwe at world class standards and competitive prices", and growth is a key strategic issue of the Authority's Strategic Business Plans.***

Currently only 20% of the Zimbabwean population has access to electricity and electricity accounts for only about 15% of the final energy supply. For over 80% of the urban and rural households in Zimbabwe fuelwood remains the predominant form of energy that is used for basic cooking and heating needs.

The desire to look for sustainable and environmentally friendly alternative sources of energy is the main reason for embarking on rural electrification. This paper highlights the initiative that have been taken in Zimbabwe by the Power utility in conjunction with Government and non-Governmental organisations in promoting rural electrification.

HISTORICAL APPROACH

Rural electrification was initiated in the early 80's, and by 1984, 23 rural growth centres were electrified at a total cost of Z$5,8 million. The next phase of electrification targeted 48 more centres and only 13 of these centres were electrified. Progress in the electrification programme was slow because of high costs and eventually the whole programme was suspended. A review of the programme was made and there was a need for better forward planning focusing on such issues as the correct criterion for choosing centres to electrify and the financing of the programme. The power utility was limited in financial resources coupled with the fact that some of the centres were not financially viable.

RURAL ELECTRIFICATION STRATEGY

The Rural Electrification programme in Zimbabwe is viewed in the wider context encompassing a number of initiatives not only limited to the extension of the National grid by ZESA but also other alternatives in which other organs play a role. The strategies currently being followed in the rural electrification programme are:-

⇒ *Provision of power to rural centres through the extension of the national grid (ZESA initiative)*
⇒ *Provision of power through mini hydro power stations in suitable localities.*
⇒ *Photovoltaic water pumping systems.*
⇒ *Provision of solar power to rural households through the Global Environmental Facility project (GEF initiative).*

RURAL ELECTRIFICATION MASTER-PLAN GRID EXTENSION

Following the suspension of the first rural electrification programmes a review was made by the Zimbabwe Electricity Supply Authority in consultation with Government. A policy and planning study for the electrification of rural areas was made with the assistance of an independent consultant. The study made recommendations of a policy and planning nature which included the following:-

- the selection criteria to be adopted in recommending viable centres for rural electrification. The criteria included economic, financial and other parameters in the determination of viability.
- the specific roles of the various participants involved in the rural electrification programme.
- the financing of the rural service centres that caters for both viable and non-viable centres.

  (viable centres meet the financial IRR of 16% or better)

Funding

Since the financial year 1994/95 the Zimbabwe Electricity Supply authority has been levying 1% on the customer bills and setting aside the money to finance rural electrification. ZESA carries out those RE projects that meet the financial IRR criterion. The Rural Electrification Fund is administered separately from the ZESA account. The fund produces its own set of annual accounts and ZESA has no access to the RE fund except borrowing on strict commercial terms.

The ZESA policy on tariffs is that for each customers category, tariffs should be based on long run marginal costs. With the exception of material connection fees, all customers within a particular category are charged the same tariff nationwide i.e. there are no special tariffs for rural electrification (grid electricity)

Following the approval of the policy and planning document it was necessary to carry out a more detailed technical and engineering study recommending the least cost and effective way of electrifying viable centres up to the year 2010. The study had in addition to carry out the following:-

- on the basis of the policy and planning study prepare projections, identify those centres that can viably be electrified by grid extension.
- prepare a detailed master plan upto the year 2010 showing the most efficient and least cost scenario.
- Prioritisation of viable centres to be electrified up to the year 2010.

A summary of the financial requirements for the RE master plan are shown on Table 1. These figures are based on the 1994 projections and need revision to take into account the current exchange rate.

Table 1
RURAL ELECTRIFICATION MASTERPLAN COST PROJECTIONS

YEAR	CAPITAL EXPENDITURE COSTS Z$	INCOME R.E. LEVY Z$	CUMULATIVE Z$
1994/5	0	22 497 000	22 497 000
1995/6	0	29 385 000	51 882 000
1996/7	44 000 000	37 136 000	45 018 000
1997/8	27 200 000	40 000 000	57 818 000
1998/9	26 500 000	40 000 000	71 318 000
1999/20	30 500 000	40 000 000	80 818 000
2000/1	45 600 000	40 000 000	75 218 000
2001/2	47 000 000	40 000 000	68 218 000
2002/3	57 000 000	40 000 000	51 218 000
2003/4	60 500 000	40 000 000	30 718 000
2004/5	61 400 000	40 000 000	9 318 000
2005/6	62 500 000	40 000 000	-13 182 000
2006/7	62 800 000	40 000 000	-35 982 000
TOTAL	**525 000 000**	**489 018 000**	**-35 982 000**

Implementation of the RE masterplan commenced in 1996/97 financial year, starting with 28 centres that were selected from the masterplan. Good progress has been made so far and the energy consumption at some of the centres are pleasing and Table 2 shows the customer type and total consumption per centre.

Table 2

ITEM	CENTRE	AREA	CUSTOMER CONNECTED (Nos.)					CONSUMPTION (kwh)	
			E1	E2	E3	E4	E5	CURRENT MONTH	YEAR TO DATE
1	Chiendambuya	Northern	24	0	0	28	0	44 576	747 101
2	Sadza	Northern	65	0	0	50		83 715	889 471
3	Madamombe	Northern	4	0	0	6	0	2 906	28 586
4	Mahuhwe	Northern	4	0	0	16	0	15 886	211 820
5	Muzarabani	Northern	53	0	1	21	1	29 197	1 105 337
6	Kachuta	Northern	2	0	0	5	0	519	641
7	Makaha	Northern	Note 1						
8	Mutawatawa	Northern							
9	Bepe	Eastern							
10	Nyaruwaka	Eastern	4	0	0	10	0	8 119	112 426
11	Devedzo	Eastern	28	0	0	5	0	6 652	41 658
12	Madangombe	Eastern	5	0	0	7	0	16 051	84 322
13	Ndanga	Eastern	35	0	0	15	0	29 521	237 426
14	Buhera	Eastern	53	0	0	18	0	18 944	109 957
15	Nyatate	Eastern	17	0	0	7	0	4 927	49 155
16	Maphisa	Western	135	1	1	55	2	129 438	963 601
17	Sipepa	Western	9	0	0	6	0	5 509	36 423
18	Tsholotsho	Western	137	0	1	65	8	150 692	677 576
19	Hwali	Western	17	0	0	13	0	25 019	31 025
20	Nembudziya	Southern	35	0	0	15	0	28 410	34 271
21	Kuwirirana	Southern	6	0	0	2	0	2 947	3 426

Key E1 Domestic Customer
E2 Public Lighting
E3 Mining & Industrial Customers
E4 Commercial Customers
E5 Agricultural Customers

The demand for RE by local communities is growing and to cater for requirements outside the masterplan, a number of financial schemes have been put in place. These schemes are designed to assist and promote self help by local communities. In addition, community participation through provision of labour and in some cases material is taken into account while costing the schemes.

The Zimbabwe Electricity Supply Authority has recognised that the resources required to electrify the whole country through grid electricity are limited. To this end, ZESA acknowledges that other cheaper alternatives need to be explored and the schemes that have been encouraged are outlined below:-

PROVISION OF POWER THROUGH MINI HYDRO POWER STATIONS.

ZESA is involved in the reticulation of an isolated area that is going to be provided with energy from a mini hydro station at Manyuchi Dam in the Southern Eastern part of the country. The mini hydro plant is financed by the E7. Besides this mini hydro plant ZESA has encouraged the commissioning of other mini hydro plants mainly in the Eastern part of the country. It buys excess power from the mini hydro plants and supplies when the plant is down.

Notable Mini hydro plants include:-

- Svinurai mini hydro (10 kW)
- Nyafaru mini hydro (20 kW) and
- Rusitu mini hydro plant

GLOBAL ENVIRONMENTAL FACILITY (GEF) :
RURAL HOUSEHOLD SOLAR LIGHTING SYSTEMS

The GEF solar project administered by the UNDP and the Government of Zimbabwe in conjunction with the Department of Energy was a pilot project expected that time to realize some 9 000 installed solar lighting systems to households in the rural areas. ZESA participated in this programme by installing 500 solar systems varying from 2 to 10 light systems. An innovative payment system was designed and became the most popular payment mode in the country. The Authority is responsible for the maintenance of the systems while the recipients pay monthly. The amount paid is determined by the size of the system installed. The current operating tariff is shown in Table 3.

Table 3

TYPE OF LIGHTS SYSTEM	MONTHLY	QUARTERLY	HALF YEARLY	YEARLY
1 and 2 lights	$70	$210	$420	$840
3 lights	$80	$240	$480	$960
4 lights	$90	$270	$540	$1080
5 lights	$105	$315	$630	$1260
6 lights	$120	$360	$720	$1440
7 lights	$135	$405	$810	$1620
8 lights	$140	$420	$840	$1680
9 lights	$145	$435	$870	$1740
10 lights	$150	$450	$900	$1800

A full project evaluation is currently being undertaken. The outcome will determine whether ZESA will offer solar installation as an option to grid electricity where the chances of grid electricity are currently remote. However, the pilot has created more demand than was anticipated particularly because of the payment system.

MARKETING RESEARCH

In 1996, the Zimbabwe Electricity Supply Authority commissioned a study, which sought to provide information for inputting into marketing decision making. This was part of the Authority's overall review of both technical and marketing aspects of services nation wide.

The marketing research was to be complementary to the rural electrification drive by providing vital information on the state of the market and the tenability of major assumption underlying current strategies. It was vital to review the current strategy in the light of low electrification rates even in the Urban Areas where electrical infrastructure is available.

The Authority postulated a number of factors that might have a direct or indirect influence on consumer choices. These had to be tested and the postulates are summarized as follows:-

- Perceived high cost of electricity. In particular household inability to meet the costs of wiring houses
- Households decision makers inability to afford cost of electrical appliances
- General public ignorance about the utility and the convenience of electricity.
- Market ignorance of the competitive costs of electricity compared to other forms of energy
- A poor corporate image of the power utility aggravated by perceptions of poor services, high cots, unreliable supply and hazards of electrocution.

The main thrust of the full project series is the establishment of a market based data base (both quantitative and qualitative) which could be used as a basis for executive decision making in three major areas.

- Establish market perceptions of ZESA with a view to developing marketing strategies that respond accordingly.
- Determine and forecast respective popularities of each form of energy and the underlying reasons for preference.
- Develop business and strategic marketing plans that respond to market size expectations
- Implement the marketing plan to optimize sales and thereby deepen sales and widen the customer base.

More specific supportive objectives to the first two above could be stated as follows:-

⇨ Establish the extent of awareness of and attitudes towards alternative forms of energy
⇨ Establish usage habits of various forms of energy and reasons for energy choice.
⇨ Estimate broad consumer and customer image of the Authority.
⇨ Assess acceptability of various possible approaches to paying for electricity – deposits, consumption. Undertake a socio-economic profiling of the market base.

A clear definition of market segments was undertaken and respondents were drawn from the following:-

⇒ Urban households – low and high density
⇒ Rural household – selected growth points
⇒ Commercial, industrial and mining concerns
⇒ Agricultural extensions

SUMMARY OF MAIN FINDINGS

The detailed findings are contained in a separate report but for the purpose of this paper some key highlights of the findings are illustrated below. The terms used in the tables are defined as follows:-

➢ Absolute Awareness Index (AAI) - a measure of the level of awareness of each energy use method.

➢ Relative Awareness Index (RAI) - implied awareness weighting factor for various energy forms.

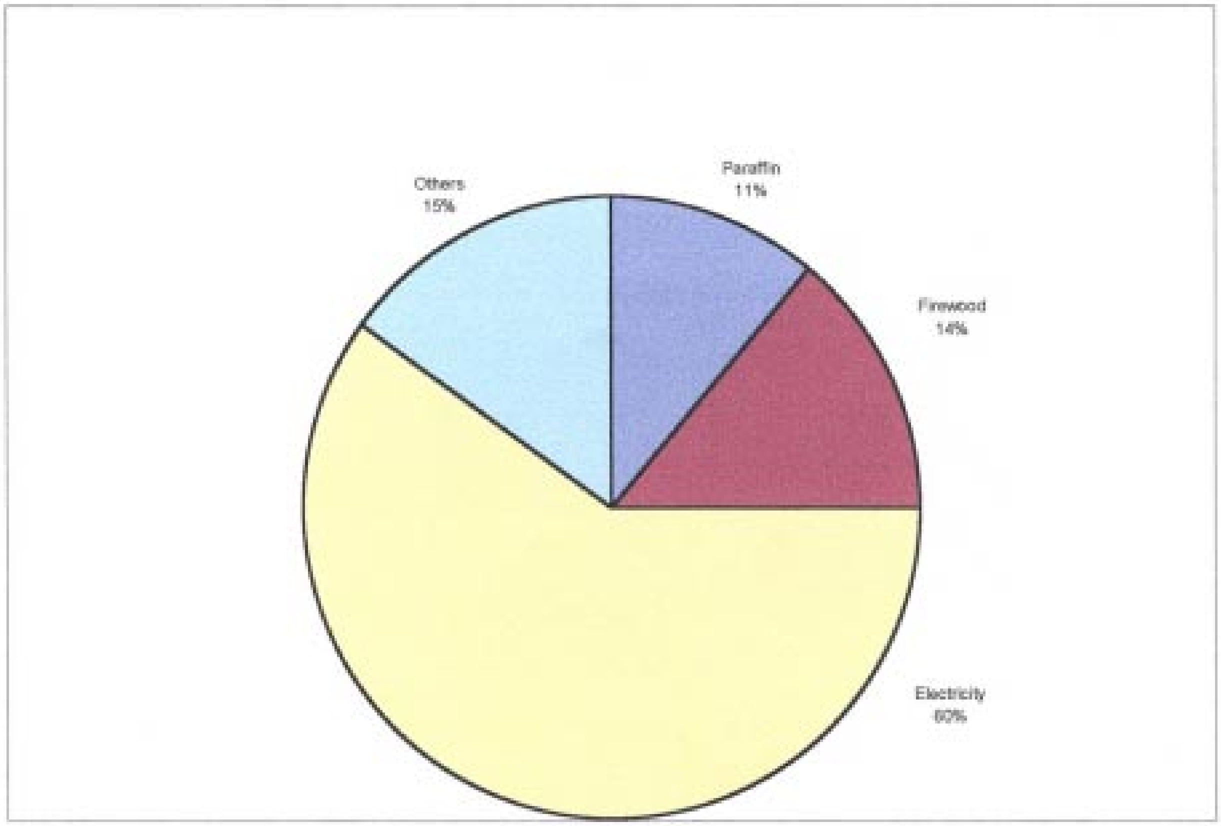
➢ Absolute Preference Index (API) - degree of preference for a particular energy method.

➢ Relative Preference Index (RPI) - ranked preference relative to other methods.

Heating

	RAI (%)	RPI (%)	RPI/RAI (%)
Grid Electricity	29	58	200
Firewood	29	14	50
Paraffin	21	11	50

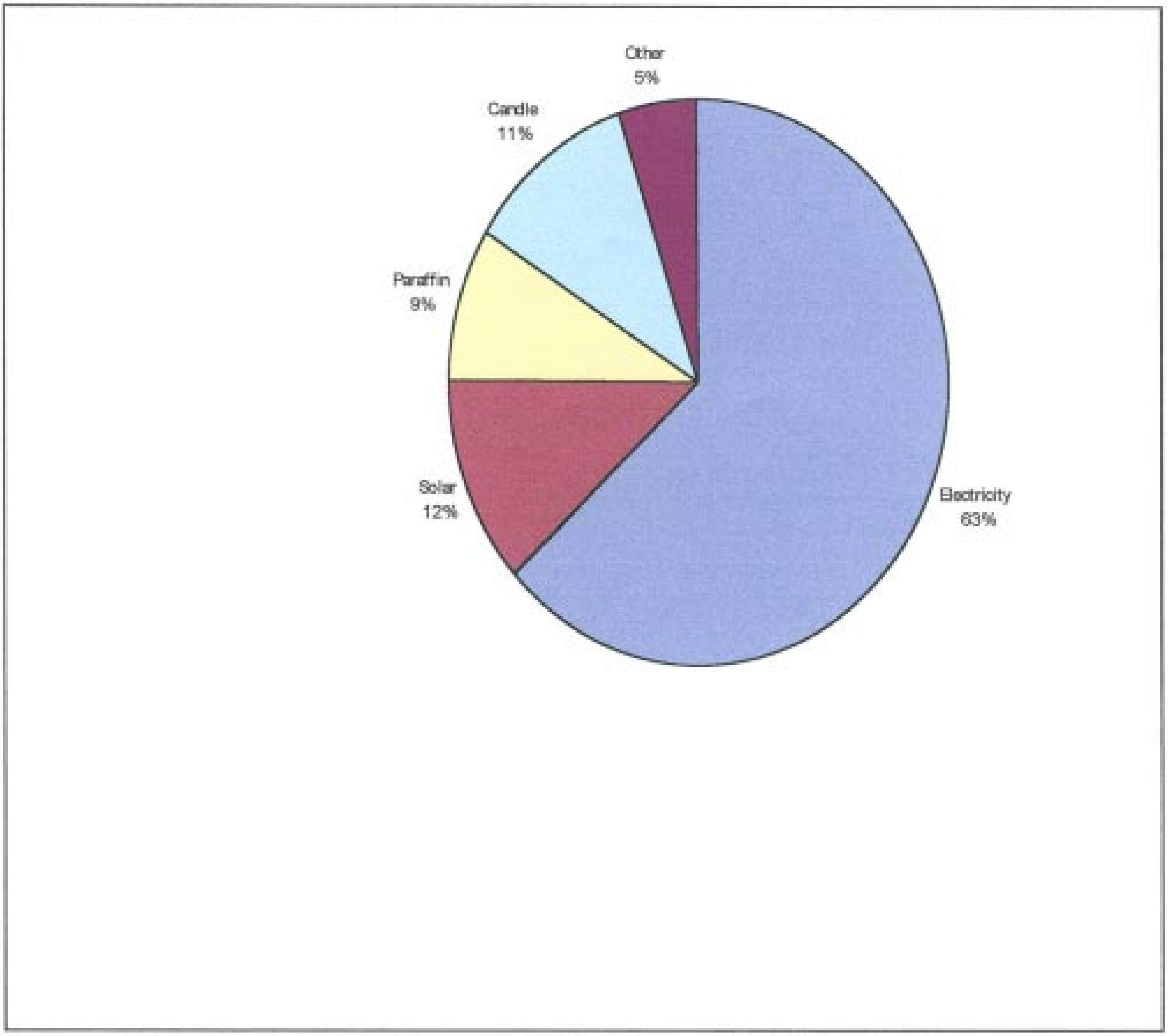
RANKED IMPORTANCE OF HEATING METHODS



Lighting

	RAI (%)	RPI (%)	RPI/RAI (%)
Grid Electricity	29	61	200
Paraffin	25	9	33
Candles	23	11	50
Solar Electricity	9	12	133

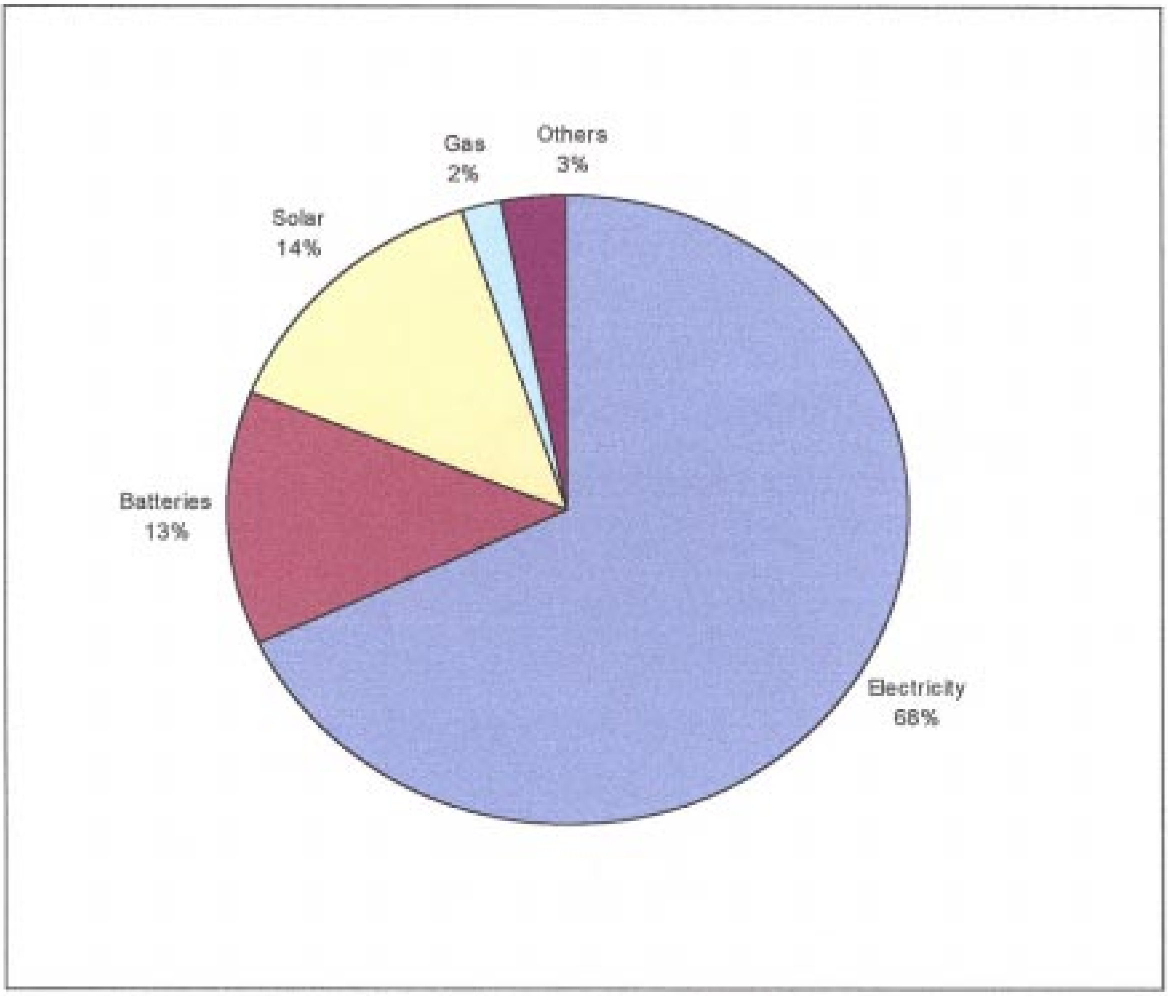
RANKED IMPORTANCE OF LIGHTING METHODS



Powering

	RAI (%)	RPI (%)	RPI/RAI (%)
Grid Electricity	37	68	180
Solar Electricity	14	14	100
Batteries - Car	14	7	44
Batteries - Dry	17	6	35

RANKED IMPORTANCE OF POWERING METHODS



One of the major objectives of the study on the energy baseline survey was to gauge the extent of off-grid electrification in Zimbabwe. The results of the baseline and the subsequent follow up for PV and gensets prove very insightful. They should provide guidance to ZESA, the Government of Zimbabwe, the World Bank and others interested in rural electrification for preparing and implementing support and development programmes in the sector.

Photovoltaics

Three general questions on use of energy were asked of respondents:

- did they use the energy source for heating?
- did they use the energy source for lighting?
- did they use the energy source for powering (e.g. TVs, radios, etc)?

Table A1.2
Respondents Using PV for Powering Appliances

Grid accessible			
Domestic	**No**	**% by category**	**% of total**
H density	8	18.6%	7.6%
L density	2	4.7%	1.9%
Rural	2	46.5%	19.0%
Employees	20	30.2%	12.4%
Sub-total	**13**	**100.0%**	**41.0%**
Other	43		
Lg scale		0.0%	0.0%
Sm scale		0.0%	0.0%
Sub-total	**0**	**0.0%**	**0.0%**
Ex-grid accessible			
Rural domestic	53	85.5%	50.5%
Sm scale		0.0%	0.0%
Lg scale	9	14.5%	8.6%
Sub-total	**62**	**100.0%**	**59.0%**
Total	**105**		**100.0%**

As Tables A1.2 and A1.3 show, 105 respondents answered they used PV for powering, while 81 answered they use PV for lighting.

This implies that there were, at a very minimum, 105 respondents, or 1,8% of the entire 6 001 respondents in the survey, who use PV. If, as should be the case, a number of the 85 respondents who said they use their PV for lighting, also use their PV for powering, then, of course, the number of interviewees using PV for both powering and lighting increases. This, then, implies that the extrapolations for general population use of PV based upon those who said they use it for power is an underestimate.

Table A1.3
Respondents Using PV for Lighting

Grid accessible			
Domestic	**No**	**% by category**	**% of total**
H density	3	0.1%	0.1%
L density	4	0.1%	0.1%
Rural	13	0.3%	0.2%
Employees	16	0.4%	0.3%
Sub-total	**36**	**0.8%**	**0.6%**
Other			
Lg scale		0.0%	0.0%
Sm scale	2	0.6%	0.0%
Sub-total	**2**	**0.6%**	**0.0%**
Ex-grid accessible			
Rural domestic	32	2.5%	0.5%
Sm scale	2	0.2%	0.0%
Lg scale	9	0.7%	0.2%
Sub-total	**43**	**3.3%**	**0.7%**
Total	**81**		**1.4%**

In the survey, and verified in the follow up in July and August, 81 respondents, or 1.4% of the sample stated they used solar electricity for lighting.

Using the higher number of those who use PV for powering (and realizing this is an underestimate, as there are surely respondents who use it for both powering appliances and lighting), and extrapolating this to the national census, we can obtain the following estimates.

Table A1.4 and A1.5 are taken from the 1992 National Census by Central Statistics Office. The Central Statistics Office estimated population in three scenarios to the year 2007, at intervals of 1997, 2002 and 2007. The team has taken the middle estimate, which puts 1997 population at 12.338 million inhabitants. This assumes an overall growth rate of 3.45% until the year 1998 (given contemporary fertility and mortality rates), with an urban growth rate of 5.17% per annum for the period concerned, and a rural growth rate of 2.65% for the same period. Again, it should be noted that these figures are taken from the 1992 Census and the CSO's projections to the year 2007.

Table A1.4
Population Estimates from 1992 Census (1997 estimate from CSO)

1992 Census	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998 (est)**
Rural	7.224.828	7.416.286	7.612.818	7.814.557	8.021.643	8.235.615	8.453.859
Urban	3.187.720	3.352.525	3.525.851	3.708.137	3.899.848	4.102.385	4.314.478
Total	**10.412.548**	**10.768.811**	**11.138.668**	**11.522.694**	**11.921.491**	**12.338.000**	**12.768.337**

Source: CSO

Table A.1.4 shows that the urban population in 1998 should be on the order of 4.3 million, and the rural on the order of 8.5 million. Taking CSO figures for urban and rural household sizes, Table A1.5 was prepared.

Table A1.5
Household Estimates from 1992 Census (1997 estimate from CSO)

1992 Census	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998 (est)**
Rural	1.409.106	1.446.447	1.484.778	1.524.124	1.564.514	1.606.246	1.648.812
Urban	777.622	817.825	860.106	904.574	951.340	1.000.748	1.052.486
Total	**2.186.727**	**2.264.272**	**2.344.884**	**2.428.698**	**2.515.854**	**2.606.994**	**2.701.298**

Source: CSO

Taking these census data and applying the ZESA baseline survey and follow up analysis figures, the following tables indicate the minimum level of PV penetration today in Zimbabwe.

Table A1.6
Estimates of PV Penetration for Powering Appliances in Zimbabwe Based upon 1992 Census and 1998 ZESA Baseline Survey

Category	**No**	**% solar sample**	**% sample**	**% national**
Domestic				
Urban	23	21.9%	0.6%	5.9993
Rural	73	69.5%	5.2%	85.002
Other	9	8.6%	1.7%	
Total	**105**	**100.0%**	**1.8%**	**90.996**

Source: ZESA, Quest Data and ESMAP

This indicates that, at a minimum, there are over 90 ,000 PV systems **in use** in Zimbabwe. The emphasis is on **in use**, as the survey asked interviwees what they used at that point in time for powering appliances. This indicates operational units, not units sold but out of use. It should be noted that, as one would expect, most units are used in rural areas. However, a higher proportion, nearly 22% use PV in urban areas, as defined above (i.e. , either high density, low density, or commercial/industrial employees in urban areas). This should be of major interest to ZESA. The "other" category indicates use in rural applications on commercial farms, at mines, and other business establishments in Zimbabwe.

Additionally, as Table A1.7 indicates, a further 81 interviewees stated they used PV systems for lighting. The data are being analyzed to determine the number of users who use their systems for both powering and lighting, as this number will be greater than 105, and will imply a higher national extrapolation for those using PV.

Table A1.6
Estimates of PV Penetration for Powering Appliances in Zimbabwe Based upon 1992 Census and 1998 ZESA Baseline Survey

Category	No	% solar sample	% sample	% national
Domestic				
Urban	23	21.9%	0.6%	5.9993
Rural	73	69.5%	5.2%	85.002
Other	9	8.6%	1.7%	
Total	**105**	**100.0%**	**1.8%**	**90.996**

Source: ZESA, Quest Data and ESMAP

Car Batteries

Another objective of the survey was to get a good idea of the number of car batteries in use in the country for providing off-grid electricity. Table A1.7 shows that 540 respondents stated they use car batteries for powering appliances (generally TVs, radios, radio cassettes and similar devices). No respondents stated they used car batteries for lighting.

Table A1.7
Respondents Using Car Batteries for Powering Appliances

Grid accessible			
Domestic	**No**	**% by category**	**% of total**
H density	203	4.6%	3.4%
L density	10	0.2%	0.2%
Rural	45	1.0%	0.8%
Employees	85	1.9%	1.4%
Sub-total	**343**	**7.8%**	**5.7%**
Other			
Lg scale		0.0%	0.0%
Sm scale	6	1.9%	0.1%
Sub-total	**6**	**1.9%**	**0.1%**
Ex-grid accessible			
Rural domestic	152	11.8%	2.5%
Sm scale	20	1.5%	0.3%
Lg scale	19	1.5%	0.3%
Sub-total	**191**	**14.8%**	**3.2%**
Total	**540**		**90.%**

One of the interesting features of both Table A1.7, above, and Table A1.8, below, is the high proportion of "urban" users of car batteries. In fact, a higher number of "urban" respondents state they use car batteries than rural. There are two explanations for this.

First, most of the urban respondents are in high density areas where there are many homes without grid connections. Many employees in the survey in the grid-accessible areas do not have electricity connections, so use batteries for their appliances. Secondly, many households have old appliances that are DC-driven, including classic stereo phonographs that are driven by lead acid batteries. This is borne out by market supply surveys that show these types of heavy batteries are widely available in urban retail outlets. It is believed that for many of these households, the costs of purchasing a new entertainment unit is prohibitive, relative to continued use of batteries.

Table A1.8
Estimates of Car Battery Penetration for Powering Appliances in Zimbabwe Based upon 1992 Census and 1998 ZESA Baseline Survey

Category	No	% battery sample	% sample	% national
Domestic				
Urban	298	55.2%	8.0%	84.722
Rural	197	36.5%	13.9%	229.390
Other	45	8.3%	8.3%	
Total	**540**	**100.0%**	**9.0%**	**314.112**

Source: ZESA, Quest Data and ESMAP

Taking the baseline and follow up surveys and extrapolating them to the overall population, it can be seen that, **at a minimum**, over 314,000 car batteries are in use in Zimbabwe, with at least 230,000 of these in rural areas. The "other" category, which includes small rural and urban businesses, cannot be currently estimated for extrapolation as there is no census or other national data available from which to extrapolate. However, given the importance in the survey group (8.3% of businesses), this probably accounts for thousands of batteries, thereby making the estimates in Table A1.8 underestimates.

OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

1. The Grid Rural Electrification programme in Zimbabwe is structured and implemented according to a master-plan. The master-plan consists of RE centres that have met selection criteria of economic and financial viability. The funding is through an RE levy which is independent of ZESA finances.

2. Other modes of rural electrification mainly renewable technologies are also being implemented by Government, non-Governmental Organisations and individuals. ZESA has implemented successfully the GEF project and a lot of experience has been gained from the project.

3. The marketing research conducted by ZESA and subsequently altered to suit ESMAP needs has identified the enormous rural demand for energy services. The research findings should assist ZESA, Government of Zimbabwe and all other stakeholders.

4. The RE programme in Zimbabwe is in our view adequately structured and the demand for Rural electricity has been amply demonstrated. This demand is in the Rural Areas where there is potential for development and thereby alleviating poverty and contributing to environmental protection. However, the programme needs better resources than is the current case. The international community is therefore called upon to support this worthy cause.

Lessons Learned at Solar Battery Charging Stations

A Presentation to Village Power '98

Stephen Graham

SGA Consulting, Ottawa, Canada

The Study

- World Bank Sponsored to answer:
  1. Do SBCS make sense?
  2. If so what are best practices?
- A four country field survey of SBCS programs
  - Brazil - 40 Stns, since 1996
  - Morocco - 30 Stns, since 1994
  - Thailand - 1350 Stns, since 1988
  - The Philippines - 225 Stns, since 1990
- Findings preliminary

Conclusion: When do SBCS make sense?

1. For small residential demand.
2. Remote from the grid.
3. Where diesel costs are high.
4. As a complement to SHS markets.

- Fluorescent lights (1-2), radio, B&W TV
- Grid BCS unless high battery transport costs
- Diesel BCS unless on-site fuel costs high
- SHS markets serve higher demand and ability to pay (ATP) - SBCS builds confidence & markets, lower cost, local service node

An Economic Analysis

- **Four Options**: Solar Station (SBCS), Diesel Station (DBCS), Solar Home (SHS), Grid Station (GBCS)
- **Base Case** -> Sensitivity Analysis for Access & Demand
  - Fuel price; Diesel BCS
  - Battery transport cost; Grid BCS
  - Demand; Diesel BCS & SHS

Assumptions:

DR = 12%, 15 yr project

Battery - SLI, 12V, 85 Ah, cycle life 100, DOD 80%, user-owned

Insolation - Design 4.2 kWh/m^2-d (Ave 5.0 kWh/m^2-d)

Economic diesel cost $0.18/ litre

Grid LRMC $0.05 / kWh

Household demand 100 Wh/day (2 lts, 3 hrs; 0.3 TV 1.5 hrs; 1 radio, 3 hrs)

No environmental benefits to solar

More Economic Assumptions & Inputs

- SBCS
  - Capacity per outlet based on full charge to battery on monthly min. solar day
  - number of outlets based on battery capacity, HH demand & assumed market size
  - battery life based on cycle life
  - Incremental Management Cost (IMC)
- Grid BCS
  - Charger capacity 60V, 20A
  - Serves broad community to always operate at capacity
  - No IMC
- SHS
  - Module capacity based on daily demand and monthly min. insolation
  - battery life assumed 36 mo.
  - IMC
- Diesel BCS
  - 3 kW capacity, e=1.55 kWh/ L
  - Charger capacity 60V, 20A
  - local diesel cost add $.02 / L
  - serves identical community to SBCS
  - No IMC

Findings of Base-Case Analysis

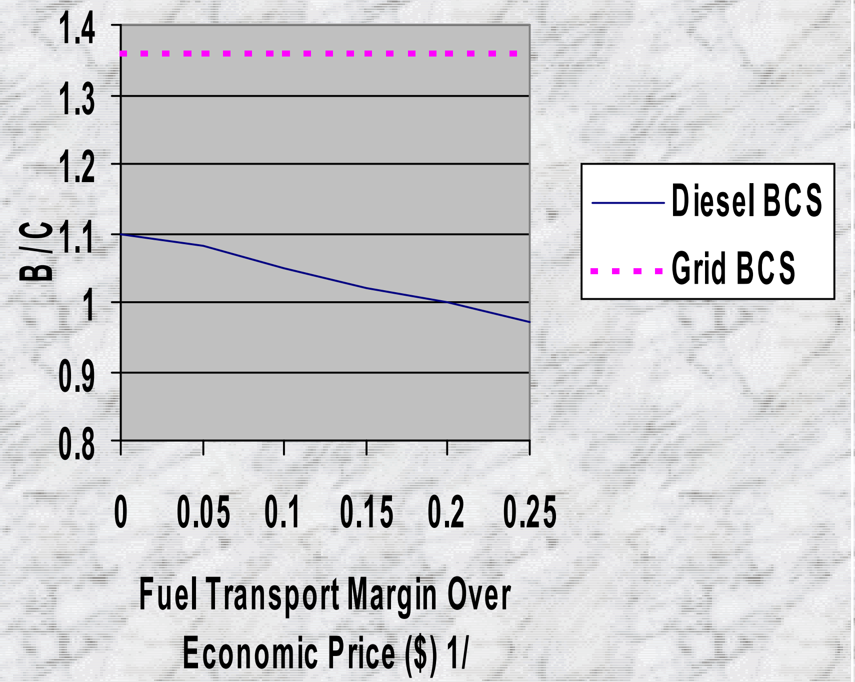
Option	NPV ($/HH-mo.)	B/C
SBCS	7.44	
Diesel BCS	6.81	1.09
SHS	10.01	0.74
Grid BCS	5.45	1.36

Sensitivity to Access: On-Site Fuel Cost

1/ National Economic diesel price assumed $0.18/ litre

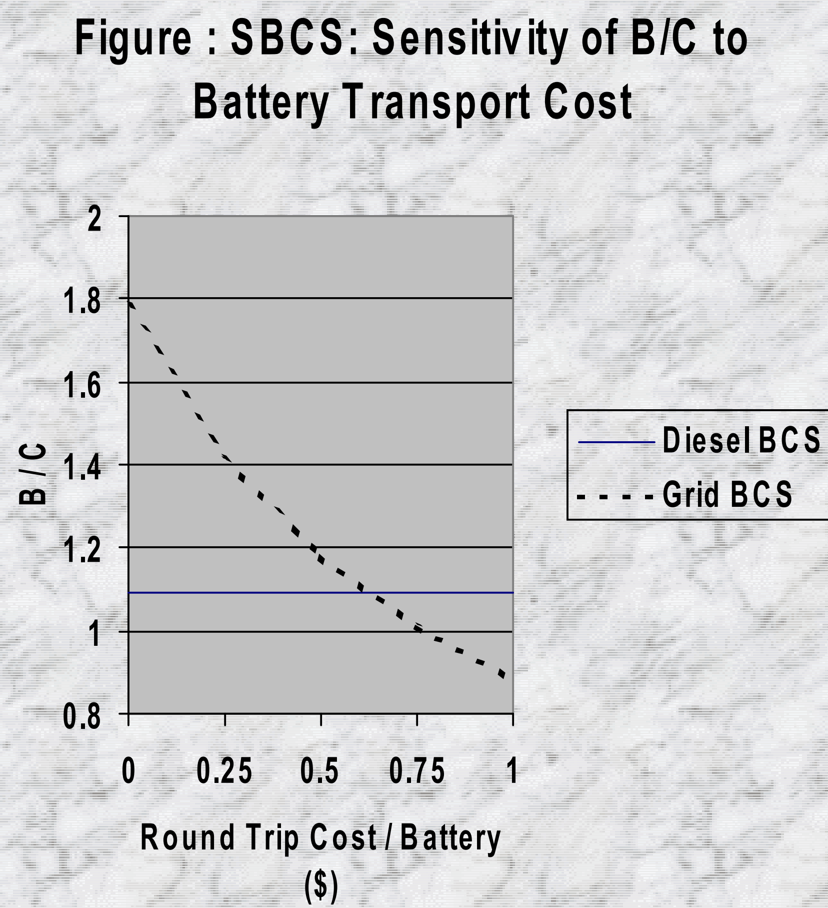
SBCS is not Diesel BCS competitive until local fuel price cost is at least 100% of economic price

Figure 2.3: SBCS: Sensitivity of B/C to Fuel Price



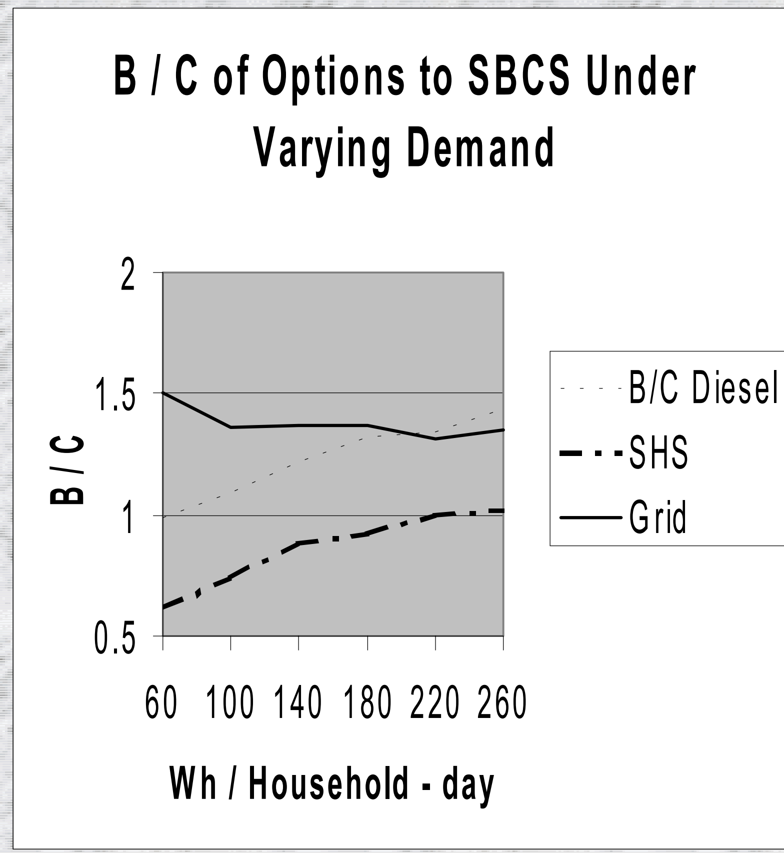
Sensitivity to Access: Battery Transport Cost

- SBCS becomes Grid BCS-competitive when economic transport costs are more than $0.75 / trip



Sensitivity to Demand: A Role for SBCS at low demands

- Low demand = lower Diesel capacity utilization
- as demand increases SHS becomes competitive - cost effective use of batteries



The Synergy of SBCS and SHS

- Same service, potential complementary markets,
- SBCS benefits over SHS markets
  - lower economic costs for low demands - serves lower ATP
  - proof of concept
  - community presence for marketing, finance and servicing SHS
  - modular for conversion to SHS
- SHS benefits over SBCS
  - convenience

Conclusion: What are best practices?

- Keep design simple and low-cost,
- serve basic market demand; allow SHS to serve higher end
- Emphasize operator skills and community participation
- Keep utilization high
- Subsidy may be necessary in remote areas and to pilot/demonstrate technology

Technical Design Features

- Minimize costs
- assume a low load demand- SHS serves higher
- no bus; dedicate panels to each charge outlet
- eliminate HVD; self-regulating system
- meters for charge status of batteries and operator control
- user owns and controls discharge of battery

Organization & Operation Design Features

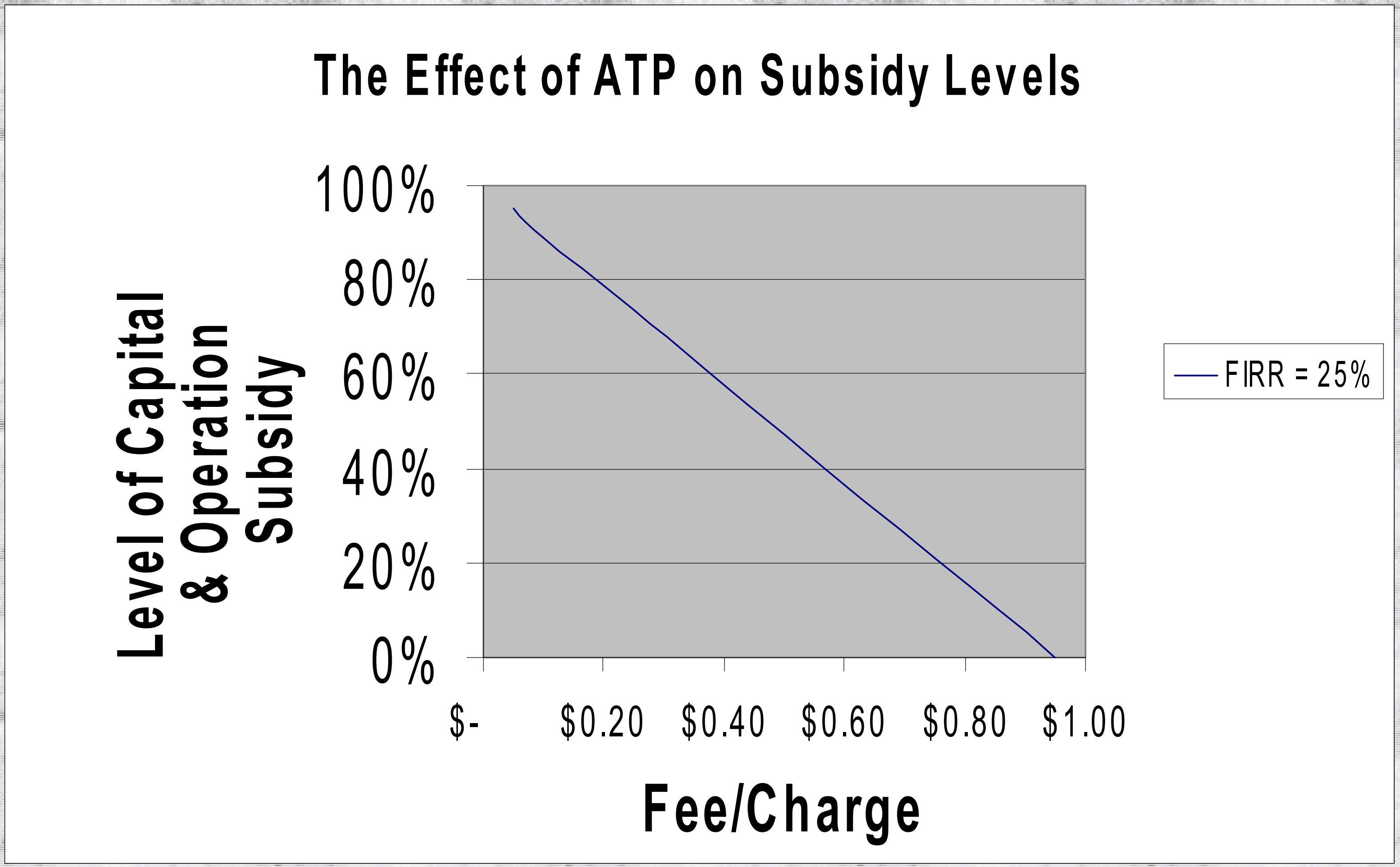
Isolated areas with low Ability To Pay (ATP)

- Often community-control
- Battery SOC rarely monitored
- users scheduled charge time; limit at Stn. (1 day)
- restricted closed market - community sets fees
- few operator incentives

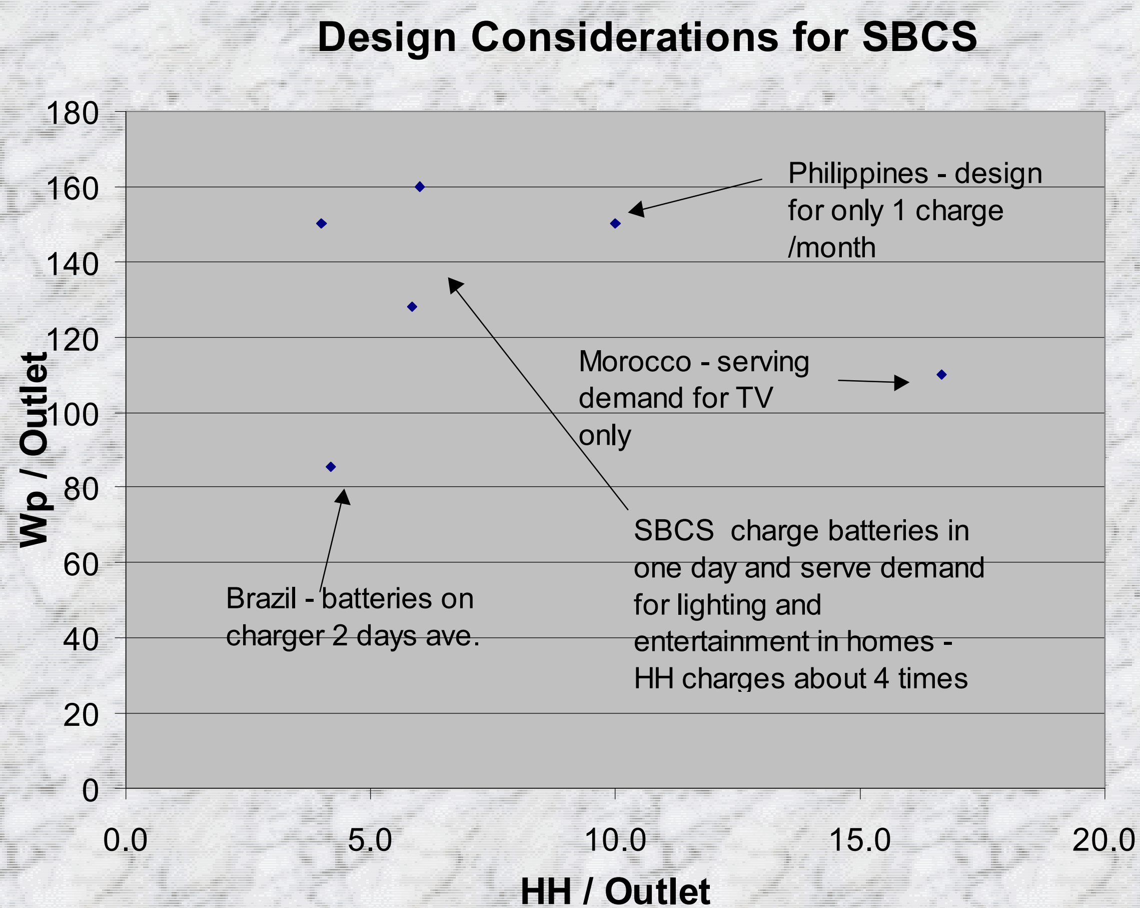
Areas with high ATP

- Owner-operator potential
- Battery SOC monitored before & after charge
- SOC determines battery residence time
- open market - competition sets fees
- operator incentives

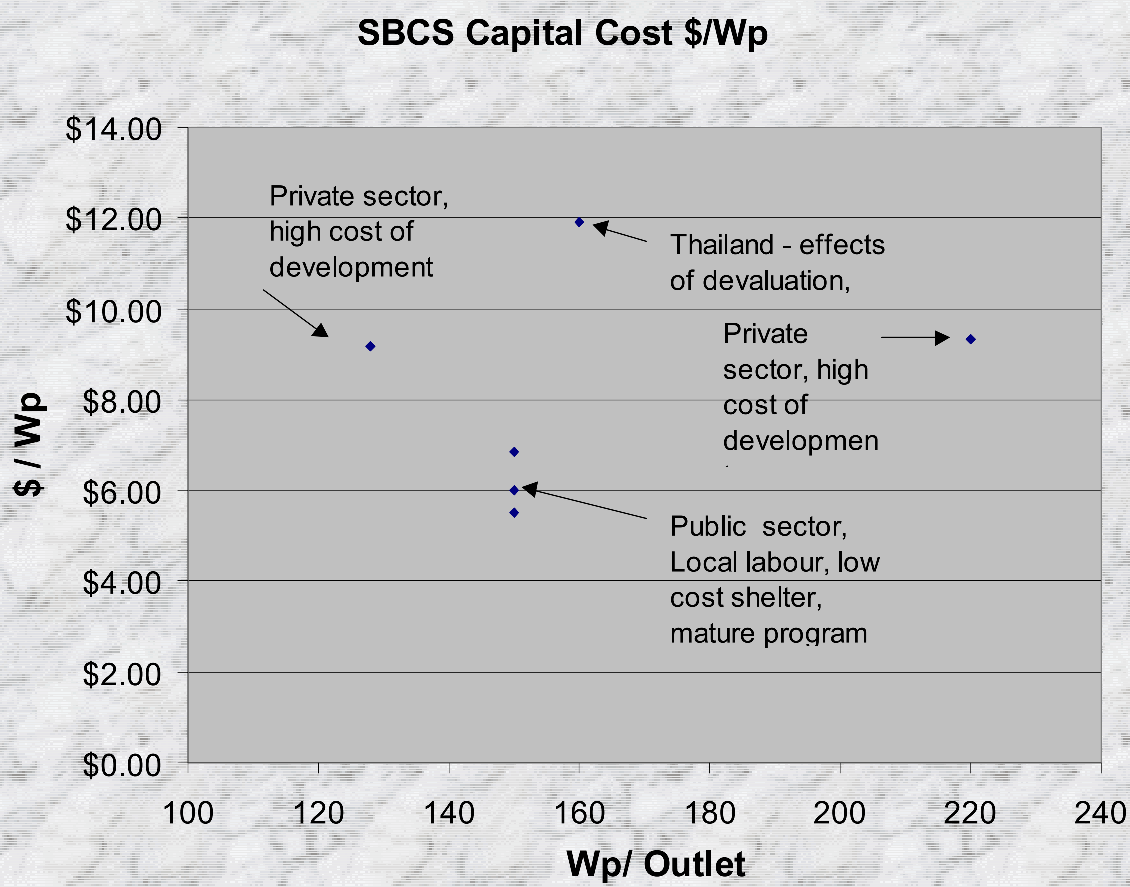
Subsidy May be Necessary



Field Experience: Design



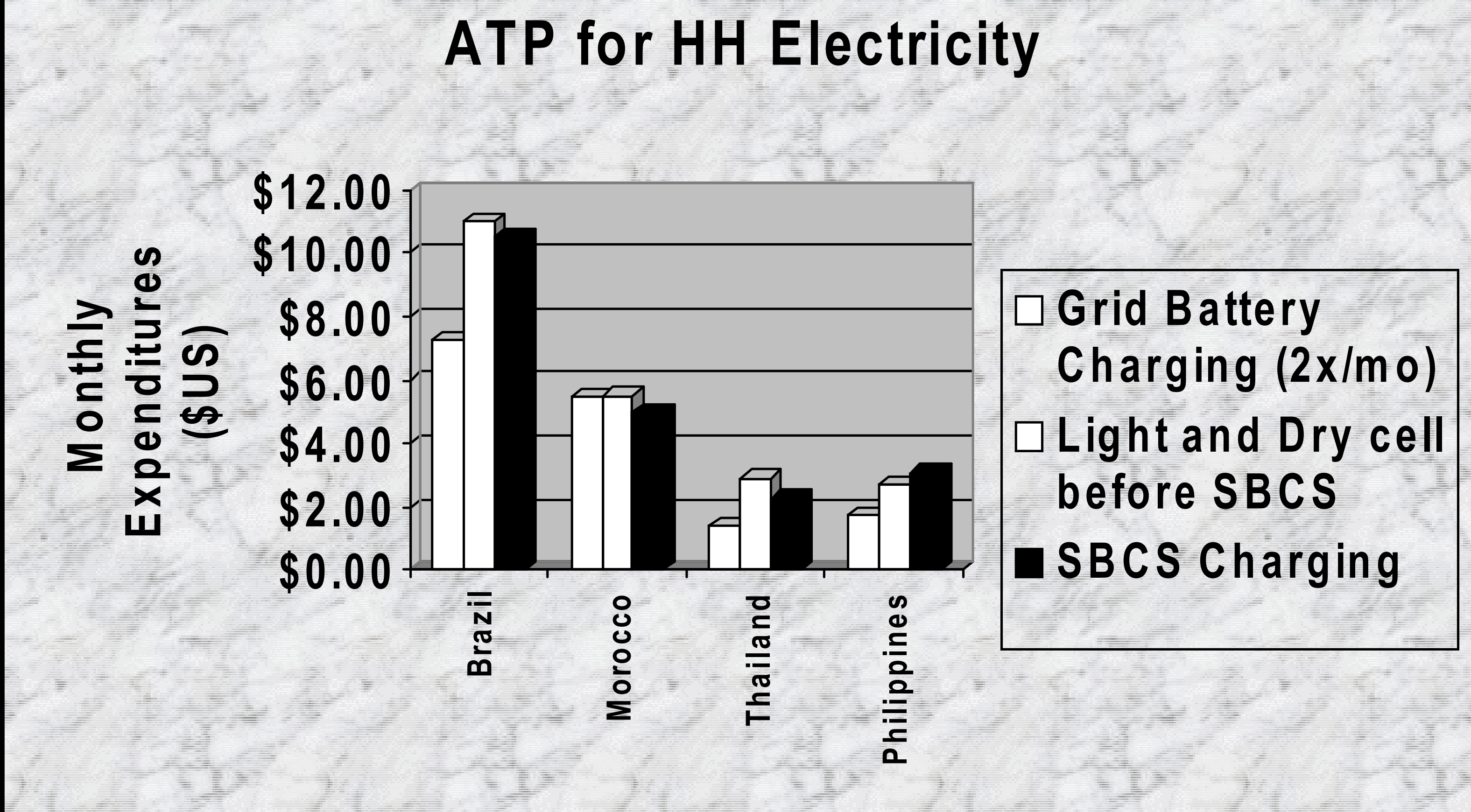
Field Experience: Costs



Field Experience: Implementation and Operation

Country	Implement Institutions	Demo. Costs Borne by:	Implementation Strategy
Brazil	National NGO	US equip supplier & Govt.	NGO mobilizes locally Equip supplier & Devpt Bank finance operator
Maroc	Private firm with franchises	Private Govt / donor aid	Franchise purchases SBCS & set up to market rural energy equip – SBCS “lost leader”
Thailand	Govt. Agencies (2)	Govt	Disadvantaged communities – strong input – capital subsidized
Philippine	Utilities- REC LGU Govt Agncies NGO’s Universities	Donor Aid	Disadvantaged communities – capital subsidized

Field Experience: Financial Considerations



Small Wind Systems for Village Power: An Update

Village Power '98

Washington, DC   Oct. 6-8, 1998

Michael Bergey

Bergey Windpower Co.

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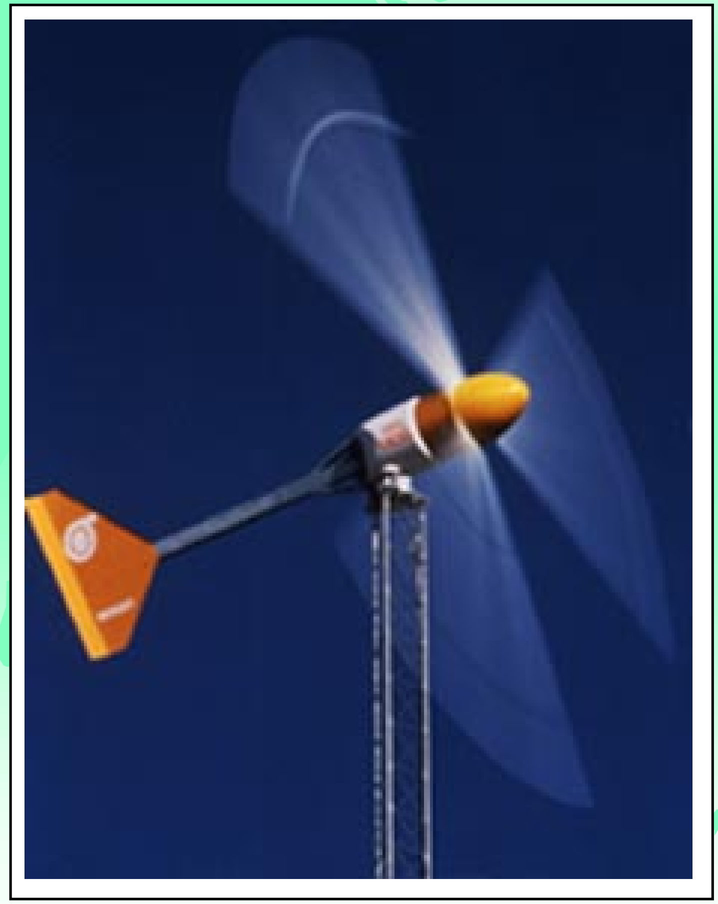
Modern Small Wind Turbines:

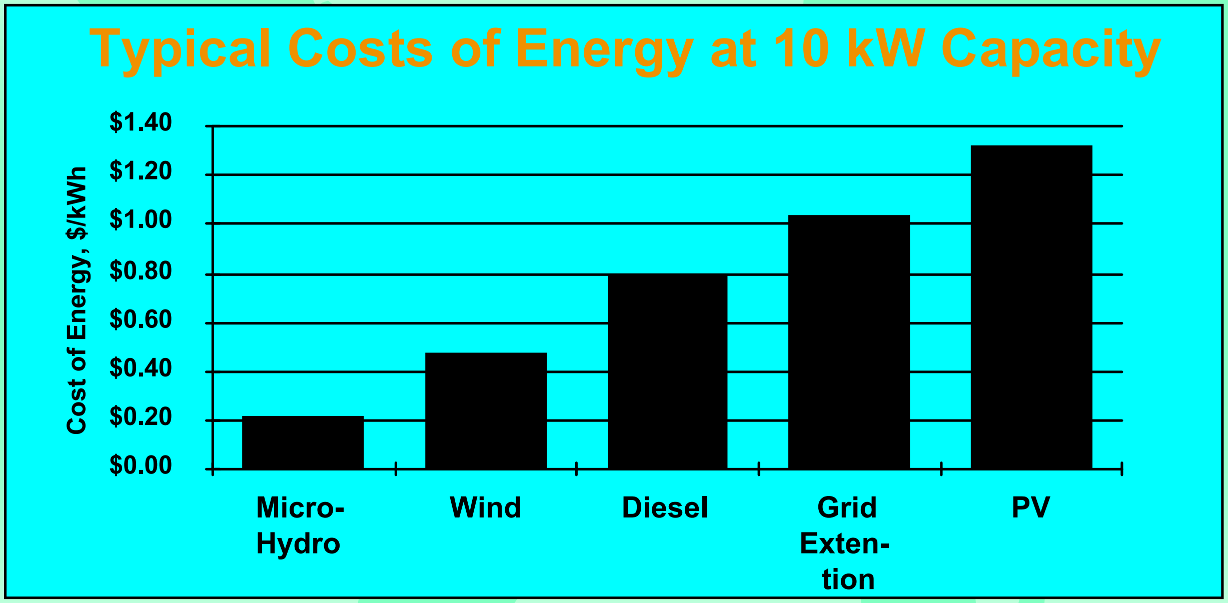
High Tech, High Reliability, Low Maintenance

- 50 W - 50 kW Capacity
- Aerospace Technology
- Mechanically Simple: 3 Moving Parts
- No Regular Maintenance Required
- Low Costs: $ 1 - 3 / Watt
- Proven: ~200,000 Installed, Over a Billion Operational Hours



10 kW Unit (Bergey)

Modern Small Wind Turbines:
A Least-Cost Option for Small Power



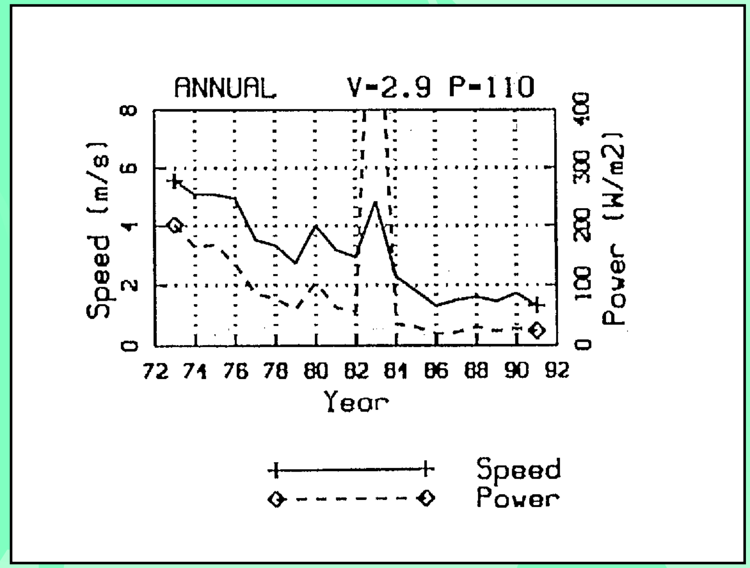
" With reasonable assumptions concerning discount rates, capacity factors, and fuel costs, micro-hydro and wind turbines can have the lowest life cycle costs in locations where the resource is sufficient."

***Fueling Development: Energy Technologies for Developing Countries*, April,1992**
U.S. Office of Technology Assessment

Existing Wind Maps

The Curse of Meteorological Data

- Sheltered Wind Sensors
  - Below Trees, Buildings, Etc.
  - Roof Mounted
- Worn Bearings, No Calibrations, Etc.
- “Disappearing Wind”
- Power ~ $(\text{Velocity})^3$; So 20% Error in Wind Speeds Means ~50% Error in Available Energy

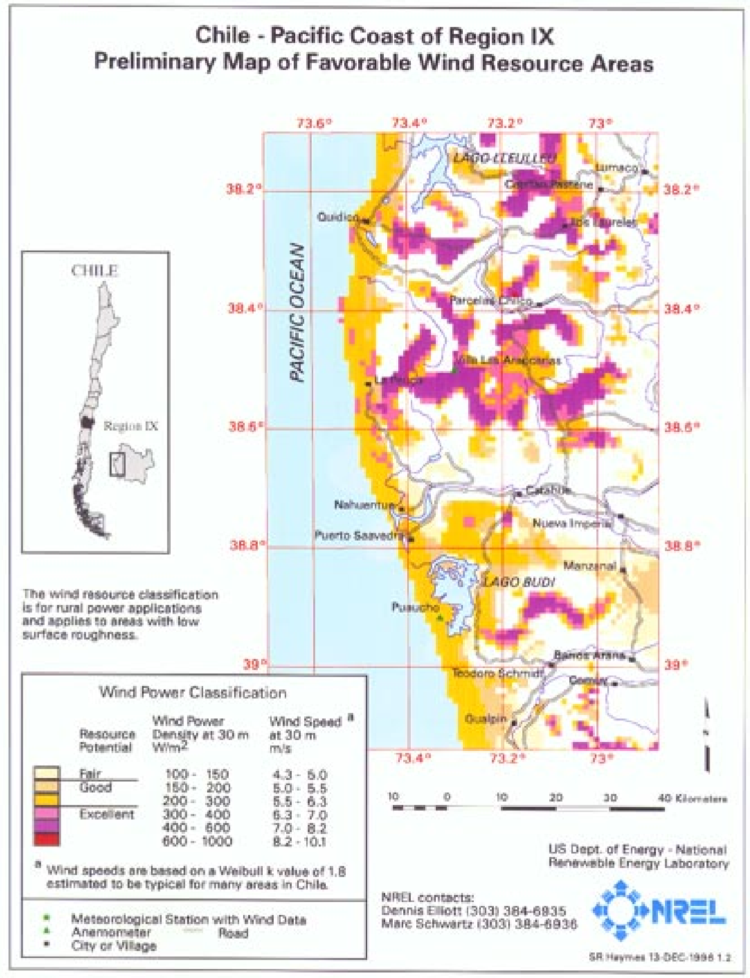


Case of “Disappearing Wind”
Kupang, Indonesia

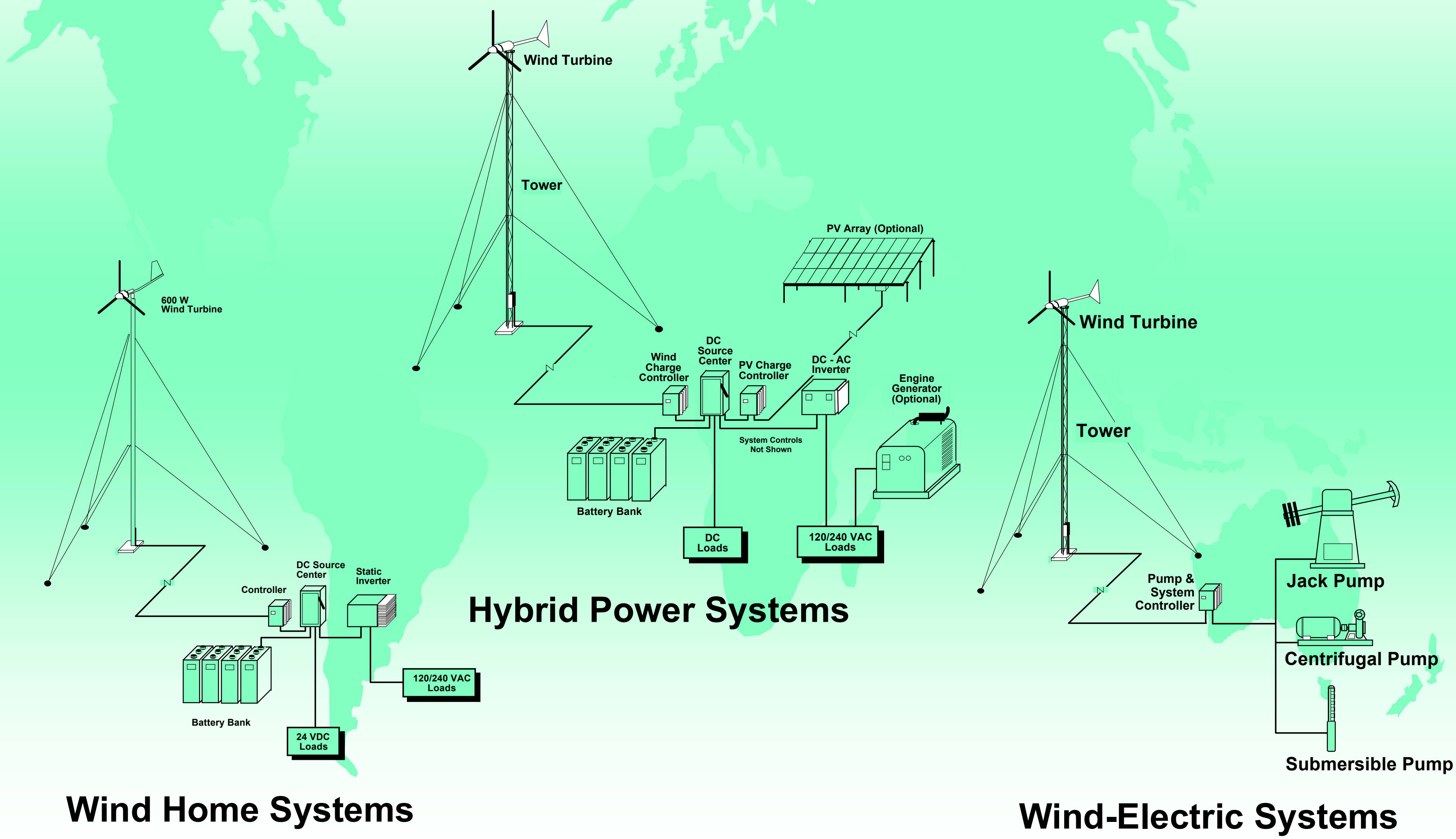
Most National Wind Maps Radically Under-Estimate Available Wind Energy Resources !

Finding the True Wind Resource

- **NREL Wind Mapping with Additional Data Sources: Satellite, Ex-Military Data, Etc.**
- **Low Cost Wind Loggers Specifically Designed for Small Wind Applications**

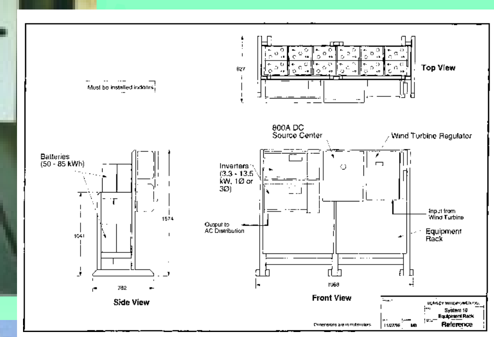


Small Wind Applications



Industry Trends

- Remote Power Markets are Expanding, Companies are Growing Nicely
- Small Wind/PV Hybrids & Wind Home Systems Entering Mainstream of Rural Electrification
- Package Standardization: Lower Costs & Easier Operational Support
- Growing Evidence of Significant Battery Life Extension Due to Charging from Wind



China Rural Electrification

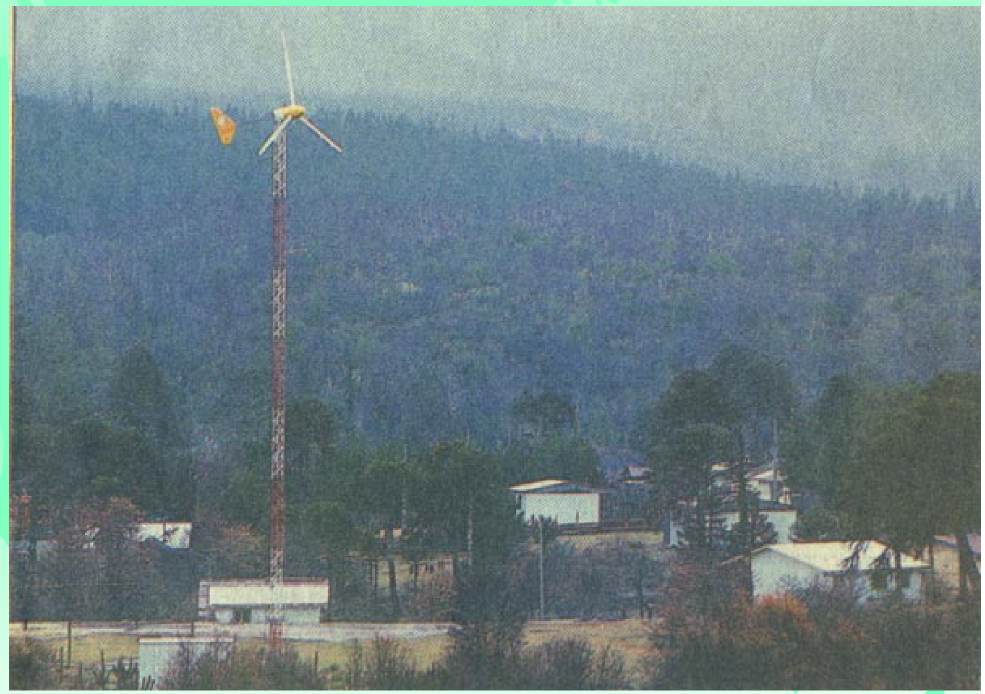
World's Largest Market for Small Wind

- **140,000 Existing Systems**
- **Wind/PV Hybrid Home Systems … SETC / World Bank Project: 30,000 New Hybrid Systems**
- **SDPC "Brightness Engineering" Village Power Program … ~ 35,000 5-10 kW Wind/Diesel Systems**
- **Foreign Cooperation to Improve Technology … Hua De (donor-aid) & Xiangtan Bergey Windpower Ltd (private sector JV)**

Chile Region X Electrification

Wind/Diesel Favored Over Diesel-Only

- **Collaboration Between CNE, Regional Governments, NREL, and NRECA**
- **1997: Region IX Pilot Projects**
- **1998: Region X Pilot Projects**
- **1999: Regional Implementation: Isla de Chiloe**
  - **~ Thirty 3-40 kW Wind/ Diesel Systems**

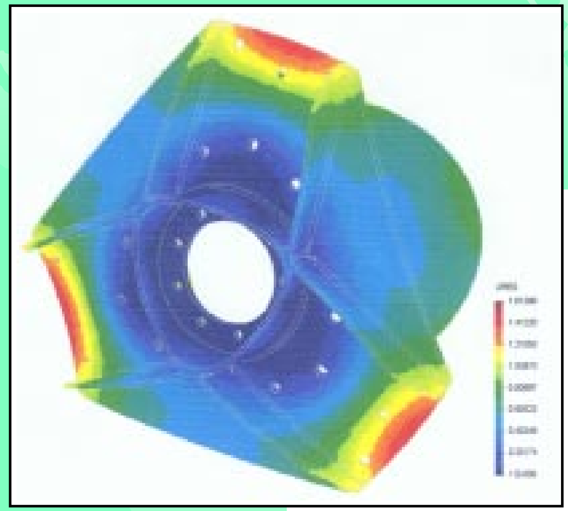


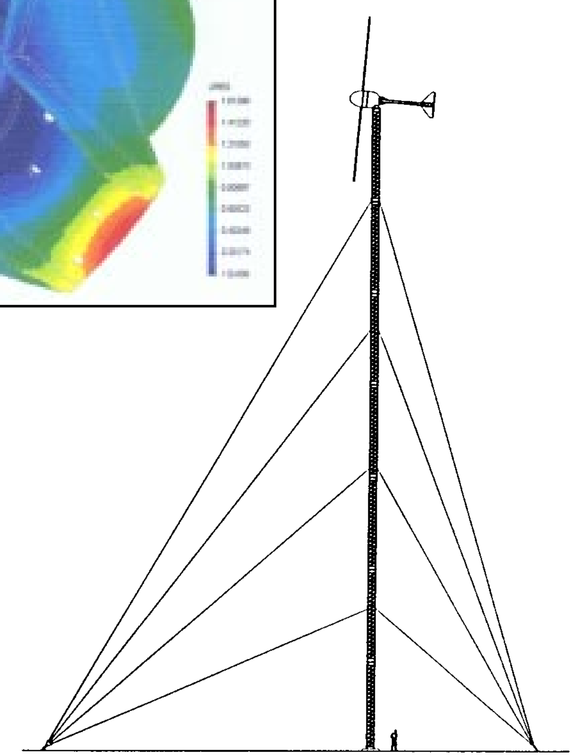
Villa Las Araucarias, Region IX

Advanced Small Wind Turbines

Technology on the Move

- US-DOE Advanced Small Wind Turbine Program … 8, 16, & 40 kW
- Injection-Molded & Pultruded Blades
- Special Low Wind Rotors
- 10 Year Preventive Maintenance Interval; 50 Year Operating Life
- Very Tall Towers, up to 82 meters (270 ft)
- Many Other Private Sector R&D Programs





Request: Let the Markets Work

- PV / SHS is Not a Silver Bullet for Rural Electrification … Consumers Often Want More Than ~ 200 Wh/Day, Direct Current
- Consumers are Technology Neutral
- Small Wind Turbines have Attractive Cost Reduction and Technology Transfer Potential
- Goal of Bilateral and Multilateral Finance and Market Stimulation Programs Should be Best Service at Least Cost
- Industry Seeks New Public-Private Partnerships to Provide Market Transformation Opportunities in Village Power

Status of Biomass Gasifier Village Systems

Ralph P. Overend
National Renewable Energy Laboratory

For: Village Power '98
World Bank Headquarters
Washington, DC. October 6 - 8, 1998

Biomass and Village Energy

Biomass is the World's 4th Energy Source

- Usage of Biomass is widespread in both Industrial and Developing Countries
- The majority is used to provide heat
  - Worldwide 15 PWh thermal and about 150 TWh electricity (15% and 1% of world totals)
- Is renewable if the resource base is managed sustainably
- Advantage in being despatchable

Biomass Utilization

Pervasive in Rural, Urban and Industrial Settings

Daily living
- Cookstoves
- Space heating

Community Applications
- District Heating, Institutions (Hospitals, Administrative Centres)
- Village Industries
  - Drying Kilns, Ovens, Lime Kilns

Industries
- Wood Processing
- Sugar Mills
- Palm Oil

Power and Electricity from Biomass

Mainly in Industry Today - Using “captive” Residues

- Commercially Available
  - Large Scale > 1 MWE output
    - Steam Boiler and Turbines
  - Small Scale < 1 MWE output
    - Steam Boiler and Turbines
    - Gasifiers and Internal Combustion Engines
- Emerging Technologies
  - Gasifier/Combustor - Stirling Cycle
  - Gasifier/Combustor - Gas Turbine (Brayton Cycle)
    - Direct-fired
    - Indirect
  - Gasifier - Fuel Cell

Biomass to Power Systems

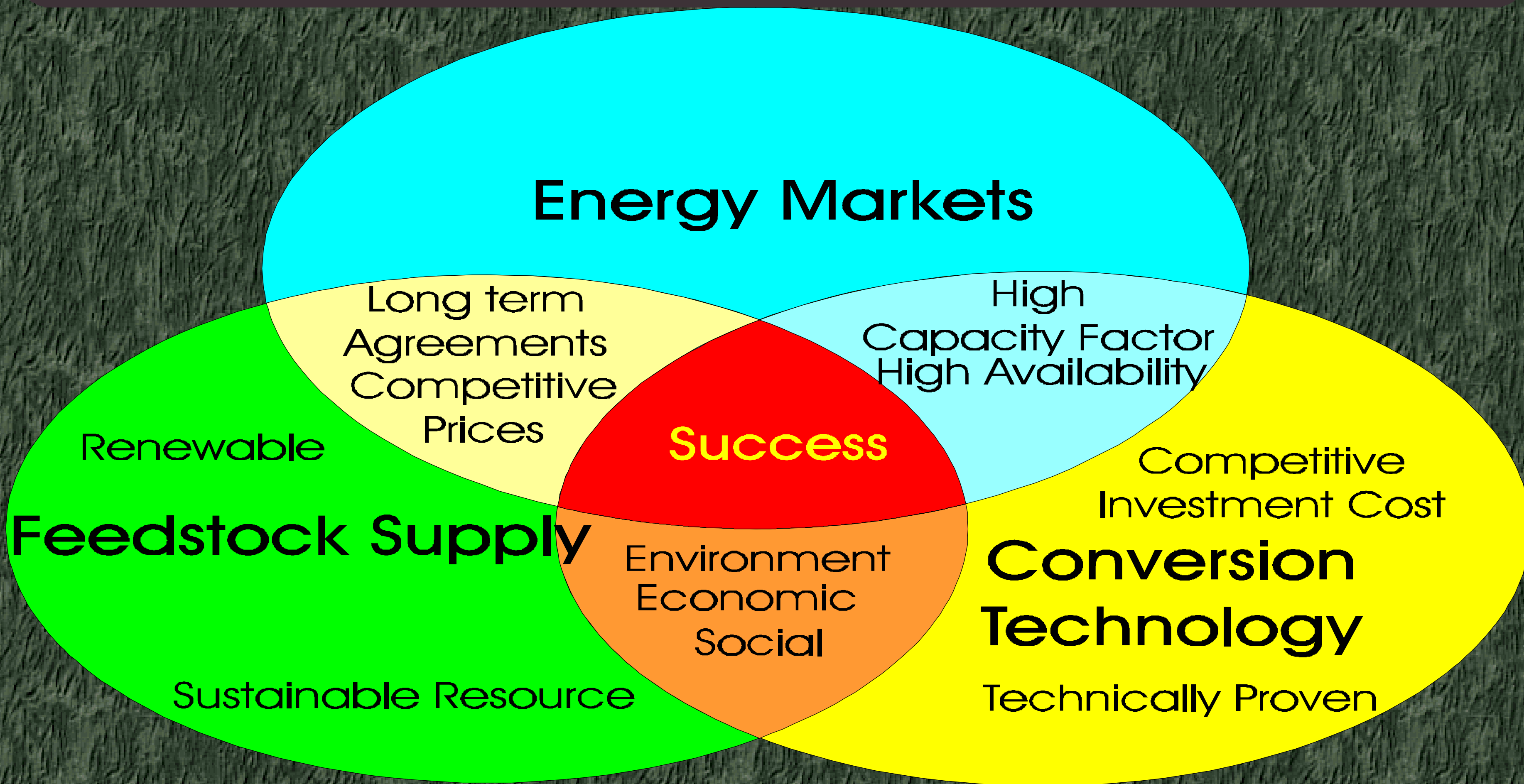
Sustainable Resources and Efficient Technologies are Needed

The essentials of a bioenergy system are:

- Sustainable Resource Base
- Reliable Technology
- Environmental Quality
- Revenue Generation to ensure Sustainability

Biomass and Bioenergy

Criteria for Success



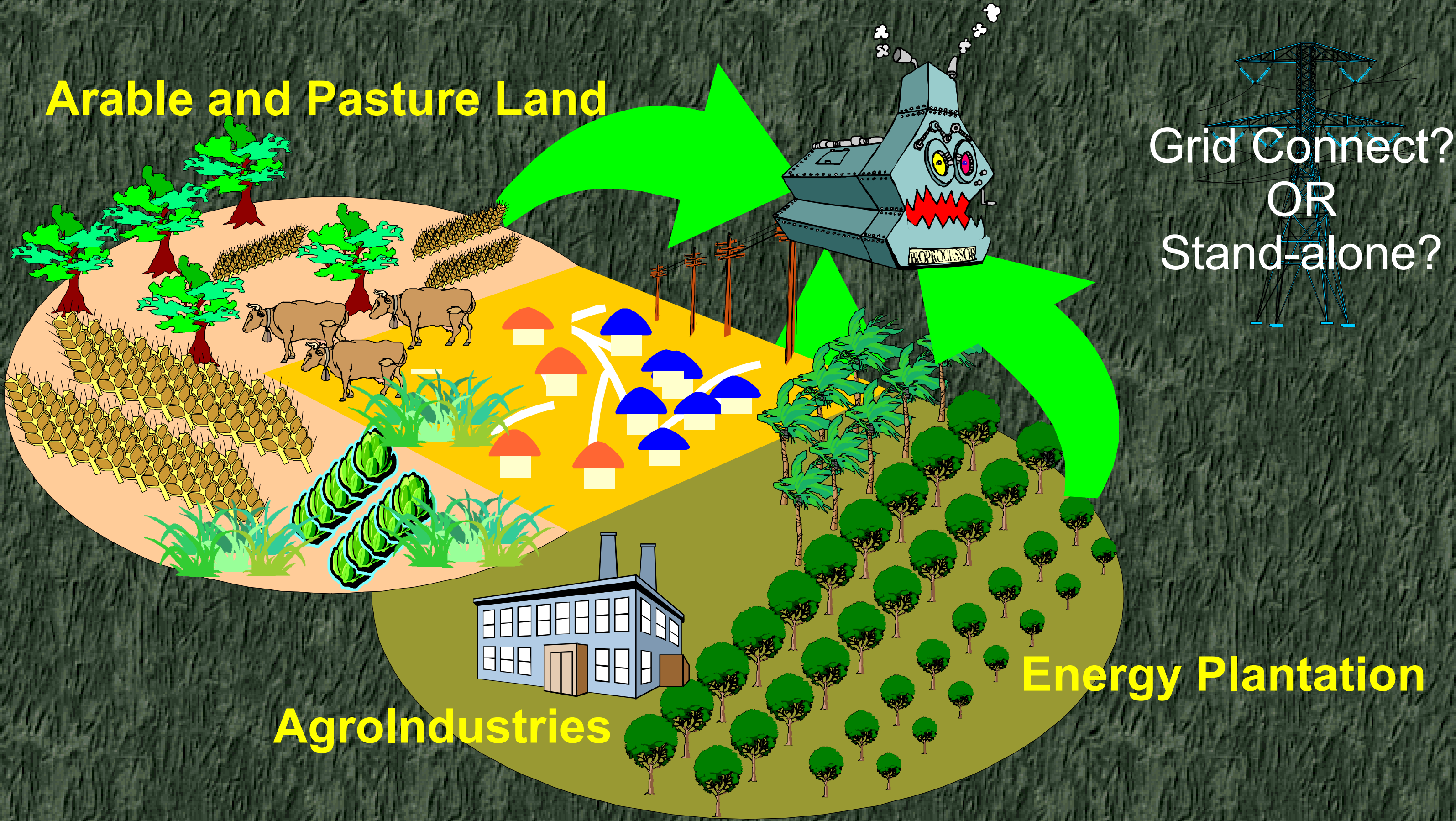
Resource Base Considerations

Available Biomass Criteria

- Available Land
- Crop Production Patterns
- Competing Uses for the Resource
- Logistics of gathering and storing prior to use

Village Power from Biomass

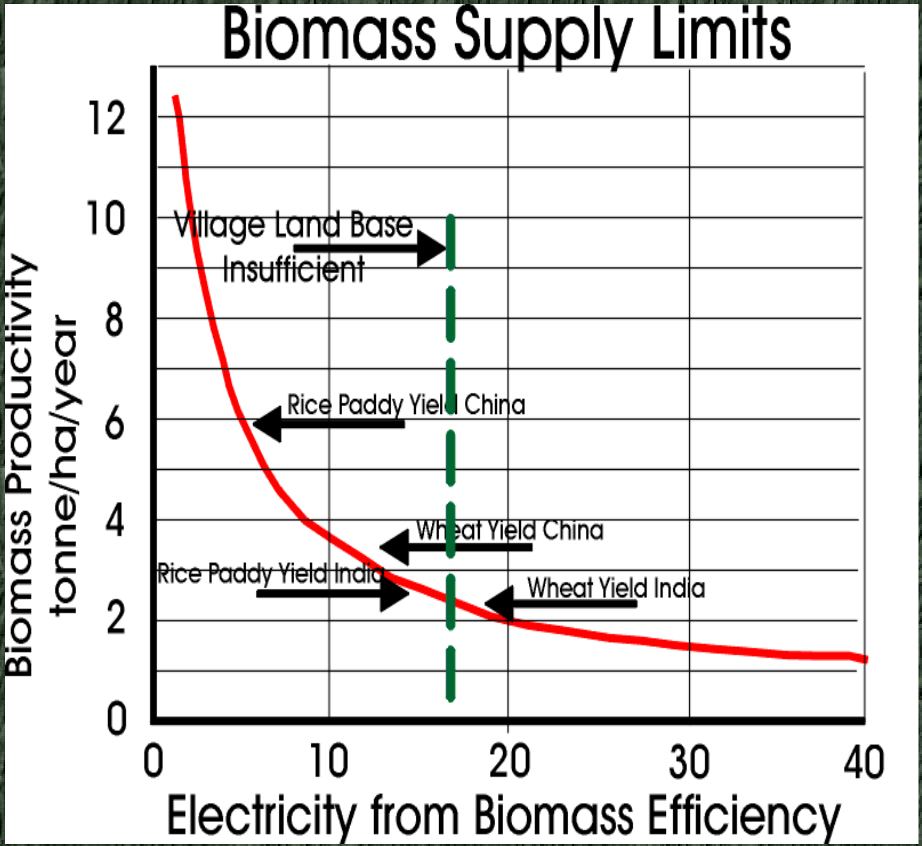
Potential Resources



Conversion Efficiency and Land Productivity

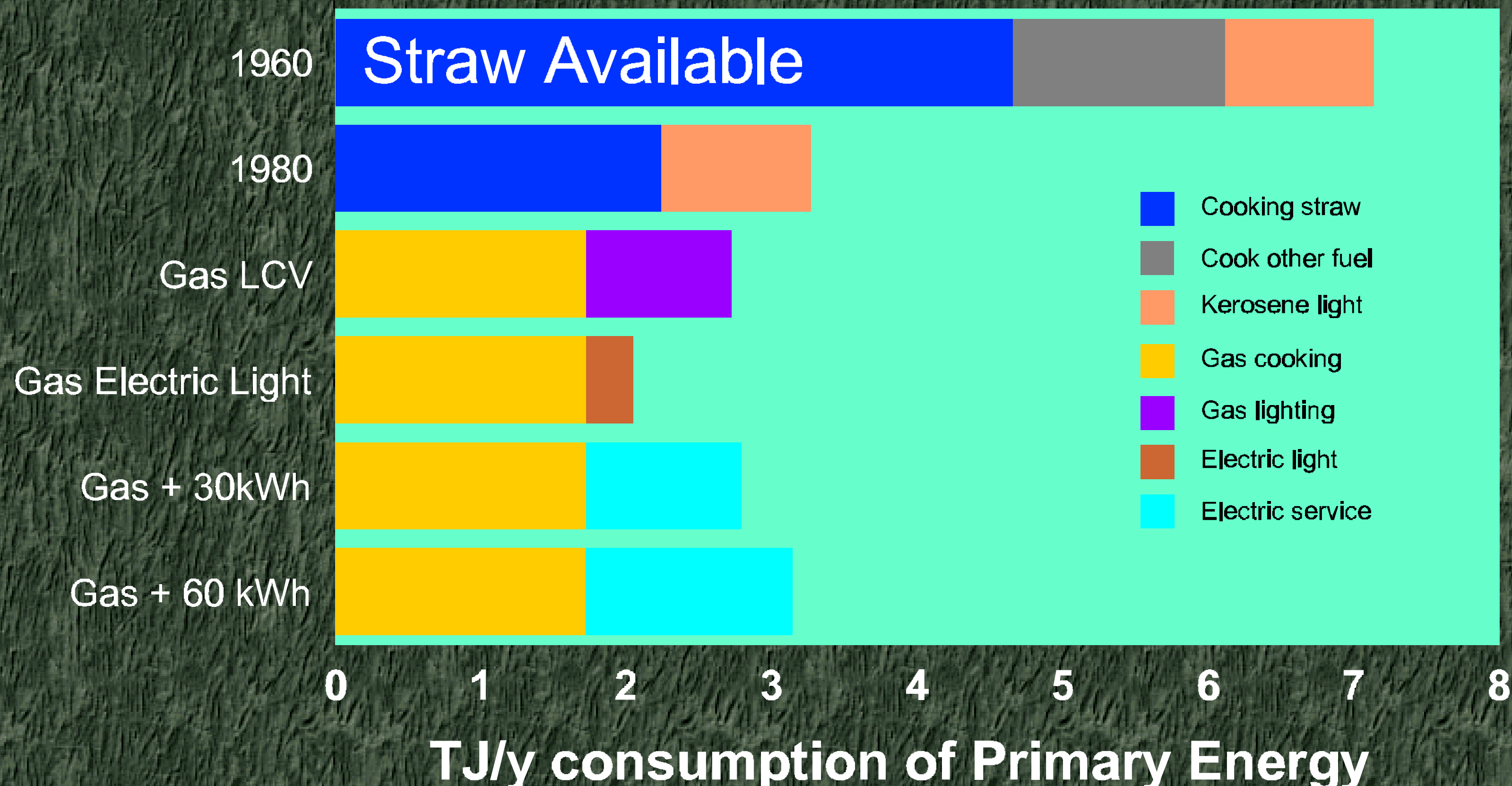
Land Limited to Village Area

- 250 Households
- 4.8 kWh/day supply
- (125 kW peak)
- Land Available
  - 500 ha Arable Land (India)
  - 70 ha of Arable land (China)
- ***NO OTHER BIOMASS RESIDUE UTILIZATION***
  - Daily Living
  - Animal Fodder
  - Animal Bedding
  - Fuel for Village Industry
  - Other products - paper



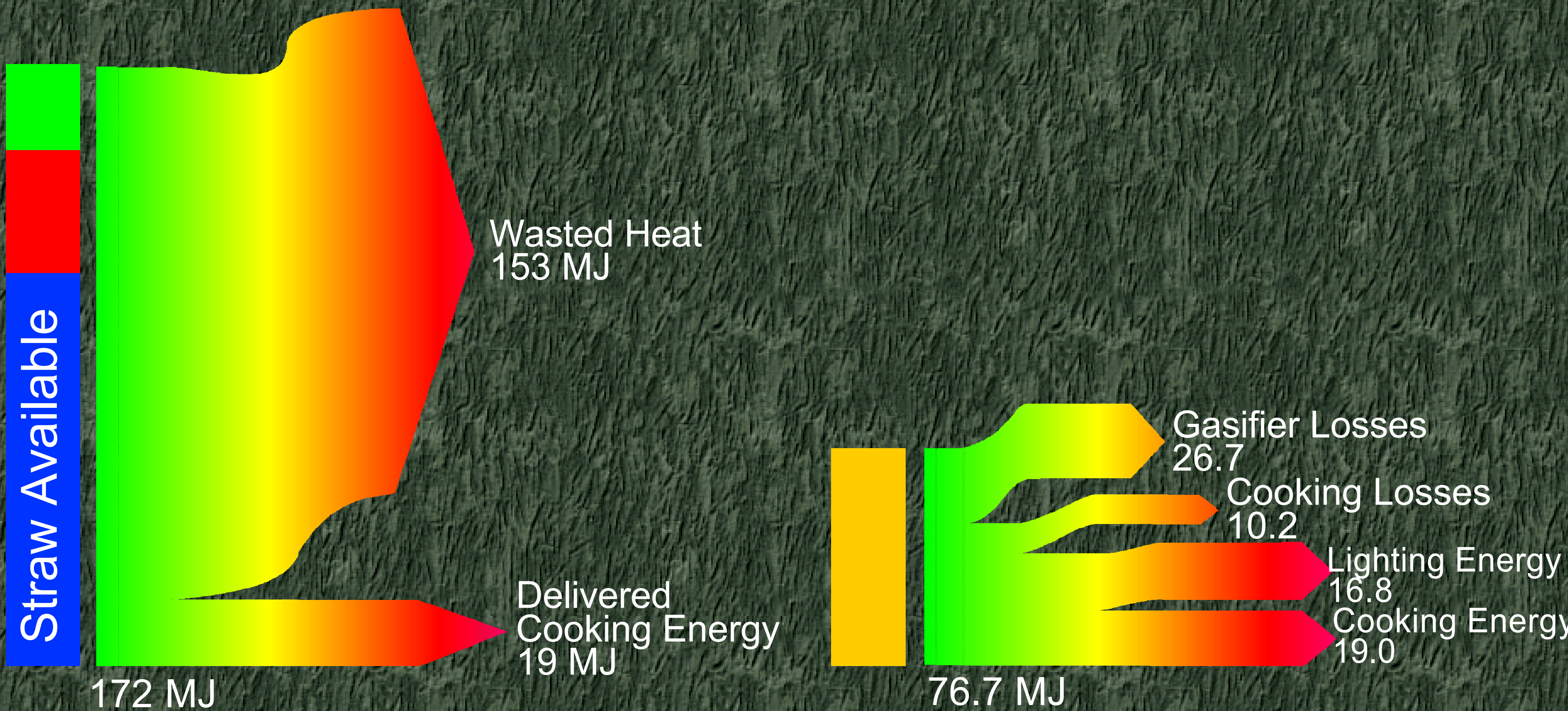
Technology Makes for Better Service

100 households 20 hA arable land - double cropped



Village Energy systems

Moving from 1960-2000



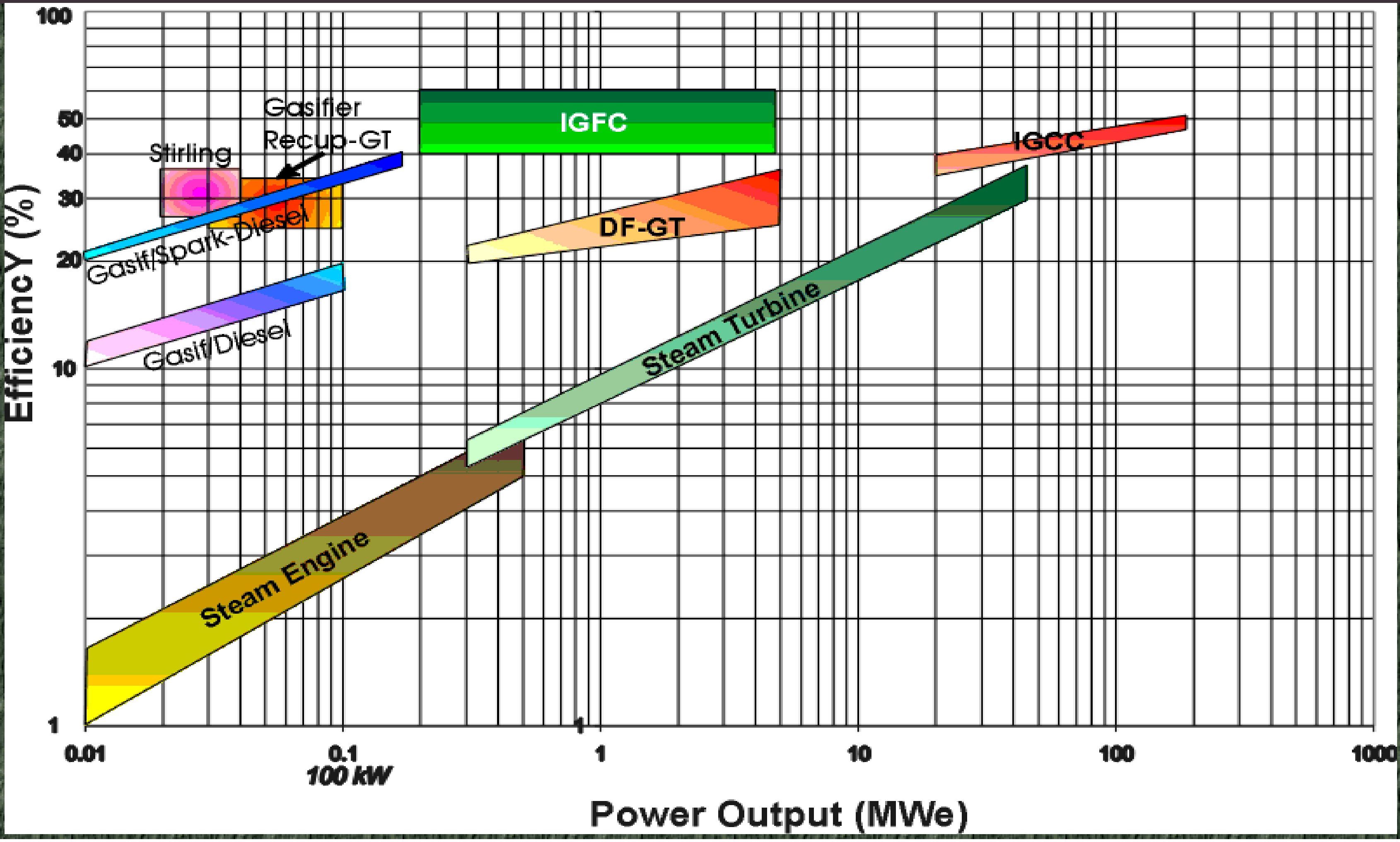
Technology Options

Biomass Pretreatment and Post Conversion

- Physical (Size reduction, slurrying, drying)
- Combustion and Steam Generation
- Gasification - Biological or Thermal Conversion

Conversion Technologies for Biomass

Efficiency and Scale Map



Russian Northwest Territories

Heat and Power from Sawmill Residues

- Verkhni Ozerski - Today
  - 215 Households, 640 Population
  - Current District Heating System and Diesel Electric
  - Diesel fuel cost = 15 - 20 ¢/kWh
  - Ratio of heat to electricity demand 4.5
- Proposed system
  - Efficient boiler to replace existing
  - Steam turbine to offset 87.5% of diesel
  - Cost effective on residues
- Source NREL /SR-210-204040 Prepared by Ecotrade 2/98

Power Generation

Direct Fired

- Steam Turbines and CHP Applications
  - Direct biomass combustion
  - Gasification close coupled to boiler or HRSG
  - Steam turbine
- Internal Combustion - AD gas, Low and Medium CV gas, Liquid Fuels
  - Gas Engines with spark ignition
  - Dual Fuel (with Diesel or Kerosene)
  - Gas Turbines
  - Fuel Cells

Power Generation

Indirect or External Coupling

- Indirect cycle gas turbine
- Stirling engines
  - Direct fired with solid fuel
  - Gas fired with AD gas, Low and Medium CV gas, Liquid Fuels
- Thermionic generators
- Thermovoltaics

Gasification - Biological a.k.a. Anaerobic Digestion (AD)

Handles wet easily hydrolyzed biomaterials

- Animal residues in slurry reactors
  - Chinese individual household systems
  - Intensive animal husbandry - swine, chickens, dairy cows, beef feedlots
- Industrial process residues
  - Sugar mill effluent, breweries, distillation plants, pharmaceuticals
- Municipal solid waste in landfills

Process

- Slurry based
- High and low rate systems
- Efficiency depends on the Resource, and Temperature
- Recycles nutrients to the land
- Costs are high if not justified for environmental reasons

Biogas Product

Anaerobic Digestion/Landfill Gas

Composition
- Methane 55-70%
- Carbon Dioxide 30-45%
- H_2S 200-4000ppm

Heating Value
- 20 - 25 MJ/Nm^3

Utilization
- Electricity via GT, Gas Engine
- Heat for Boilers

Thermal Gasification

Scale limits choices

Simple Process Concept - Difficult to Engineer

Heat + Biomass = gas + pyrolysis oils + char + ash + steam

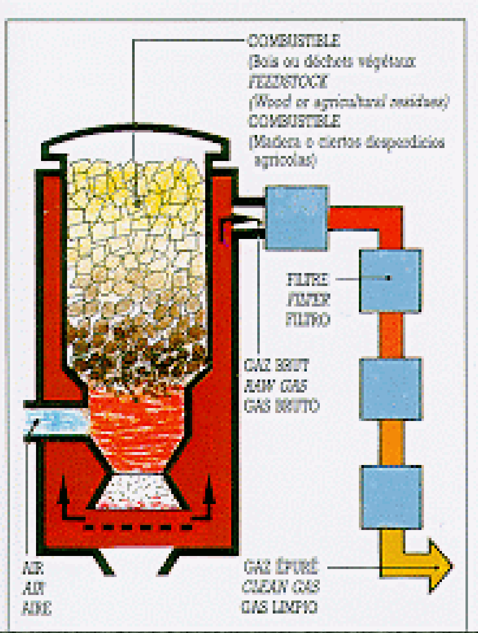
- Internal or External Heating
  - Internal - heat transfer and mixing
    - Counter current gasifiers (Updraft)
    - Co-current gasifiers (Down and cross draft)
    - Fluidized beds - Bubbling or Circulating
  - External Heating
    - By-product gases from charcoal kilns
    - Indirect gasifiers
      - Battelle etc

Biogas Product

Never Clean!

Gas	Heating Value	Percentage	Contribution
Carbon Monoxid	12.6	20.5	2.58
Hydrogen	12.8	17	2.18
Methane	39.8	2	0.79
Ethane	70.4	0.1	0.07
Ethylene	64	0.1	0.06
Nitrogen	0	49.2	0
Carbon Dioxide	0	11.2	0
Heating Value			5.68

- Composition (see Table)
  - Contains water, tars and dust
- Heating Value
  - 15% of natural gas
- Safety
  - Carbon Monoxide is a toxic gas
  - Excess water produced - tar contaminated
  - Tars contain carcinogenic PAHs
- Utilization
  - Close Coupled - >85% efficiency
  - Cold-clean gas 60 - 70% efficient



Commercial Gasifier Technologies

India and China Lead in Units in Service

India

- MNES sponsored subsidy program
- Leading manufacturer ANKUR has installed > 500 systems
  - Moral hazard of subsidy for diesel/gas dual fuel systems
    - 10% of units continue on biomass, the rest mainly on diesel
- Several manufacturers and developers
  - Agroindustry acceptance good
    - Skilled personnel
    - High capacity factors
    - Available low cost residues
- Typical Efficiency 18 - 20%
- Costs (in country) 900 $/kW (3.5 kW) to 400 $/kW (100 kW)

China

Rice Hull Gasifiers

Rice Hull Gasifiers

- Designed for use in central rice processing facilities
- 120 - 150 units of about 160 kW in operation
- Hongyan Motor Works 88.3 Litre gas engine (SI)
  – Compression ration 8.5
  – 600 rpm
- Efficiency 11 - 16%
- Cost (in country) 265 $/kW (1995)

China

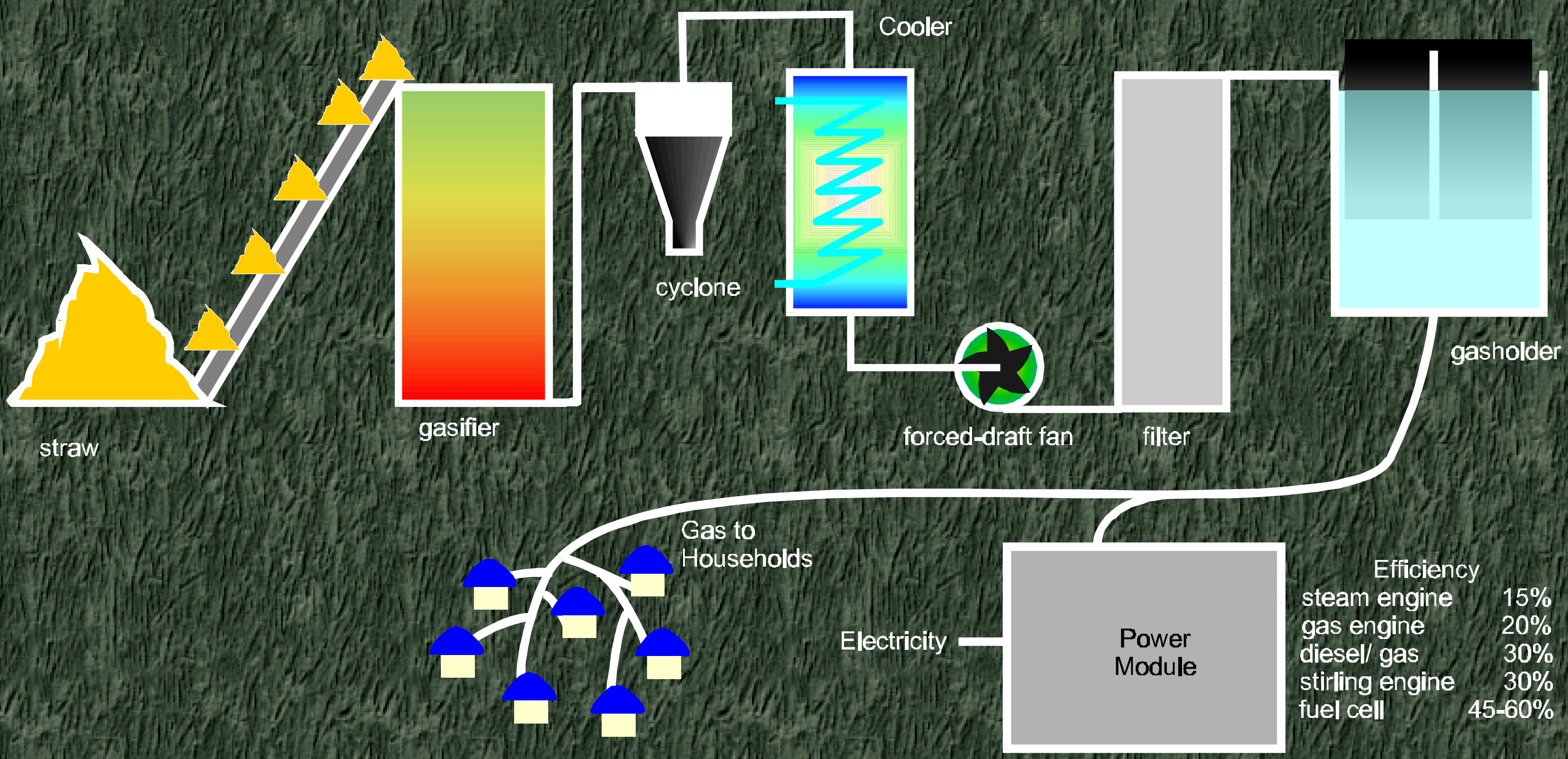
Village Gas - Distribution

Shandong Energy Research Institute

- 100 and 200 Household modules
- Uses agricultural residues
  - – Wheat straw
  - – Corn stover
- Gas Distribution
  - – Low pressure
  - – Plastic lines
- Efficiency overall 42 - 48 %
  - – Cold gas efficiency 70 - 75%
  - – Cooking efficiency 65%
- Investment costs 200 $/household

Shandong Village Energy System

> 20 Village Demonstrations



DOE's Small Modular Biopower Projects

To provide power in the 5 kW - 5 MW range

To develop small modular biopower systems that:
- are fuel flexible
- are efficient
- are simple to operate
- have minimum negative impacts on the environment
- are for domestic and international markets

Multi phase Project:
- Phase 1: Feasibility Studies
- Phase 2: Prototype Development and Testing
- Phase 3: Integrated Systems Demonstration

Team Management - DOE, NREL, SNL

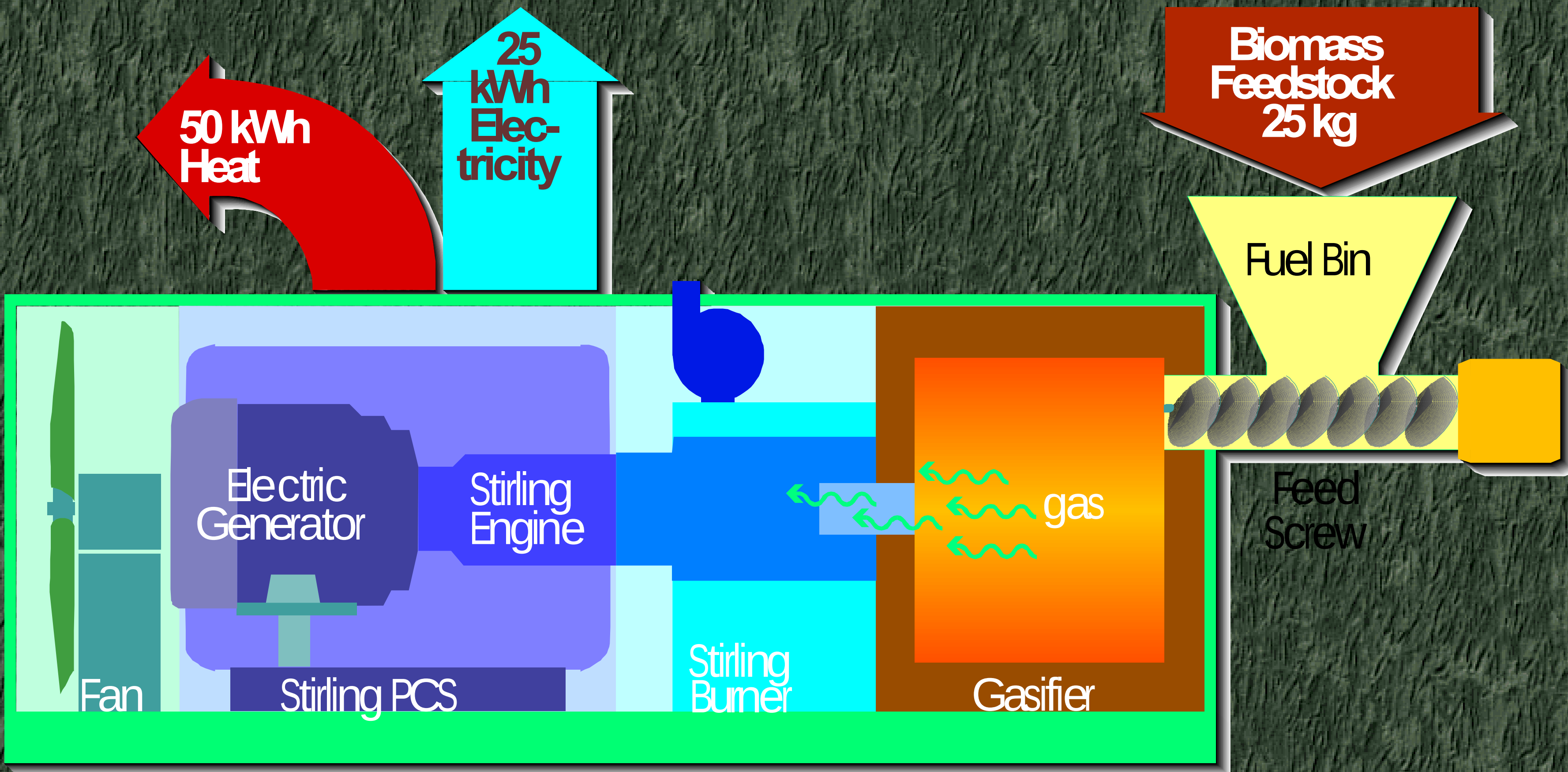
DOE's Small Modular Biopower Projects

Phase 1 Contracts Awarded

Agrilectric	Fluid-Bed Combustor/Steam Turbine	500 - 5000kW
Bechtel	Gasifier/Engines/Gas Turbine	500 - 1500kW
Bioten	Direct-Fired Combustion Turbine	5000kW
Carbona Corp	Gasification/ Steam Turbine	1000 - 3000kW
Community Power Corp	Gasification/IC Engine	10 - 25kW
EERC	Fluid-Bed Combustor/Steam Turbine	500 - 5000kW
Niagara Mohawk	Gasification/IC Engine/Gas Turbine	500 - 5000kW
Reflective Energies	Gasification/Gas Turbine	100 - 1000kW
STM	Gasification/Stirling Engine	25 - 70kW
Sunpower	Gasification/Stirling Engine	1 - 10kW

Biomass fueled Stirling Engine

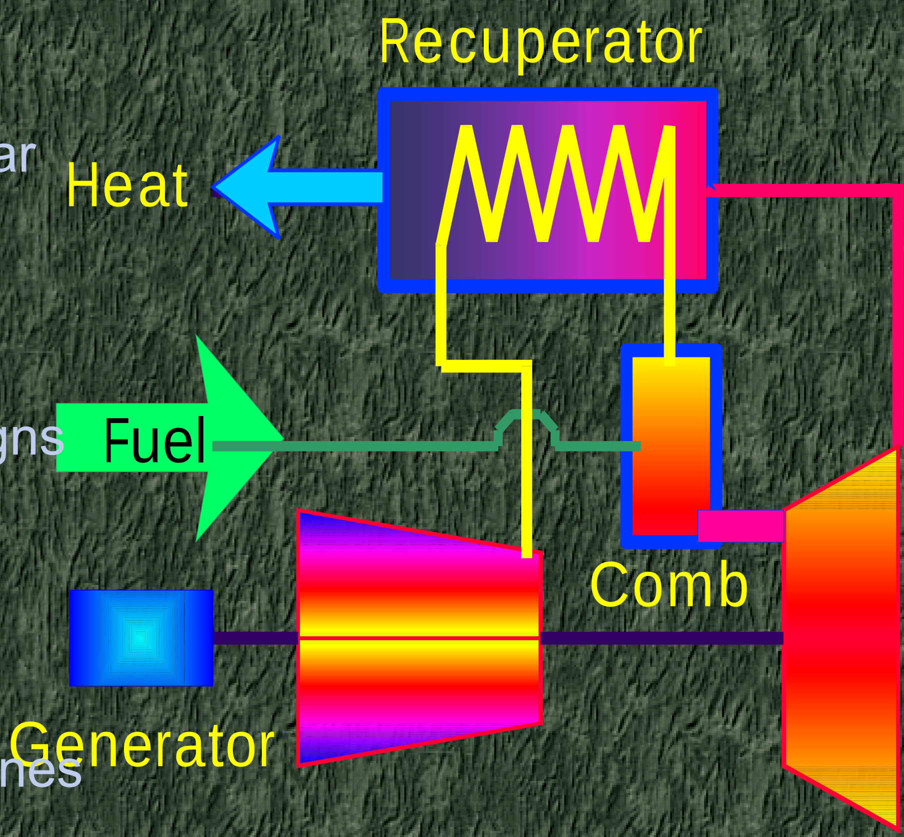
Proof of concept demonstrated in USA and Europe



Innovative Turbine Concepts

Reflective Energies

- Central Problem in Gas Compression
  - Requires clean gas (particle and tar free)
- Low Calorific Value Gas Combustion
  - Challenge to existing turbine designs
- Novel Concept
  - Catalytic combustion
  - Use of turbine inlet compressor
    - To compress a fuel and air mix
  - Applicable to a wide range of turbines
    - Micro-turbines 40 - 75 kW
    - Multi-MW units



Conclusion

Key Elements for Development

- Ability to use Agricultural Residues at High Efficiency
  - Fuelwood declining
  - Ag crops increasing, Urban/Village wastes growing problem
- Future Systems Have to make Productive Use of Heat
  - All systems are heat engines
    - – Turbines and Stirling concepts can produce high quality heat
- Environmental Performance Improvements are Needed for GASIFIERS-IC Engines
  - Overall system performance with respect to
    - – Air emissions - Nox, CO and particulate
    - – Water emissions - particulate, tars, phenols
- Advanced Technologies
  - Increased efficiency
  - Potential synergy with automotive and other developments to reduce costs

Acknowledgments

The mistakes and omissions are mine!

The NREL Team: Rich Bain, Kevin Craig, Helena Chum, John Scahill, Matt Ratcliff, Esteban Chornet

The China Team: Deng keyun, Dai lin, Li jingming, Sun li, Bai jinming, Zhang zhengmin, Li jingming, Wang yaojun, Luo weihong

Thomas B. Reed (doing a gasification survey!)

Ed Gray- Antares, Stephen Brand - Thermogenics, Inc., Rob Walt - Community Power Corp., Eric Larsson, Princeton, Prof. H.S. Mukunda IIS-Bangalore, Stephen Joseph -BEST, Lennart Johansson - STM, Serge Adamian - Ecotrade, Edam Prabhu -Reflective Energies, Dean B. Mahin Consultant, Lakshman Velupillai - LSU, Pat DeLaquil -EnergyWorks, Hubert Stassen -BTG, John Black -BBC Engineering, Mark Paisley -Battelle.

Work carried out under the USDOE - OUT Power Program -Gary Burch and Ray Costello

NREL is a national laboratory of the USDOE managed by Midwest Research Institute

Contract DE-AC36-83CH10093

A Hybrid Renewable Energy Based Rural Electrification Project for Eastern Indonesia

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INTRODUCTION

Through a large scale rural electrification project it is planned to supply 66 villages in Eastern Indonesia with renewable energy based hybrid electricity systems which have peak kW power delivery capacities from 20kW up to 50kW. The anticipated respective energy outputs of these systems will be in the range of 50kWh up to 150kWh per day. The hybrid power system is a combination of conventional and new renewable energy sources.

Indonesia, the fourth most populous nation in the world, is an archipelagic country with over 13,000 islands and a census population in 1990 of 182.6 million. This number now exceeds 200 million people. The country is comprised of 27 provinces that consist of 63,000 villages. In the last decade (1980-1990) the national population grew at 2.13% per year in average. At 1990 over 77% of the national population was living in rural areas and 23% in urban areas.

Major infrastructure developments needed in Indonesia include transportation, communications, education, health, clean water, sewerage and energy supplies. Energy supply is especially important within the economic development question in that it is also a basic resource needed for most of the above infrastructure items. Beyond this the rapid growth in the need for additional electricity capacity imposes significant impacts, not just upon Indonesia but also in a global sense with increasing international concern over the greenhouse issues.

Advanced Energy Systems Ltd (AES) has been involved in various project activities in Indonesia and elsewhere internationally since 1988 at which time AES was subcontracted by the Western Australian Government to undertake a study of the potential for new energy technologies in South East Asia. In August 1994 representatives from the Indonesian Agency for Assessment and Application of Technology (BPPT) visited Australia and this was followed by an invitation for AES to attend a UNESCO round table conference held in Jakarta early in 1995. A number of visits have been made to Eastern Indonesia whereby a great deal of data has been compiled in regard to regional requirements, demographics and cultural issues.

DEFINITION OF THE DEVELOPMENT PROJECT

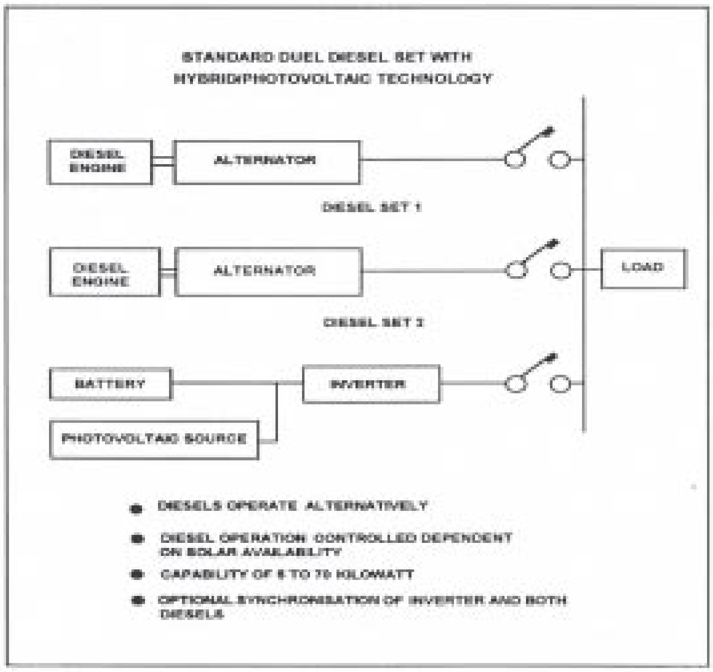
Each village included in the project will have a localised distribution network installed and connected to the centralised renewable hybrid power station. The renewable hybrid system (as depicted in the block diagram below) will comprise various components that will be integrated into the total system. It is planned that two systems will be utilised; System A which will serve villages from 75 to 125 households and System B which will serve villages with 150 to 250 households.

The components include the following:

- Renewable component such as photovoltaic modules or small wind turbines
- Storage devices such as lead acid batteries
- Power electronic conversion unit or inverter
- System control module with inbuilt remote monitoring and control capability
- Diesel engines
- Small power station enclosure
- Electrical distribution system

- Household wiring kit
- Prepayment meter system

The hybrid design approach is considered to be technically superior to the solar panel home lighting approach as the hybrid system can deliver much greater amounts of energy at lower cost per kWh while also meeting industry, education and health needs in the process. The hybrid system is expandable and very flexible with both the service and the cost being able to be spread over the whole village. This ensures equity in cost sharing and access to the service.



Hybrid System Overview

An Integrated Electricity Plan (IEP) will be implemented at the cooperative level (KUD) with revenue being collected through the rural banks. The local village KUD or another authorised KUD will manage designated locations at which electricity will be prepaid and will also be involved in future demand and supply side management options. It is intended that this will incorporate metering capable of storing a credit payment system.

The network and hybrid power station will have communication mechanisms installed which will enable remote monitoring and local service networks to ensure that the village's IEP plan is maintained. The initial support, transfer of ownership and eventual full local support of the system will be a central part of the projects objectives.

SECTORAL DEVELOPMENTS RELEVANT TO THE PROJECT

The application of renewable energy and solar electric photovoltaic (PV) systems in Indonesia is directed especially towards rural areas, remote islands or areas where an electricity grid is not available. During the 1990s the utilisation of PV systems has been growing and the total capacity of PV systems installed by the end of 1993 was estimated to approach 2MWp. This included more than 16,000 solar home system (SHS) units, approximately 370 units solar PV for small refrigerators for rural health clinics, approximately 110 units of PV water pumping systems, 22 small scale television repeater stations, 120 public television receivers and 50 telecommunications repeaters.

It is relevant to understand the institutional environment in Indonesia. As the power utility (PLN) undergoes corporatisation and possibly fully privatisation in the near future it will then be likely that many areas of remote Indonesia will not be serviced with electricity. Such rural energy services are typically loss making for a mainstream utility and not commercially attractive for any utility. Ministerial decrees have been issued in regard to the conditions relating to private power providers.

This project lays the basis for possible private sector operation of renewable energy systems in the areas not currently or likely to be serviced by PLN.

Four PV hybrid pilot systems have been installed to study the potential of optimising the energy resources available. As a continuing effort in rural area electrification an installation of 50MWp total capacity of SHS (one million households) is to be implemented during the FYDP VI (1994/95-1999/2000). These programs have placed Indonesia in the forefront of international developments of renewable energy systems.

RECIPIENT GOVERNMENT PRIORITY

In order to promote the social and economic development of rural Indonesia the Government has established rural development and electrification as an issue at the highest political levels. Unfortunately the fragmented geography of Indonesia creates special problems for rural electrification not faced by most countries. Local grid projects using generation from wind, photovoltaic, hybrid or geothermal sources are in the pilot or planning stages and individual household photovoltaic systems have been installed in pilot villages.

The Indonesian Government places this project high in relevance to national, regional and provincial strategies. The priority for the development of new and sustainable infrastructure in Eastern Indonesia has been well documented. President Habibie outlined the case most succinctly at the 1995 UNESCO round table conference in Jakarta when he said:

"Solar energy utilisation in Indonesia will get an attention. It is used to solve the micro economic problem of ratio of GDP growth toward population growth in remote villages. 61.3% of Indonesians do not enjoy electricity. How can you ever expect small industries to be very efficient and productive if they do not have electricity."

Solar photovoltaic generation and its application in utility grade hybrid systems is of particular interest because of its flexibility, low environmental impact and greater freedom from fuel requirements. In the last five years the Government of Indonesia has participated in projects resulting in the installation of over 1MWp of photovoltaic capacity in rural areas of the country.

AUSTRALIAN DEVELOPMENT ASSISTANCE OBJECTIVES

Australia's assistance program aims to address more effectively Indonesia's emerging development priorities.

Over five years, commencing 1993/94, the documented AusAID policy has been:

- Continue to focus mainly on projects in Eastern Indonesia with an emphasis on poverty alleviation, infrastructure development and environment management
- Maintain and consolidate the sectoral focus on human resource development
- Contribute to poverty alleviation through family planning and maternal and child health activities and support for local community development activities
- Promote closer economic and commercial linkages and relations between the Australian and Indonesian private sectors and productive enterprises through activities which support Indonesia's development goals

In accordance with Indonesia's priorities Australia's program seeks to:

1 Contribute to Indonesia's development through practical cooperation in areas of mutual interest, particularly in sectors where Australia offers a high degree of relevant expertise

2 Promote bilateral economic links which are consistent with sustainable development and conducive to long term partnership

Poverty alleviation has become a major focus of Australia's development cooperation program. Australia's technical assistance projects in Eastern Indonesia focus on agricultural development and the provision of infrastructure. The environment and ecologically sustainable development and the involvement of women are key issues which touch on all of Australia's development cooperation objectives. The success or otherwise of many of Australia's development cooperation activities in Indonesia depends on community commitment and involvement.

PROJECT DEVELOPMENT ISSUES

Based on the experience gained to date from developing renewable energy in rural areas there are several major issues, particularly appropriateness of technology, affordability and sustainable human resource development. Renewable energy technology requires a significant capital investment and this must be accounted for in the financial arrangements of the project. However the life cycle cost of extending utility power is higher and will be loss making for the power utility involved. Other points are as follows:

i) The renewable energy hybrid system offers a new approach whereby an affordable service can be provided to all of the villagers.

ii) This project seeks to specifically build in sustainability and support as a key part of the project itself. Sustainability is to be achieved by the development of local economic activity and a training program to build local capability.

iii) Renewable energy technology information needs to be improved. Many prospective producers and users do not understand the technology and therefore are not aware of the potential and advantages of utilising renewable energy systems. This project will assist in overcoming this by the promotion of the project that will be achieved.

PROJECT IMPLEMENTATION

The project will be implemented in stages by the participating groups through a consortium approach; ie, the Australian contractor (AES), BPPT, and an Indonesian partner company (PT LEN) of Bandung. The project will be implemented as follows:

1 The main participants will form a project management committee to oversee the project. This committee will include a membership to the National Utility, PLN, such that the provision of a hybrid system to each region can be carried out without potentially conflicting with any existing PLN programs.

2 PT LEN will lead the role of coordination with the KUDs and assist in local planning for shipping, freight and general transport requirements.

3 In each region where systems can be operated on a cluster basis there will be appointed a central service company acting in conjunction with the KUDs. This company will attend to local service and support of the systems by holding spares and any necessary components.

4 PT LEN will routinely receive status reports on performance of the cluster in their area. It is expected that only five to seven such agents will be appointed. This greatly simplifies the maintenance requirements and enhances the sustainability of the power systems.

5 Each KUD will enter into an agreement for the system to be installed and manage a basic level of service and liaison. This will include purchase of stored value cards and distribution to the households.

6 The project management committee will monitor and manage this process over the three year installation phase.

7 By staging the installation carefully over the three years it is expected that the transfer of skills and expertise will be very successful.

FINANCIAL ANALYSIS

A standard financial analysis has been carried out on the proposed project. The basic power systems are classified as System A and System B. These systems have been designed to meet the electrical loads in typical villages of 100 and 200 houses respectively. A detailed energy analysis has been undertaken to confirm that the designs will reliably operate villages in the range of 75 to 125 and 150 to 250 houses. Tables 1 and 2 attached provide more specific design detail.

A range of base data points and some assumptions have been made for the project. These are as follows:

- The average village is 200 houses with 5.2 people per house
- The ability to pay is set at 13600 Rps per month per household
- Systems will be installed with two sizes:
  System Size A is for 75 to 125 houses/village
  System Size B is for 125 to 225 houses/village
- The average energy consumption per house per day is 250 Watthours
- The peak available power per house is 200 watts
- A constraint is placed upon the appliances that may be used in households
- Power is available for industry; ie, crafts, fishing and other services
- Each system will cost approximately US$154,000 with other costs to be defined
- The life of the systems is 20 years
- Value of the fixed plant at the end of the period is nil
- Reduction in the multiple use of small diesels will reduce noise and pollution
- Each newly connected household will save on kerosene, paraffin and battery costs
- A cluster of five to ten systems will be installed in a local region so as to minimise operating costs and achieve effective training of staff
- It is assumed that 80% of the households will buy electricity regularly
- Electricity will be sold to industry enterprises separately

The results from the design of the systems has been thoroughly evaluated using computer based simulation techniques. This approach has been proven at AES over a ten year period.

An associated FIRR over the arrangement terms of a 7 year grace period and 25 years repayment has been calculated. This shows an actual FIRR of -2.52%. Sensitivity analyses have been carried out as required within the AusAID appraisal guidelines.

ECONOMIC ANALYSIS

The economic analysis has been carried out over the planned twenty year lifetime of the project itself. This has been chosen as the lifetime of the photovoltaic modules and the inverter control system itself.

The following economic costs have been identified:

a) The project will impose new minor costs in terms of recycling components that have exceeded their useful lifetime. Batteries are one such item. Indonesia has a battery manufacturing industry and there already exists a battery recycling program. Industry designated collectors will pay for spent batteries and then return them to the manufacturer for recycling.

It is recognised that disposal of batteries will need to managed appropriately. It is suggested that this issue is not difficult in the case of hybrid systems given that a centralised approach is adopted and that each power system operates under a service agreement.

b) The operation of the systems will impose costs in terms of land use, investment in training and procedures as well as the need for safety training in handling heavy items such as engines and batteries.

c) There are existing household energy budget costs, especially in the area of batteries, paraffin and kerosene. These costs are currently met by the villagers and will be displaced by electricity supplied by the new hybrid system.

A number of economic benefits have been identified as accruing from the project. These are:

a) Industry development

In this area it is calculated that there will be an increase in net income successively each year due to availability of electricity. Typical areas include refrigeration for fishing and consequent sale of high quality fish, local crafts and arts, small scale tourism and local economies in general such as stores and consumer goods.

b) Education

Educational benefits accrue in two key areas. Firstly the availability of electricity for schools will greatly enhance the learning process. Secondly, households with lighting will offer far superior home learning facilities.

c) Environment issues

A range of benefits will accrue in regard to the environment benefits. This includes a reduction in both transport costs and future emissions from conventional power plant.

d) Health

This project will introduce net positive benefits in the area of health and health care. In the households in each village there is a current practice of burning firewood, kerosene and use of lead acid batteries for home lighting. The burning of wood and kerosene releases airborne pollutants which have been shown to have a detrimental effect on health. The hybrid system will provide clean electrical lighting for households, thus overcoming this problem. The use of batteries can lead to spillage of sulphuric acid which is also a health hazard within the home.

The supply of electricity will also be made available to health clinics where refrigeration of medicines will provide for an improved level of health care overall. The hybrid systems will show their full effect in health care in the fourth year when all systems are installed and operational.

e) Recreational

One of the problems of maintaining the family unit in rural areas is the lack of personal interests that may be broadly termed recreational interests. The provision of electricity will enable local entertainment via communications and the use of radio/TV/stereo units. Coupled with much improved evening lighting this facility brings a net positive value to the village.

f) Households

There will be an economic benefit accruing to each household as a result of having a safe and reliable electricity system. Higher quality lighting and basic amenities in the house such as low powered fans for cooling will generally enhance the quality of life for each family. Pursuits such as reading will be facilitated and this benefit will also be linked to improved educational outcomes for the village overall. It is believed that these benefits will accrue primarily to adults and especially to women who have the major responsibilities for home management.

The EIRR for the project has been calculated to be 22.4%. The calculation has been carried out over the life of the system which is estimated to be 20 years. A number of the economic benefits will however extend beyond this 20 year period. Sensitivity analyses have been carried out as required within the AusAID appraisal guidelines.

IMPLEMENTATION SCHEDULE

Planning and Implementation

As previously discussed it is proposed that the project be carried out over a three year period with a scale up of installation activities over that time. This approach would assist in minimising any difficulties encountered in establishing all aspects of the project. These aspects include securing an adequate transport system, setting up local training, avoiding difficulties in coordinating installation over the various weather patterns in Indonesia and other such matters.

Implementation Stage

- Final survey to select location
- Lease/purchase contract agreement between users and KUDs or appointed bank
- Hardware procurement and delivery
- The consortium will agree on the appointment of the team to be trained for the installation
- Hardware installation will be carried out under the supervision of the supplier and the organising committee
- Commissioning will be conducted by the consortium, KUD or similar body and local government team

ORGANISATION/MANAGEMENT SYSTEM

In this project a well organised project plan covering the hardware delivery, distribution and installation will be developed. There is a need for the local management organisation to collect the regular instalments from the users. The local KUD will implement the program at the village level.

During the repayment period BPPT will enter into appropriate arrangements with the KUDs who will effectively own the power systems. The KUDs, with support from BPPT, will contract the local commercial partner (PT LEN) to support the systems.

RISK ASSESSMENT

Several risks may be considered to exist within the framework of this project. It would however be useful to outline a number of areas which are **not** considered to be risks:

1 The technology and products are not considered to be a risk. The systems are standard products which have been developed, evaluated and field proven over a period of ten years.

2 The partners are key participants have long developed expertise in their respective countries. BPPT is well known and their expertise in these types of projects has evolved over many years. AES has been established for ten years but the founders' involvement in renewable energy began in 1980.

3 Cost trends will work strongly to assist this project. It is predicted that solar energy equipment will continue to reduce in cost in the coming years while fossil fuel costs are expected to gradually increase.

4 The demand for electricity will continue to rise in the future and the service as proposed will not become redundant.

5 Environmental issues in regard to atmospheric warming will increase as a problem and developing countries will progressively be requested to use cleaner technologies.

Project Risks:

There are two main risks associated with the project:

- project management arrangements
- the ability/willingness of the end users to pay

These risks have been accounted for in the sensitivity analyses and the general financial models.

The project management risk is one that is under the control of the project management team itself. The effective management of the installation, commissioning and handover processes must be carried out efficiently and effectively at all times. A skilled manager will be used for this task.

The other risk relates to payment for the electricity itself. In this case prepayment cards are to be used to ensure payment for the power. This approach overcomes the problems of non payment for delivered energy. The prepaid cards can be used as currency and processes must be put in place to protect against loss or theft.

PROJECT SUSTAINABILITY AND TRAINING

The ongoing sustainability of the project remains the key aspect in regard to the monitoring schedule and overall responsibilities and therefore further description is provided in regard to the training and its application. Training for the villagers and more particularly for the local service agencies will be provided in Perth.

The project management group will formulate and conduct the training courses for the hybrid system end users. Australian and BPPT personnel will supervise the installation and commissioning on site for each system.

Full system training is to be provided to the regional agents on a cluster basis. All villages will receive basic training in system functions and capabilities. It is also planned that local government agencies will be included in aspects of the training sessions. This is to improve the overall exposure of the systems and promote the technologies within each region.

The training sessions will include the following broad areas:

i) General description of the hybrid system
ii) Operation and maintenance of the system
iii) Organisation and management
iv) Revenue collection and smart card distribution procedures

The hybrid system needs to be provided with clear and easy to understand documentation. With this information the project implementation team will provide training on technical management to the cluster agencies. The training will be implemented from an early stage of the project such that the agencies and the village end users will be familiarised with the systems.

CONCLUSION

The proposed rural electrification project for Eastern Indonesia will be the largest application of hybrid energy systems technology implemented to date. The project has been planned and developed over a four year period with specific attention given to the economic benefit accruing at village level.

System cost recovery has been a crucial part of the development process. Due to the small number of kWh consumed by each household the total monthly tariff is expected to be well within the financial capability of the villagers.

Based upon final approval from the financial underwriters the project is expected to commence in December 1998.

Table 1 - Inputs for Systems A and B

		System A				System B			
1	No of Houses	75	100	125		150	200	250	
	No of Villages	12	12	12	36	12	12	12	36
2	Daily System kWh	31.57	41	50		62	78	99	
3	Design kW / day	7	8	10		11	11	11	
4	Engines hours/day	2	3	4		4	5	6	

5	Components		Cost	Energy kWh/d	Years	M+O ($)		Cost	Energy kWh/d	Years	M+O ($)
a)	**Photovoltaics**		($/Wp)								
	Array kWp	6000		30.00			8000		40		
	$ / W	6.16					6.16				
	MO per year					154					250
b)	**Diesel Engines**		($)								
	Replacement hours	25000	11165		20		20000	11165		20	
	Major overhaul	12500	4620		20	135	10000	4620		11	421.58
	Minor overhaul	5000	1155		14	84	5000	1155		5	210.79
	Service	500	154		1	112	500	154		1	281.05
	Hours per day	2					5				
c)	**Battery**										
	Lifetime in years	5					5				
	Annual M+O	2	77			77	2	77			77.00
d)	**Inverter**										
	Lifetime in years	20					20				
	Annual M+O		231			231		231			231.00
e)	**Reticulation**										
	Lifetime in years	20					20				
	Annual M+O		193			193		193			192.50
f)	**Fuel / day (litres)**	**kWh/l**	**litres**	**Cost**	**hrs/day**		**kWh/l**	**litres**	**cost**		
	75 houses	40.22	0.79	0.30			5.93	10.45	4.02		
	100 houses	7.48	5.47	2.11			4.29	18.23	7.02		
	125 houses	4.95	10.16	3.91			3.53	28.06	10.80		
	Cost fuel per litre		0.39					0.39			
g)	**Annual O + M**	kWh			Total	986				Total	1663.91
					$/kWh	0.09				**$/kWh**	0.13

Table 2 - Technical Data for Systems A and B

	System A	Single Phase		
1	No of Houses	75	100	125
2	No of Villages	12	12	12
3	Load Composition	Hours	Wh/day	
	Lights 4* 10 watts	5	90	
	Radio 1* 5 watts	8	40	
	TV 1*12 watts	6	72	
	Averaged Total		200	
4	People per house	5.2	5.2	5.2
	Watts pk/ house			200
5	Houses / Village	75	100	125
	People served	4680	6240	7800
				18720
	Growth Margin			20%
6	Design kWh / day	31	40	50
	a) Domestic	18	24	30
	b) Industry	14	17	21
7	Daily System kW	7	8.3	9.6
8	Load Growth Margin			30%
	Diversity Factor			70%

System B	Single Phase		
No of Houses	150	200	250
	12	12	12
Industry Power			
	No Units	kWh/d	kW
Ice making	2	8	1
Craft tools	10	5	1
Clinic	1	0.5	0.2
School	1	0.8	0.5
Area lights	5	2	0.5
Communications	1	1	0.2
	150	200	250
	9360	12480	15600
			37440
Growth Margin			20%
Design kWh / day	62	78	98
a) Domestic	36	48	60
b) Industry	26	30	39
Daily System kW	10.9	13.5	16.1
Load Growth Margin			30%
Diversity Factor			70%

DIESEL RETROFITS: THE ALASKAN EXPERIENCE

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Prepared for:

Village Power '98
World Bank Headquarters
Washington, D.C.
October 6 - 8, 1998

1. There are about 150 remote villages in rural Alaska – a lot of villages but the median village size is small, only about 250 people. The overall population of rural Alaska is also very small – only about 75,000 people altogether. Alaska is almost entirely undeveloped and these villages – nearly all of them without road access – are about as remote as any settlements could be. They are almost entirely dependent on oil fuels for heat, transportation, and electric power. Most are located along the coastline or on navigable rivers, and where a viable economy exists, it is typically based on commercial fishing.

   There have been major improvements in living conditions over the last several decades – especially since oil development took off about 25 years ago: improvements in education, communication, housing, and health. A major government initiative to bring adequate water and sewer facilities to rural villages has made a tremendous difference and is still under way. Access to electric power is now essentially universal. Compared with many developing regions in the world, the material standard of living in rural Alaska doesn't look bad at all.

   There are some surprising pockets of real prosperity as well, but village life overall still revolves mostly around the daily and seasonal demands of subsistence hunting and fishing, supplemented by a limited cash economy. Average cash income is very low compared with urban Alaska or with the rest of the country, and the prospects for major gains any time soon aren't good. It is difficult to come up with a scenario of solid economic growth on a broad scale in rural Alaska – the resources just aren't valuable enough in most instances to overcome the logistical challenges and costs.

2. Although average incomes are relatively low, costs are high. Retail residential rates for electric power are typically in the neighborhood of 40 cents per kWh, compared with about 10 cents in urban communities. Because electric power for nearly all of the villages is supplied by isolated diesel power plants, it is often assumed that this 30 cent differential is primarily due to the high cost of fuel. But, as many of you know, that is a mistake. The cost of diesel fuel in rural villages is typically around 7 cents per kWh. By comparison, the cost of fuel in Anchorage – Alaska's largest city where most of the power is generated by burning natural gas – is about 2 cents per kWh. A difference of 5 cents per kWh in fuel costs is significant but doesn't go very far in explaining a 30 cent differential in retail rates.

   What the State has done for the last 15 years or so is to fund a rate subsidy program for rural villages that, on average, pays out about $550 per year to each residential customer, which is about half of the typical residential bill. That's a very effective way to lift the cost burden from rural electric consumers in the short term. And realistically, the subsidy program is sustainable financially over the long term if the politics would permit it. But the politics probably won't permit it and, besides, a genuine reduction in electricity costs, if it could be accomplished, would be a much firmer foundation for whatever economic development might be possible.

3. So how can actual electricity costs be reduced? What seems to explain most of the urban/rural differential in retail power rates is simply economies of scale – each isolated vil-

lage requires a relatively high level of fixed costs, consisting of its own power plant, operators, and management. Because opportunities to increase power sales within the village are very limited or nonexistent, we continue to look at two other approaches to improve scale economies:

A. The first is to build transmission lines between villages so one or more diesel power plants can be turned off. But this has nearly always proven to be uneconomic given the relatively long distances between villages and small village loads.

B. The second approach is to seek administrative economies of scale by merging utility organizations, even though independent power plants must still be operated and maintained. We have found some advantages in doing this, but near term rate reduction is not one of them. What we find instead is that regional utilities tend to take on costs that individual villages typically do not, such as a higher level of preventive maintenance as well as property damage and liability insurance. In our experience, rates tend to go up as a result of rural utility mergers rather than down.

4. We have tried to improve energy efficiency by using the waste heat from the diesel engines to supply district heating systems. But after building about 10 of these, we are hard pressed to find any more village locations where the cost of the district heat system can be recovered from the value of the waste heat. The heating loads tend to be too small and too widely dispersed.

5. We have tried a number of renewable energy options and continue to do so. Some have been more successful than others. I'll touch on them briefly:

A. The State of Alaska spent over $5 million trying to develop a geothermal power plant in the geologically active region of the Aleutian Islands. This particular prospect, which is the best prospect we know of, is located near a volcano a few miles from one of the most productive, high volume fish processing communities in the United States. The processors currently supply their own power from diesel generators and would have been interested in buying from the geothermal plant except for two problems. One was that, despite proposed government subsidies of up to half the capital cost of the project, the projected cost of power was still not quite competitive with diesel. The second was that, due to the unpredictable nature of the fishing industry, none of the processors were willing to sign long term commitments to purchase power at any price. And without long-term purchase commitments, conventional financing for any portion of the project was not available. So the project appears to be dead for the foreseeable future.

B. There has been some consideration of photovoltaics, but PVs have not made any headway with village utilities although they are widely used by industry in supplying power to remote, unmanned locations such as telecommunications facilities. The obvious obstacle in rural Alaska is that energy demand peaks during the winter when sunlight is in short supply. This problem can be solved for a price if enough panels and batteries are installed but, to date, we haven't seen any numbers that suggest it is economically feasible to do so.

C. Small hydro projects have been built successfully in a handful of villages – nearly all of these are run-of-river projects with no dam or impoundment, and nearly all have required sizeable government subsidies. Most villages in rural Alaska do not have suitable hydro sites anywhere nearby. A number still do, however, and we are finding that private utilities and independent power producers are able to build these projects at much lower cost than the State government had previously projected, and they are building them reasonably well. In fact, the Division of Energy has just issued its first market-rate loan to an independent power producer to build a small hydro project in rural Alaska without any government grant support at all. A rural utility that is now running diesel engines has committed to buy that power. Small hydro can still make a contribution if private developers can continue to cut costs.

D. Finally, although there may not be a lot of sunlight in Alaska during the winter, there is plenty of wind. The State and federal governments are presently funding wind demonstration projects in two communities in rural Alaska – one a relatively large regional center and the other a small village. The State has been asked a few times over the last couple of years to issue grants for additional wind projects but our policy has been that we cannot recommend them for small, rural utilities until they are proven under Alaska conditions with respect to performance, durability, and cost. So we are waiting for the results of these demonstration projects and are hoping that the results will be clear enough to support such conclusions. This leads back to the question of "scaling up". Not scaling up access to electricity in rural Alaska, since this has already been achieved – but rather scaling up the application of renewable energy – in this case, wind.

During the 1980s there were about 100 wind turbines installed in Alaska. As far as we know, few of these operated for more than a year and those that did required major additional investment. People remember this, and the natural legacy is skepticism. So there are questions on long-term performance and concerns about the complexities of maintenance and repair that will be difficult to answer in a 2-year demonstration project.

6. Beyond this, it should be kept in mind that every purveyor of a project or a technology brings along the output of a computer model showing that their project or technology has the lowest long-term cost. It may be obvious but I'd like to say that it is not enough to evaluate project economics with a complex computer model and a statement of factor inputs and results. Without sacrificing depth, greater simplicity and clarity is needed in economic evaluations of renewable energy, as well as clearly favorable results, before most rural Alaska utilities would consider launching into a new technology and before the State could recommend it. Diesel generators are nearly universal in rural Alaska not because of market failure, but because they do well on a broad range of criteria compared with the

competition. At least in Alaska, I believe that economic and financial evaluation of renewable energy demonstration projects must be given a higher priority if the widespread adoption of these technologies is going to occur any time soon.

The Provision of Access through the Expansion of Micro Hydro and Mini-grids

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

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Draft of 25 September 1998

1 An introduction to the main issues

1.1 It is a basic hypothesis for many people that micro hydro power schemes[1] involve a mature technology that in certain circumstances can provide "access" to electricity and motive power to relatively poor people on a financially and environmentally sustainable basis[2].

1.2 If this is a mature technology, the argument goes, is it now time for the grant-aided sector (of both official development assistance and non-governmental organisations) to hand over the challenge to the private sector and let them take up this technology and run with it.

1.3 It is certainly the case that the NGO sector, which has been a major promoter of the technology (at least outside China) cannot expand the scale of its operations without major private sector involvement. However, the evidence that micro hydro is a secure and profitable investment does not yet appear convincing to a significant number of financial institutions.

1.4 The answer to these issues has many points of entry: first, the evidence that micro hydro is financially profitable is not yet established (particularly in forms and from sources that investors find credible). Second, the growth and sustainability of the micro-hydro sub-sector depends on certain types of infrastructure and institutional investments. But it is not yet clear which of these is essential and how they are best financed. Third, the value of electricity to poor people may well exceed their ability to pay for it. This paper, and the on-going research upon which it is based[3], will try to shed light on these issues.

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[1] Micro hydro in this context is defined as being in the range 10 to 200 kW.

[2]. See for instance, **Rural Energy and Development**: Improving Supplies for Two Billion People. World Bank, 1996

[3]. This research is being carried out by Intermediate Technology under contract to the UK Department for International Development as part of the World Bank's programme to determine best practice in a number of areas of rural energy development. The project leader is Dr Smail Khennas (smailk@itdg.org.uk), and research teams have been established in Nepal, Sri Lanka, Peru, Zimbabwe, and the UK.

1.5 But first it is important to clear up a possible source of confusion. Aid Agencies (including the World Bank) start from a concern about providing access to "modern forms of energy" to resource-poor and marginalised people. Recent understanding suggests that even relatively poor people already spend considerable cash sums to meet their energy requirements (particularly for electricity, through batteries, and lighting, through kerosene). Suppliers of equipment, and supporters of particular technical options are interested in expanding their sector and selling their product. While increased sales (diffusion and market penetration) may help poor people, they do not necessarily do so. It is therefore important to distinguish between policy interventions that are primarily intended to increase sales (in this case) of micro hydro and those that are intended to increase the "access" of specific groups of people who are particularly resource-poor or live in remote areas (that will not be reached by the central grid for some time, if ever). Failure to make this clear appears frequently to result in disappointment and to ineffective policy advice[4].

1.6 A number of commentators now see the most pressing issue is to find ways of using public (soft) fund to "leverage" private (hard) funds from the private financial institutions to expand the access of renewable energy to relative poor rural communities, in some form of "public/private" initiatives[5]. This is probably a more interesting reformulating the more long standing arguments over the treatment of "subsidies". The issue now is not so much whether there should be subsidies (even the World Bank and IMF believe there are occasions - such as through the Global Environment Fund - when subsidies are justified), but rather the question is how to use public (and charity) funds in this sector in ways that are innovative and stimulating rather than stultifying and bureaucratic[6].

1.7 But the design of mechanisms to leverage of public and private finance depend heavily on whether the problem is how to kick start "an infant industry", or to compensate for the fact that the target "customers" do not have sufficient purchasing power to enter the market at all.

2 Background

2.1 There is now a quite wide range of experience in providing access to electricity for resource poor people. The largest experience is probably from China and Vietnam, but while these provide valuable lessons in terms of the technology, their unique social context, and the little documentation (so far) in English, limits their usefulness to the

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4. This confusion is well documented in the case of attempts to market photo-electric systems in India, where attempts to increase sales require quite different business choices from attempts to enable resource-poor people to gain access to PV systems (see PhD thesis by Damian Miller, Judge School of Management, Cambridge University UK, forthcoming).

5. "Financial Intermediation in Support of Small-Scale Energy Investments" a report to the World Bank by deLucia and Associates July 1998. See also Russel J de Lucia *Availability and Access for financial support for renewables: issues and an illustrative innovation*, **Natural Resources Forum** Volume 22, Number 2, May 1998.

6. These issues are discussed in more detail in a note by the author relating to the situation in Nepal.

current discussion. Similarly there are many lessons to be learned from OECD countries, particularly about financial and institutional innovation with but they are outside the direct scope of this paper.

2.2 The following table provides a summary of the experience of a number of countries with micro hydro programmes, and suggests that there is a huge diversity of experience and success.

Maturity of programmes	Strategy
Nepal Several hundred schemes.	Subsidies through the Agricultural Development Bank of Nepal, and focus on developing the manufacturing sector.
Sri Lanka Over 40 schemes	Institutional and managerial innovation through the creation of Electricity Consumer Societies in the target villages.
Peru Over 20 schemes	Innovations through a revolving fund based on Inter-American Development Bank loan.
Zimbabwe/Mozambique Less than 10 schemes	Experience of transferring Asian experience to the quite different circumstances of rural Africa.

2.3 Micro hydro, like many other renewables, is characterised by high up front capital costs, and low running costs, relative to the alternatives such as diesel generators. And as with many other means of generating electricity (ie except modules of PV) there are economies of scale particularly in distribution and transmission, such that the geographic density of demand, and the characteristics of the load (daily and seasonal peaks) makes a considerable difference to the viability of electricity supply at a particular location. The growth of micro hydro has been limited in some areas because the primary demand is for electricity for lighting, but unlike other productive uses, tends not to generate an adequate increase in cash flow. Related to this, the costs of end-use equipment is always significant, and may well represent more of a cost burden to consumers than gaining access to electricity supply.

3 An analytical framework

3.1 The early work on the economic analyses of renewables (or small scale decentralised energy supply options more generally) focussed on the “micro” analysis of individual investments. Unfortunately such analyses rarely compared the costs of one option against the costs of the best alternatives, and so were of only limited value to policy makers or to consumers.

3.2 These micro analyses also tended to neglect (or find difficult to deal with) the costs of the systems involved in supporting and marketing larger numbers of installations. In work carried out in the late 1980's by IDRC[7] all the costs of these "macro" level inputs were referred to as the "system overhead costs" Such costs range from R and D to training of manufacturers, the identification of sites and equipment, the community development necessary to get communities to take ownership of the plant, design and installation, trouble shooting, repair and maintenance systems etc. What became clear, as these costs began to be uncovered, was that existing "conventional" technologies, such as diesel generators, had a considerable advantage in that the massive systems in support of these technologies were already in place (often as "sunk costs").

3.3 A key issue in the current policy debate is the identification of these activities at the macro or sub-sector level and how their costs are to be covered, and by whom. To some extent the costs are included in the price paid by the plant owner, but more generally they are paid (directly and indirectly, knowingly or inadvertently) by NGO and other agencies as a form of a grant or subsidy.

3.4 It is important to recognise that these are real costs and that real activities need to take place, how ever they are paid. As the sector is expanded there may well be "economies of scale" in that some of these costs will fall in relation to each hydro plant installed. But equally, inputs that are currently supplied at no cost (because the input is small or is provided by enthusiasts) may well have to be provided for directly if the sub-sector is to expand successfully. Neglect of these activities and their associated costs in any attempt to replicate hydro development in other countries is likely to undermine the sustainability of the sector.

3.5 The current challenge is how to bring together all these diverse concerns: the micro and macro analysis, the question of costs and who is to cover them, and efforts to combine public and private initiatives. One approach that appears to offer considerable analytical insight is to draw on the idea of "financial intermediation" and consider three additional forms of intermediation, namely technical intermediation, social intermediation and organisational intermediation[8].

3.6 In this approach an attempt is made to identify **all** the activities associated with the installation and operation of the individual plant (and quantify the associated costs) for all of the various actors (manufacturers, contractors, plant owners, customers and other beneficiaries, government, banks, utilities, and the various "intermediators").

3.7 The interest in intermediation derives from the observation that many of the so-called "win win options " in the area of energy and environment are not being implemented to the extent predicted. Various skills and enthusiasms are needed to get the schemes going and these things have costs. But current experience is suggesting that private financial institutions cannot or will not cover all or most of the cost associated with organisational

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7. *The Diffusion of Energy Technologies in the Rural Areas of Developing Countries: A synthesis of recent experience*" edited by Andrew Barnett, **World Development**, Volume 18 Number 4, April 1990, pages 539-615.

8. The various types of "intermediation" are described by DeLucia in his report mentioned earlier. See also the work of Lynn Bennet at the World Bank on "social intermediation".

and technological intermediation, and probably will have considerable difficulty in covering the relatively high transaction costs of even "retailing" their capital resources.

3.8 *Organisational Intermediation* involves not only the initiation and implementation of the programme, but also the lobbying and policy change required to construct an "environment" in which the technology and the various players can thrive. This will involve putting in place the necessary infrastructure, and getting the incentives firing the right way to encourage owners, contractors, and financiers.

3.9 Such organisational intermediation is probably usefully distinguished from the *Social Intermediation* involved in the identification of owners and beneficiaries and the development of the capacities necessary to take on and run each individual investment project. Social intermediation plays a major part in taking on the transaction costs that communities would have to incur if they themselves were to source, select and contract suppliers of everything from money and to machines.

3.10 *Technical Intermediation* may well have to start up stream by undertaking the necessary R and D, the importation of the technology and know-how, "down" through to the selection and development of the capacities to supply the necessary goods and services (site selection, system design and technology acquisition, construction and installation of civil, electro-mechanical and electrical components, operation, maintenance, Trouble Shooting, overhaul and refurbishment).

3.11 *Financial Intermediation* ranges from the "bundling" of projects together to make them attractive to finance agencies, dealing with the transaction costs of administering loans, assessment and assurance of the financial viability of schemes, assessment and assurance of the financial credibility of borrower, supply of wholesale finance (from aid agencies, governments, development banks), supply of retail finance (equity finance, loan finance), the management of guarantees, collateral ("financial conditioning") and the management of loan repayment.

3.12 These types of intermediation, which in practice will overlap and may be carried out by the same agencies, form the link with and between the numerous actors involved in micro hydro development. Even in a modest hydro development programme these are likely to involve: the government (national and local); the utility; the main change agents, the project developers or "agents", the aid agencies; the financial institutions; the equipment manufacturers, assemblers and suppliers; the providers of Technical Assistance; the contractors; the plant owners; the community developers ("animators"); the Communities; the beneficiaries (and indeed the people bypassed or harmed by the investment)..

3.13 Each of the functions carried out by "intermediators" operates on the context in which hydro development occurs. The viability of micro hydo is clearly context specific. But this specificity refers not only to the location of a particular site (is there enough water and enough concentrated "demand") at the micro level of analysis, but also at the specifics of the institutional arrangements at the macro level. The development of micro hydro has required one or more organisation to develop the national energy context and policy in ways that support (or are at least not hostile to) micro hydro. The characteristics of a favourable "enabling environment" are relatively easy to list, but often require huge effort to put in place. They include policies for domestic direct and indirect taxes and subsidies (on things like equipment, training, R and D, surveys etc); import taxes, rules for depreciation and so on. In practice much of the pre-existing policy environment have unplanned and negative effects on the hydro sector, but are kept in place by the powerful forces that benefit from them.

3.14 Micro hydro development will also be helped or hindered by the regulatory context in which it operates (and the extent to which regulations are enforced). Usually there will be regulations about who can generate and sell electricity; and regulations covering both finance and construction (such as Health and safety in construction, safety standards for electricity installations, and environmental standards) but there may also be regulation of competition between energy supply options, water resource use, and land ownership (access and rights of way).

3.15 Intermediation also takes place in the context of the many markets in which micro hydro is to be developed. Certainly, in some countries there is concern as to whether there is a sufficiently large market to sustain more than a very few contractors and suppliers. And it is to be expected that, in remote locations, particular suppliers will have local monopolies. The local market will be influenced by these local monopolies and the effects of subsidies in the hydro and related sectors, and of course from competition from the grid, PV, diesel and other energy sources. The market itself will be strongly influenced by the capacities, skills and experience of the various actors involved. For instance, the market for finance for micro hydro plant is likely to limited because financial institutions will have little experience of the sector on which to base their judgements about projects and clients.

3.16 So this is the background, the hypotheses and the analytic framework for our analysis. The search is now on to identify and describe the "best practice" and innovative arrangements for dealing with each of them. In what follows, secondary sources of information are used to provides insights into some of these issues (though of course any errors of fact or interpretation remain the author's responsibility!)

4 The case of Peru[9]

4.1 One of the most successful programmes to develop micro hydro has been in Peru. The main innovation would appear to be the experience of a revolving credit fund, financed by a soft loan from the Inter-American Development Bank.

4.2 After the technical issues had been largely mastered in the early 1990's, the main difficulty appeared to be the lack of access to finance in general, and the lack of financial intermediaries who could "retail" credit in the rural areas in particular. It also became clear that the State was unwilling (even if it were able) to provide substantial grants to the

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[9]. **The information in this section is largely taken from the paper by Alfonso Carrasco V "Alternatives for Rural Electrification" (June 1998) available from ITDG in Peru (Karina@itdg.org.pe), and from other internal documents from ITDG.**

micro hydro sector, because it was focussing it resources on the power grid. This led to the development of a revolving fund by the "intermediary" Intermediate Technology(IT), with resources provided by the Inter-American Development Bank. There was a soft loan of $400,000 (1% service charge and repayment in 25 years in local currency) and a technical assistance grant of $120,000. Since its initiation in 1992 this fund has now resulted in the installation of 15 plant. $465,718 worth of loans have been disbursed and these have drawn in other funds to a total value of $1.7m. The installed plant have ranged in size from 175 kW down to 3 kW with an average of 40 kW. The capital cost has averaged $2,874 per kW installed (giving an average cost per installation of $115,333).

4.3 Of the 15 loans, 5 were to individuals and 10 were to "municipalities" (as village organisations - Comités de Gestión -did not have legal status to accept loans). A certain amount of social intermediation was necessary to form these pre-electrification committees or other ad hoc organisations to operate and maintain the plant. The investments appear secure, but again considerable effort and cost is associated with building the necessary capacities to operate and maintain the plant and to administer the collection of tariffs. Only time will tell if this has been sufficient.

4.4 The lack of local financial intermediaries meant that the programme sponsors, Intermediate Technology, had to set up a "Credit Operator" to provide financial services such as financial assessment of each loan applicant, appraisal of each scheme, administration of the loans and their recovery (although Intermediate Technology remained responsible for the "wholesale" loan from the IDB). IT felt that it was essential that the financial intermediary operated at arms length from technical and organisational intermediation.

4.5 While this arrangement has worked very well, with very high loan repayment levels, two problems quickly emerged. First, that even with low interest rates, there was little demand for micro hydro. Considerable time and effort had to be expended to "market" both the fund and the idea of hydro. Potential consumers would also have had to incur considerable "transaction costs" to locate the technology, contractors and finance if IT had not acted as intermediary. These were costs that could not be carried by the financial intermediary, nor by the loan charges (interest and administrative fees).

4.6 And second, even when the demand did pick up, rural communities (where households are said to have an annual income of $500[10]) could not afford the full cost of the plant. At the current time for every $100 spent on a project:

$27 is covered by a loan and spent largely on equipment

$43 comes from grants and is spent on civil construction and distribution lines

$13 grant to TA and "promotion" of the demand

$17 is the equity contribution from the owners and is supplied in part by contributions in kind such as labour.

[10] It is not clear from the report whether this is a per capita income, or a total household cash income.

5 The case of Sri Lanka[11]

5.1 Sri Lanka also represents a very positive experience with micro hydro. The programme has essentially consisted of four strands: an effort to develop the technology and local capabilities through the rehabilitation of hydro on the Tea Estates; a village hydro scheme with a strong emphasis on community development; the nurturing of a group of village hydro specialists who act as "catalysts"; and, following the liberalisation of the power sector in 1994, grid connected systems. Approximately 40 village hydro plant have been constructed (or are nearing completion) in the 1990's.

5.2 The programme has had considerable success in absorbing the technological know-how and improving it through local manufacture (including electronic load controllers and the use of electric motors as generators), developing local capabilities in manufacture and installation, and in pushing for changes in the regulations to provide a viable standard for grid connection.

5.3 The village hydro programme set considerable store by the creation and involvement of Electricity Consumer Societies (ECS) who are responsible for implementing and operating each scheme. Extensive community development skills are deployed by the social intermediators to identify project "initiators" (who ideally become the Founding President of the ECS, so as to allow the leadership qualities of other village members) and to deal with the various village factions identified in preliminary socio-economic surveys of each site.

5.4 As the programme developed it has been possible to build up the capacities of six "manufacturer/catalysts" to guide ESC at the implementing stage, and to provide an outreach services to neighbouring areas. These grass roots specialists are enterprising individuals who usually come from within the villages with access to hydro electricity.

5.5 Substantial variation has been experienced in the cost of installations (partly as a function of variations in the standards which the different funding source stipulate), and that plant below 5kW are significantly more costly than those above this figure. Very approximately (using 56 Rupees to one US dollar, and taking no account of the changes in currency values over the 10 years of the programme) the average of cost of the small plant is $2,500 per kW, and the cost of the larger plant is $1,500 per kW. This means that a typical plant (eg the one at Andaradeniya) had a total capital cost of UD$ 39,200, for an installed capacity of 23 kW, supplying electricity to 100 beneficiary households ($392 per household) and 2 households were excluded by their remote location. The most expensive plant in terms of installed capacity (at Weddagala) cost $14,400 for 5kW ($2,880 per kW) for 25 households ($576 per household) and ten households were excluded.

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[11]. **This case draws largely on the work of Dr Moira Tampoe's draft evaluation report on micro hydro development for ITDG in Sri Lanka , 1997, Draft (contact Lahiru Pereira, E-Mail: lahiru@itdg.lanka.net).**

5.6 At the initiation of the programme it was accepted that people in these relatively remote areas were unlikely to be able to meet a substantial part of the cost of the schemes. There were considered to be part of the social infrastructure such as feeder roads, or water supply. But the scheme promoters (Intermediate Technology) insisted that the ECS provided 30% of the capital cost of the project and this would be provided in "cash, kind and sweat equity", and would cover civil works and transmission. A survey at the end of 1996 showed that most consumers pay less than one rupee per watt, averaging 50 rupees per month ($11/year) for each household (whereas a tariff which covered capital and operating costs would probably range from 80 to 170 rupees per household per month ($17-$36/year)[12].

5.7 From the point of view of mini-grids, it is interesting to note that the ECS were able to contribute their 30% of the cost to cover the civil works, but were often unable to raise the funds from their own resources to cover the cost of the transmission. They frequently had to seek supplementary funding from the Provincial Councils for this, thereby adding delays to the project implementation (often over a year), though in the end their perseverence resulted in success. The costs of transmission are greatly affected by the standards used, and where the Ceylon Electricity Board (CEB) Standards were use the cost could rise substantially.

5.8 Similarly house wiring costs have risen dramatically over the years from 2-3000 Rupees in the early 1990's to 4-8,000 rupees in 1997 ($70-$140). The standards required in schemes implemented by the CEB costs were as much as 11,000 rupees (nearly $200) per household.

[12]. Village Hydro Monitoring Report, November 1996, IT Sri Lanka, page 38. A rate of 56 Rupees to one US dollar has been assumed. It would appear that the tariff rates remain largely unchanged even in the face of inflation.

5.9 The electricity is used primarily for lighting and cassette radios, (but surveys also show some ownership of TV, electric irons and heaters). It is recognised that the financial viability of plant would be increased if cash generating end uses were included in the schemes (for instance battery charging and rice milling). In one case where there is a mill attached (Katepola), it was able to operate only 2 days a week, and while it does add significantly to the cash flow of the hydro scheme it would not be able to if it had to cover a commercial rate of interest on the mill itself[13].

5.10 Village hydro in Sri Lanka is now moving into a more commercial phase with attempts to introduce more commercial funding and to set up the catalyst/manufacturers as small businesses. The recently started World Bank's Energy Service Delivery Project (WB-ESDP) includes village hydro and has a grant component (funded by the Global Environment Facility) which softens the terms of commercial money by extending its payback period from between 2 and 5 years to ten years.

5.11 The Waddegala scheme mentioned above is also funded in part by a loan from the Hatton National Bank (negotiated before the WB-ESDP), with a grant from the Rotary Club of 200,000 Rupees ($3,500). The interest is at 20% over 5 years. Repayments were reported to be "satisfactory and on schedule".

6 The lessons learned

6.1 The first lesson is that while huge progress has been made in developing and understanding the technology, many of the plant examined are not (yet?) financially sustainable in the sense of bing able to recoup the full capital and running costs of the installations from revenues. Probably those larger plant that can be sell surplus power to the grid are far more financially attractive than plant that are primarily concerned with increasing access which are by definition remote from the grid. This must be a cause for concern, and until there are reliable data on costs and performance of a large sample of micro hydro plant, risk averse funding institutions will remain unwilling to invest.

13. "If the capital cost recovery is also calculated [the] rice mill will not be a profitable venture" Monitoring report 1996, page 63. But this should be contrasted with the statement in a more recent sources which states that "the income from the mill has been more than satisfactory and is an indicator of the economic viability of rice milling as a hydro end use", Tampoe, op cit, page 82, quoting 1997 data.

6.2 Second, the schemes in both countries described are making efforts to blend hard and soft money. This is an important trend if the sector is to be scaled up. But there are two clear consequences of this. Rightly, there will be greater pressure to undertake schemes with end-uses that generate a cash flow. This suggests that funding schemes will probably need to include complementary "down stream" investment in the funding packages[14]. But more troubling for people, such as the World Bank, concerned primarily about "access for poor people", will be the pressure to locate plant only in those areas that already have an ability to pay commercial rates of interest.

6.3 Third, the success of the current schemes has involved very active "intermediation" both at the macro level and at the micro level. Funding packages have needed to be put together from a wide range of funding sources, and time has to be spent begging for charitable donations to cover a large element of these transaction costs (though, there appears to be sufficient grant funds available for Micro hydro for those intermediaries with sufficient skill and persistence). It is not clear which of these tasks will be necessary in future, nor indeed how they can be delivered more cost efficiently in future (there are both economies and diseconomies of scale, but it is not yet clear which will rise or fall as the programmes are scaled up).

6.4 It seems probable that "soft" grant money will be required for some time to come. It will be required to enable people with insufficient purchasing power to gain access to electricity, to assist in the building of technical and other capacities in which the private sector tends to under invest (as the value of trainees is lost to them when staff move from one job to another), and to finance the finance the necessary intermediation and credit retailing.

6.5 Experience also suggests that the use of soft money can both help the expansion of the sector and harm it. The whole question of support to the sector (including subsidy, and tax policies) needs to be thought through both to establish which are necessary conditions for expansion and to define more clear what is best practice. The reasons why agencies of the state (whther national or multinational) should intervene are clear in the most general terms (to remove a hostile "enabling" environment, because there are clear externalities (health, educ, welfare, income, environmental); to kick start an infant industry; and for reasons of equity and human rights. But as always the "devil is in the detail" and in the specifics of each context.

[14]. This was one of the implications of the seminal work by Fred Fluitman, published in 1983! (The socio-economic impact of rural electrification in developing countries: a review of experience, World Employment Programme Research Working Paper, WEP 2022/wp 126, ILO

Annex 1:

A check list of options in considering the support necessary to expand and sustain the development of the Micro Hydro Sub-Sector.

The Ownership Options

- how are the projects put together
- What forms of ownership operate and why (is there a trade-off between the profitability of the plant, the type of owner - utility, individual or community - and of the type of beneficiary?)
- The organisation of social and other pressure to repay loans

The Financial Options

- how is the problem of high pre-investment costs dealt with
- how is the problem of high cost of administering large numbers of small loans
- how is technical assistance and the provision of financed linked - putting the "package together".
- Tariffs (price per kWh) versus flat (capacity) charges
- Metering as a option (prepayment as an option)

The Technology Options

- What is the pre-existing technical capacities of Manufacturers, Contractors and system designers (and how much do they need to be enhanced).
- How to identify, build and pay for the capacity to manufacture, install, maintain and operate (who, how, when at what cost, what problems, what lessons)
- The relative costs and performance of domestic as opposed to imported equipment (particularly from China). What are the effects (costs and benefits) of local manufacture.
- How much can villagers (owners) do and how much can be contracted from outside.

The Access Options

- What effect arises from conflicts between the various objectives for MHP, such as to maximise the sale of Micro Hydro Plant, versus the need to provide poor people access to electricity, versus the need to protect the environment.
- What attempts have been made in the selection of projects or in the design of projects to increase the access of relatively poor people to hydro power.
- Is special attention given to increasing the access of women and children to power (should it be increased, how and why).

The Participation Options

- How are the various parties consulted; What form of social organisation is required; how can it be improved; what are the costs of doing it and of not doing it.

The End-Use Options

- Effects on the financial viability of the MHP
- Novel markets
- How is end use technology financed and owned.

The Environmental Options (land, diversion of water, fuel substitution etc).

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The Provision of Access
through the
Expansion of Micro Hydro Mini-grids

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

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- **An introduction to the main issues**

basic hypothesis

micro hydro power schemes
involve a mature technology
that in certain circumstances
can provide "access" to electricity
and motive power
to relatively poor people
on a financially
and environmentally
sustainable basis.

- Why is it not being taken up by the private sector
    - The evidence that micro hydro is financially profitable is not yet in a form investors find credible
    - It is not yet clear what types of infrastructure and institutional support is necessary for growth and sustainability of the micro-hydro sub-sector
    - The value of electricity to poor people may well exceed their ability to pay for it.

- On-going research will try to shed light on these issues.
    - research is being carried out by
      Intermediate Technology
      under contract to the UK Department for International Development
      Part of the World Bank's programme to determine best practice in a number of areas of rural energy development.
      The project leader is Dr Smail Khennas (smailk@itdg.org.uk),
    - Research teams have been established in Nepal, Sri Lanka, Peru, Zimbabwe, and the UK.

- Need to distinguish between policy interventions
  Intended to increase sales of micro hydro
  vs
  Intended to increase the "access" of specific groups of people who are particularly resource-poor or live in remote areas

  Failure to make this clear appears frequently to result in disappointment and to ineffective policy advice.

- "public/private" initiatives.

  reformulating the more long standing arguments over the treatment of "subsidies".

- Micro hydro, like many other renewables, is characterised by
  - high up front capital costs, and low running costs, relative to the alternatives such as diesel generators.
  - economies of scale particularly in distribution and transmission,
  - primary demand is for electricity for lighting, but unlike other productive uses, tends not to generate an adequate increase in cash flow.
  - costs of end-use equipment is always significant, .

- An analytical framework

  - "micro" analysis of individual investments.
  - "macro" level inputs "system overhead costs"

  - existing "conventional" technologies, such as diesel generators, has massive systems already in place
    (often as "sunk costs").

  - A key issue in the current policy debate is the identification of these activities at the macro or sub-sector level and how their costs are to be covered, and by whom.

  - real costs and need to be paid.

- Analytical insight from
  idea of "financial intermediation"

- Consider three additional forms of intermediation,
  - technical intermediation,
  - social intermediation and
  - organisational intermediation.

"win win options" not being implemented to the extent predicted - energy to kick start them?

- *Organisational Intermediation* involves not only the initiation and implementation of the programme, but also the lobbying and policy change required to construct an "environment" in which the technology and the various players can thrive. This will involve putting in place the necessary infrastructure, and getting the incentives firing the right way to encourage owners, contractors, and financiers.

- *Social Intermediation* involved in the identification of owners and beneficiaries and the development of the capacities necessary to take on and run each individual investment project. Social intermediation plays a major part in taking on the transaction costs that communities would have to incur if they themselves were to source, select and contract suppliers of everything from money and to machines.

- *Technical Intermediation* starts up stream by undertaking the necessary R and D, the importation of the technology and know-how, "down" through to the selection and development of the capacities to supply the necessary goods and services (site selection, system design and technology acquisition, construction and installation of civil, electro-mechanical and electrical components, operation, maintenance, Trouble Shooting, overhaul and refurbishment).

- *Financial Intermediation* ranges from the "bundling" of projects together to make them attractive to finance agencies, dealing with the transaction costs of administering loans, assessment and assurance of the financial viability of schemes, assessment and assurance of the financial credibility of borrower, supply of wholesale finance (from aid agencies, governments, development banks), supply of retail finance (equity finance, loan finance), the management of guarantees, collateral ("financial conditioning") and the management of loan repayment.

- link with and between the numerous actors involved in micro hydro development.

- The viability of micro hydo is clearly context specific

  - location of a particular site (is there enough water and enough concentrated "demand") at the micro level of analysis,
  - specifics of the institutional arrangements at the macro level.
    - The Enabling Environment and
    - The Regulatory Environment
    - The context many markets in which micro hydro is to be developed.

- The search is now on to identify and describe the "best practice" and innovative arrangements for dealing with each of them.

- **The case of Peru**
  - successful programmes
  - The main innovation would appear to be the experience of a revolving credit fund, financed by a soft loan from the Inter-American Development Bank.
  - revolving fund by the "intermediary" Intermediate Technology(IT), with resources provided by the Inter-American Development Bank.
  - soft loan of $400,000

- (1% service charge and repayment in 25 years in local currency)
- a technical assistance grant of $120,000.

- Since its initiation in 1992
  - installation of 15 plant.
  - $465,718 worth of loans
  - Total investment of $1.7m.
  - Plant from 175 kW down to 3 kW
  - (average of 40 kW).
  - Av. Capital cost $2,874 per kW installed
  - Av Capital cost per installation of $115,333
  - Of the 15 loans, 5 were to individuals and 10 were to "municipalities"
  - Village organisations - Comités de Gestión - no legal status to accept loans.
  - Considerable social intermediation to form these pre-electrification committees or other ad hoc organisations to operate and maintain the plant.
  - Sponsors, Intermediate Technology, had to set up a "Credit Operator"

    to provide financial services such as financial assessment of each loan applicant, appraisal of each scheme, administration of the loans and their recovery

    Operated at arms length from technical and organisational intermediation.

    Very high loan repayment levels,
- Two problems quickly emerged.
  - First, there was little demand for micro hydro or credit
  - Second, rural communities (where households are said to have an annual income of $500) could not afford the full cost of the plant.

- For every $100 spent on a project:

  $27 is covered by a loan and spent largely on equipment

  $43 comes from grants and is spent on civil construction and distribution lines

  $13 grant to TA and ?promotion? of the demand

  $17 is the equity contribution from the owners and is supplied in part by contributions in kind such as labour.
- **The case of Sri Lanka**

  - Sri Lanka also represents a very positive experience with micro hydro.
- Four strands:
  - an effort to develop the technology and local capabilities through the rehabilitation of hydro on the Tea Estates;
  - a village hydro scheme with a strong emphasis on community development;
  - the nurturing of a group of village hydro specialists who act as "catalysts"; and,
  - grid connected systems.

- The programme has had considerable technological and institutional success
- Approximately 40 village hydro plant have been constructed (or are nearing

completion) in the 1990's.

- Importance of Electricity Consumer Societies (ECS)
- Extensive community development skills are deployed and various village factions identified in preliminary socio-economic surveys of each site.
- six "manufacturer/catalysts" to guide ESC at the implementing stage,
- Substantial variation has been experienced in the cost of installations
- variations in the standards
- the average of cost of the small plant is $2,500 per kW,
- and the cost of the larger plant is $1,500 per kW

- Typical plant (eg at Andaradeniya)
  - total capital cost of US$ 39,200,
  - installed capacity of 23 kW,
  - supplying electricity to 100 beneficiary households
  - ($392 per household)

- The most expensive plant in terms of installed capacity (at Weddagala) cost $14,400 for 5kW
  - ($2,880 per kW)
  - 25 households ($576 per household) and ten households were excluded.
  - People cannot afford :ECS to provide 30% of the capital cost
  - provided in "cash, kind and sweat equity", and would cover civil works and transmission.
  - consumers pay less than one rupee per watt, averaging 50 rupees per month ($11/year) for each household
  - full cost covering tariff which covered capital and operating costs 80 to 170 rupees per household per month ($17-$36/year).
  - Had to find extra money for distribution from the Provincial Councils adding delays to the project implementation (often over a year)
  - The costs of transmission are greatly affected by the standards used, and where the Ceylon Electricity Board (CEB) Standards were use the cost could rise substantially.
  - House wiring costs have risen dramatically over the years from 2-3000 Rupees in the early 1990's to 4-8,000 rupees in 1997 ($70-$140). CEB costs were as much as 11,000 rupees (nearly $200) per household.
  - end uses: primarily for lighting and cassette radios, (but surveys also show some ownership of TV, electric irons and heaters).
  - financial viability helped by cash generating end uses
- Village hydro in Sri Lanka is now moving into a more commercial phase
  - set up the catalyst/manufacturers as small businesses.
  - World Bank's Energy Service Delivery Project (WB-ESDP)

    softens the terms of commercial money by extending its payback period from between 2 and 5 years to ten years.

  - The Waddegala scheme
  - the Hatton National Bank loan with interest is at 20% over 5 years. Repayments were reported to be "satisfactory and on schedule".
  - Rotary Club of 200,000 Rupees ($3,500).
- **The lessons learned**

    - huge progress has been made in developing and understanding the technology,
- many of the plant examined are not (yet?) financially sustainable
    - larger plant that can be sell surplus power to the grid are financially attractive
    - until there are reliable data on costs and performance of a large sample of micro hydro plant, risk averse funding institutions will remain unwilling to invest.
- the schemes in both countries described are making efforts to blend hard and soft money.
    - But

        greater pressure to undertake schemes with end-uses that generate a cash flow. complementary "down stream" investment in the funding packages.

        pressure to locate plant only in those areas that already have an ability to pay commercial rates of interest. (Problem of access)
- success involved very active "intermediation"
- "soft" grant money will be required for some time to come.
    - to increase access
    - to build technical capacities (market failure)
    - to fund the necessary intermediation and credit retailing.

- Experience also suggests that the use of soft money can both help the expansion of the sector and harm it.
    - The whole question of support to the sector (including subsidy, and tax policies) needs to be thought through
    - which are necessary conditions
    - define more clear what is best practice.

- "the devil is in the detail" and in the specifics of each context.

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16:30-18:00 **Rural Energy Service Models** - *Chair, Jerry Weingart, Weingart & Associates*
•Concessions: The Argentina Experience - *Aldo Fabris, Ministry of Energy, Argentina*
•Sunlight Power International Approaches in Morocco
 - *Jeff Serfass and Dr. Abdelhanine Benallou, SunLight Power Morocco*
•Battery Charging in Brazil - *Michael Davis, Golden Genesis*
•Transition from NGO to Profit-making Enterprise - *Priyantha Wijesooriya, Sri Lanka*
•Challenges for Viable RESCOs - *Art Lilley, Community Power Corporation*
•Empowering Rural Villages - *Charlie Gay, ASE Americas*
•Solar Lighting for the Church of Africa - *Bishop Alden Hathaway, Jr.*

RURAL CONCESSIONS: THE ARGENTINA EXPERIENCE

Lic. Aldo FABRIS
Director for Research and Development
Energy Secretariat
Ministry of Economy and Public Works and Services

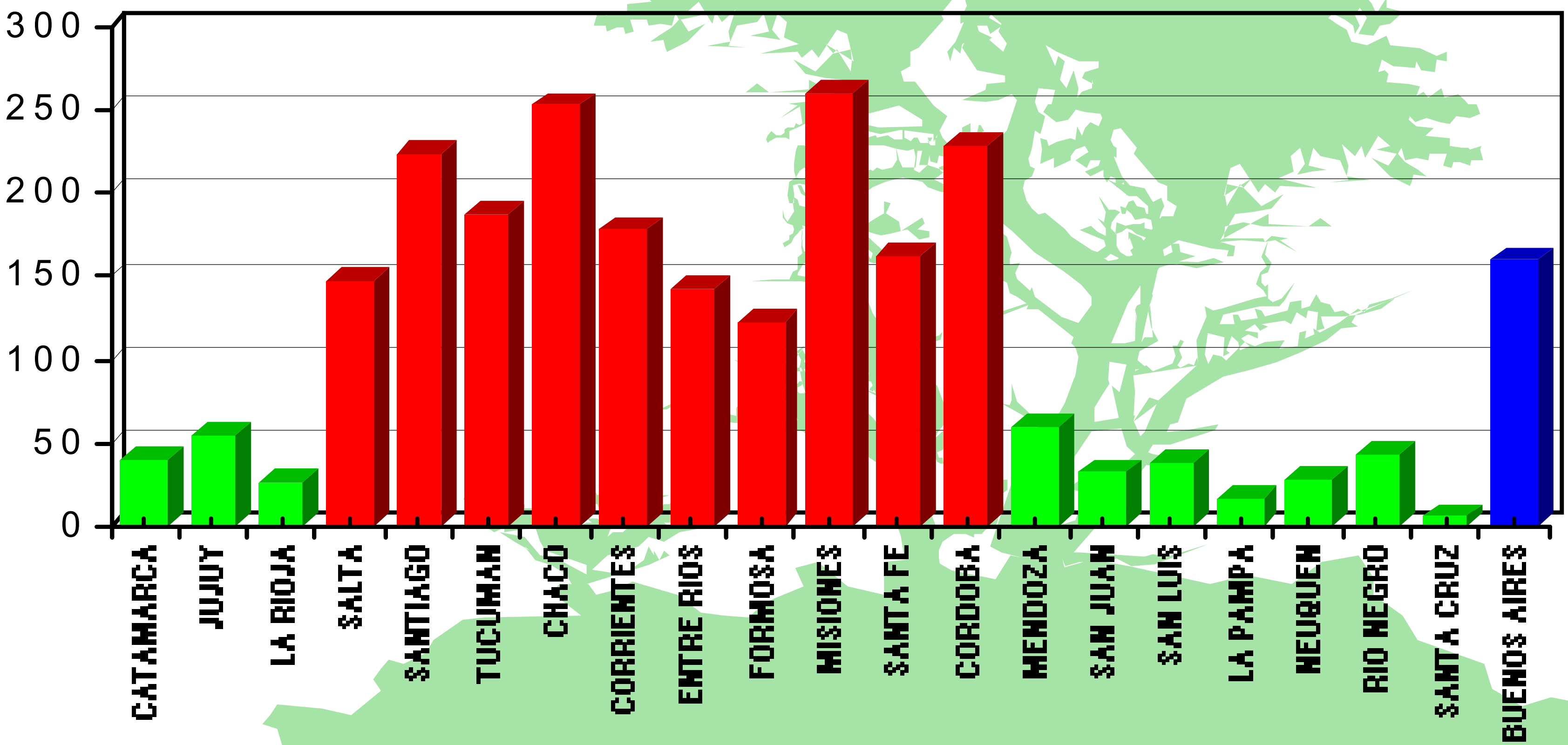
VILLAGE POWER 98 - WB - nrel - 6-8 October WASHINGTON DC

THE PROBLEM/ARGENTINA

- Even 92% of the Argentinians have electricity services, around 2,5 and 3 million remain without mainly due geographicdispersion problems.
- Reletively high number of public services with no electricity supply (schools, first aid medical centers, water services, etc.). Nearly 6000.
- Electricity supply by grid extension not feasible due to high extension costs by new incorporated user. A study for Argentina shows mean values of U$S 8000/user with minimums of U$S 5000/user and maximun of U$S 25.000/user.

DISPERSED RURAL POPULATION WITHOUT ELECTRICITY SERVICES BY STATE (PROVINCE)

(THOUSAND OF INHABITANTS)



DIAGNOSIS

- **RENEWABLE ENERGY (SOME OF IT , TIPICALLY SHS) TECHNOLOGIES ARE ELECTRICITY SERVICES SUPPLY READY BECAUSE THEY ARE:**
  - **TECHNOLOGICALLY MATURE.**
  - **ECONOMICALLY COMPETITIVE.**
  - **SOCIALLY ACEPTED.**
- **THE MAIN DETECTED PROBLEM IS SUSTAINABILITY DUE TO PROGRAMS WITH A STRONG EMPAHSYS IN SOCIAL WELFARE NOT LOOKIN FOR MEDIUM/LONG TERM ISSUES THAT DOES NOT CARE OF:**
- **MAINTEINANCE AND PARTS REPLACEMENT.**
  - **PEOPLE TECHNICAL TRAINING.**
  - **ECONOMIC SUSTAINABILITY OF SUPPLY.**

ELECTRICITY SUPPLY PROGRAM GOAL AND GUIDELINES (PAEPRA)

- **PROVIDE MINIMUM ELECTRICITY SERVICES TO DISPERSED RURAL INHABITANTS AND RURAL SERVICES (LIGTHS AND SOCIAL COMMUNICATIONS) USING THE MOST ECONOMIC TECHNOLOGY.**
- **SHARED RESPONSIBILITY:**
  - **USERS (THE PAY A TARIFF IN ALL CASES)**
  - **STATE GOVERNEMENTS (THEY USES HIS ELECTRICITY PROMOTION FUND PARTIALLY FOR THE PROGRAM)**
  - **FEDERAL GOVERNMENT (ASIST TO THOSE STATE IN WICH THE LOCAL AVAILABLE FUND ARE NOT SUFICIENT**
- **ELECTRICITY SERVICES PROVIDED BY PRIVATE CONCESIONAIRES WHOSE INCOME IS ENOUGH TO RUN THE BUSINESS UNDER PREVAILING ECONOMIC CONDITIONS IN THE PRIVATE SECTOR.**
- **TECHNOLOGY FREEDOM OF THE CONCESIONAIRE BETWEEN SEVERAL OPTIONS IN ORDER THE CHEAPEST ONE BE ELECTED UNDER LIFE CYCLE CRITERIA.**

ELECTRICITY SUPPLY PROGRAM GOALS

- REACH WITH ELECTRICITY SERVICES TO 1.400.000 INHABITANTS (315.000 users) and 6000 PUBLIC SERVICES WITH SEVERAL TECHNOLOGIES. MOST OF THIS SERVICES RENEWABLE ENERGY TECHNOLOGIES WILL BE USED.
- MINIMUM TARIFF TO USERS OF ABOUT $15 A MONTH.
- MINIMUM SERVICES QUALITY IS OF ABOUT 4 KWh/MONTH.
- WORKING POSITIONS INTHE PRIVATE SECTOR ARE CREATED.

FINANCING

FIVE YEARS PROGRAM

- TARIFAS A USUARIOS(1) $147.000.000
- FONDOS ESPECIALES (2) $113.000.000
- FONDOS ADICIONALES $ 54.000.000

TOTAL $314.000.000

(1)VALOR PRESENTE NETO DE BALANCE DE TARIFAS
(TARIFAS - COSTOS DE O&M) 10% - 20 AÑOS
(2)FONDOS EXISTENTES SECTOR ELECTRICO (FCT)

WORLD BANK RESPONSE

- RENEWABLE ENERGY PROJECT IN RURAL MARKET (PERMER)
  - FIRST PHASE UP TO 10 STATES
  - WB LENDING TO THE ARGENTINIAN GOVERNEMENT OF ABOUT U$ 40 MILLIONS.
  - GEF SUBSIDY (CO_2 MITIGATION) OF AROUND U$ 13 MILLIONS.
- VERY IMPORTANT TECHNICAL ASISTANCE PROGRAM TO OVERCOME THE BARRIERS FOR THE INTRODUCTION OF RENEWABLES.
- WB PARTICIPATION GIVES TO THE GOA INITIATIVE CREDIBILITY WORLD WIDE.
- CREDIT NEGOTIATION SOON.

PRESENT SITUATION/ 1

- DISPERSED MARKET OF SALTA PROVINCE.
  - PRIVATE CONCESIONARIE SINCE SEPTEMBER/96.
  - 18000 POTENTIAL PRIVATE USERS.
  - MAXIMUN TARIFF STRUCTURE FIXED.
  - NO INITIAL SUBSIDIZATION. AFTER A COUPLE OF YEARS YES.
  - BIDDING IN COMBINATION WITH THE CONCENTRATED MARKET WITH CROSS DEFAULT PUNISHMENT.
  - WINNER UNION FENOSA & EXCEL GROUP.
  - AROUND 130 SCHOOLS UNDER CONSTRUCTION AND 120 ADDITIONAL TO BE COMPLETED BEFORE THE END OF 1998.

PRESENT SITUATION/ 2

- DISPERSED MARKET OF JUJUY PROVINCE.
  - PRIVATE CONCESIONARIE STARTING IN DEC/96.
  - INVESTEMENT GROUP WITH CGE AS OPERATOR.
  - JOIN OFFER WITH CONCENTRATED MARKET ALTHOUG CLEARLY IDENTIFIED.
  - CROSS DEFAULT STATEMENT
  - 6500 POTENTIAL PRIVATE USERS.
  - 300 PUBLIC SERVICES.
  - THEY IMPROVED SIGNIFICANTLY THE SERVICE QUALITY.
  - 14 SOLAR VILLAGES (2 INITIALLY)
  - 48 SCHOLLS REPOWERED(FROM 50/100 TO 300 Wp)
  - AUTOMATION OF 5 EXISTING MICRO HYDRO.
  - NOW BUYING 600 SHS FOR PRIVATE USERS.

PRESENT SITUATION/ 3

- RIO NEGRO MARKET
  - 8000 PRIVATE POTENTIAL USERS.
  - PRIVATE CONCESIONARIE OF GRID MARKETS USE AN OPTION TO PROPOSE A CONTRACT AND TARIFF STRUCTURE TO ATTEND THE DISPERSED RURAL MARKET.
  - THE STATE GOVERNEMENT REJECT THE PRIVATE COMPANY PROPOSAL. THEY DECIDED TO CALL FOR A NEW CONCESIONAIRE.
- LA RIOJA MARKET
  - IS UNDER NATIONAL AND INTERNATIONAL TENDER FOR THE ELECTRICITY AND WATER RURAL MARKETS.

GOOD NEWS FOR WIND AND SOLAR ENERGY

- **LAW FOR WIND AND SOLAR ENERGY**
  - **VAT FINANCING FOR PEOPLE USING WIND OR SOLAR SYSTEMS FOR ELECTRICITY PRODUCTION FOR PUBLIC SERVICES PURPOUSES.**
  - **SUBSIDIZATION OF U$S 10/MWh.**
  - **TAXES STABILITY.**
- **PROVINCIAL(STATE) LAW FOR WIND ENERGY.**
  - **SUBSIDIZATION OF U$S 5/MWh.**
- **A QUICK EXAMPLE:**

  A WIND GENERATOR WITH A TODAY MARKET PRICE OF U$S 25/MWh CAN RECEIVE ADITIONAL PAYMENTOF AROUND U$S 15/MWh BECAUSE OF THESE STIMULUS.

CREDITS

- DOE-NREL-NRECA
- ASEA-AWEA
- WINROCK - E Co
- UNDP
- EC - THERMIE B - ICAEN - MADRID UNI - ISE
- FRANCE COOPERATION:WORLD BUSINESS/TRANSENERGIE.
- GEF
- WORLD BANK

FOR INFORMATION

INTERNET

http://www.mecon.ar/energia/energia.htm

afabri@mecon.ar.

SunLight Power Maroc -

PV Service Model for Rural Morocco

What does it take for Scale-up and Success?

Presented by Mr. Mark F. Opel and Dr. Abdelhanine Benallou

Village Power '98

Scaling Up Electricity Access For Sustainable Rural Development

October 6-8, 1998

Washington, DC

SunLight Power International Holdings, Inc.

Mission Statement

To be a leading global supplier of solar electric services to unelectrified populations

SunLight Power's Business

- Developing Countries
- Off-grid, Unelectrified Customers
- Photovoltaics - Small Systems - 25-75 Watts
- Own and Operate
- Full Service Provider - Installation, Maintenance, Upgrades, Appliances, Community Outreach

SunLight Power Business Strategy

- Payment Options - Fee-for-Service, Credit, Cash
- Local Partnerships
- HQ/Operating Company/*SunLight Service Center*™ Team Relationships
- Controlled, Profitable Growth
- Private Capital

SunLight Power Maroc

- First Operating Company of SunLight Power
- Transferability of the Business Model
- Profitability at 2,500 Customers per *SunLight Service Center*™
- Ability to Attain 5,000 Customers in first 12 Months
- Test SunLight Power Policies and Procedures Planned for Global Network of Operating Companies

SunLight Power Maroc
Why Morocco?

Environment

- Political and Economic Stability
- Political and Utility Support
- Market Distortion Limited
- Important Market Potential

Why Morocco?

Need

- Rural Population: 13 Million+
- Unelectrified Villages: 40,000 (70% of Rural Population)
- Current Electrification Rate (Grid and Other): 10-15%
- Large Dispersion of Households
- Estimated Potential Market:
  16,000 Villages - 1,600,000 Customers

Market Characteristics

- Households, Mosques, Schools and Rural Health Clinics
- Mostly Agricultural Incomes
- Large Demand for Lighting, TV, Satellite Dishes
- Important Traditional Energy Budgets
- Ability and Willingness to Pay

SunLight Power Maroc
Overview

- Incorporated in March 1998
- Capitalized with over US$1 Million from SPH
- HQ in Rabat
- Technician Teams
- Operations in 2 *SunLight Service Centers™*
- Contractual Relationships with Local Intermediaries for Marketing and Revenue Collection
- Over 300 Customers - 2/3 Fee-for-Service, 1/3 Credit/Cash
- 2,500 Customers at Each SSC in 12-Month Period

SunLight Service Center™ and HQ

Typical Houses in Sefrou and Taza

SPM Customers

Technicians Installing *SunLight Power Systems™*

SunLight Power Maroc
Aggressive Scale-up is Critical

- Prove Fee-for-Service Model
- Prove Financial Viability
- Gain Additional Necessary Capital
- Prove Ability to Local Utility and Government
- Stay Ahead of Local Competition

SunLight Power Maroc
Scale-Up Issues and Difficulties

Capital

- Capital Intensive Business Model
- Success Requires Expanding Capital Base

SunLight Power Maroc
Scale-Up Issues and Difficulties

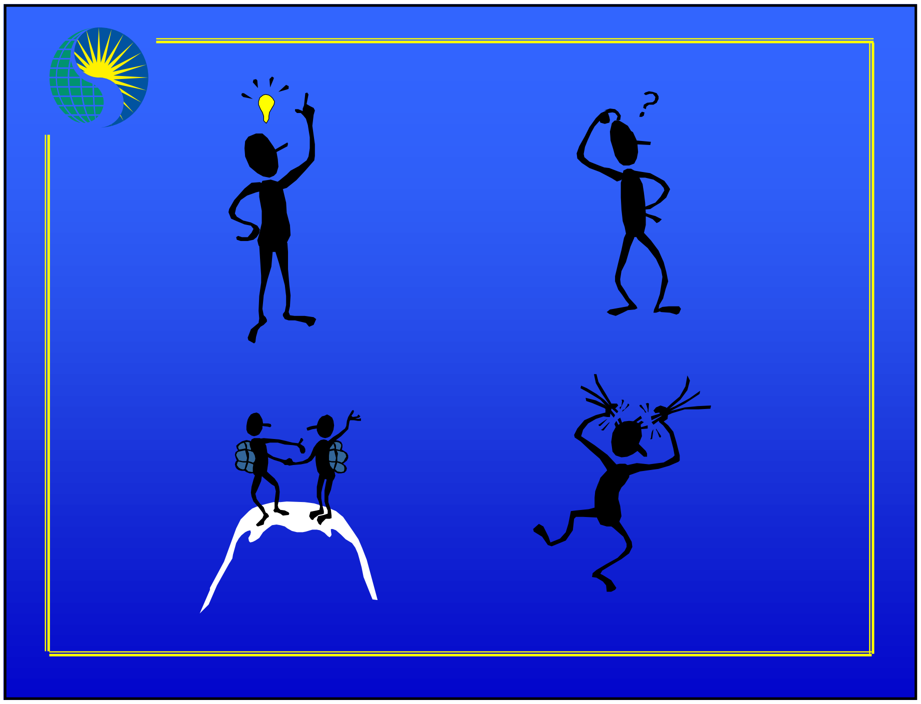
Operational

- Logistics
- Marketing
- Training
- Quality Control
- Education
- Contractual Relationships
- Revenue Collection
- Geographical Issues
- Local Income Patterns and Cultural Issues

SunLight Power Maroc
Scale-Up Issues and Difficulties

Political

- Local Authority Structure
- Local Competition
- Relations with National Utility and Government



Challenges for Viable RESCOs

Art Lilley, VP
Community Power Corporation

Village Power ‘98

October 6-8, 1998

Washington, DC

Outline

- Definition
- Challenges
  - Customers
  - Competition
  - Funding
  - Setup
  - Operation
  - Uncontrollables
- Conclusions

Definition: Energy Service Company

An entity delivering application-based energy products and/or services, at market prices, over time, to customers isolated from a formal energy supply network.

Further Clarification

- Entity:
  - sole proprietor, corporation, govt. agency, cooperative, NGO, etc.
  - both for-profit and not-for-profit
- Application-based: focus on application of energy not on kWh sales
- Energy-based products or services: Liquid fuels, solid fuels, maintenance/repair/charging services, consumable materials (batteries, candles, wicks, globes, mantles), etc.
- Market price: Value of the energy service weighed against the user's willingness and ability to pay; not a regulated price or uniform tariff
- Over time: long-term relationship not a one-time product sale
- Customers isolated from formal energy supply network: Typically homeowners and small enterprises without near term access to a grid.

Examples Meeting the Definition

Conventional ESCOs

- Retail sellers of conventional fuels: kerosene, diesel fuel, firewood, dry cell batteries, candles, bottled gas
- Entrepreneurs selling energy services from an engine generator:
  - battery charging
  - light fixtures and power points for near-by neighbors
- Community-based AC power systems: gen-set, hydro

Emerging ESCOs (RESCOs)

- PV battery charging or solar home system leasing companies
- Community-based AC power system: hybrid, wind, biomass, etc.

Finding/Attracting Consumers

- Are they serviceable?
  - site accessibility
  - resource
- Enough of them?
- Density?
- Willing and able to pay?
- Willing and able to purchase?

Case Study to Determine Whether Rural Consumers Prefer SHS Leasing or Ownership

- **Payment Options Offered: Assumptions:**
  1. Cash: 100% down
  2. Credit: 25% down, pay balance up to 7 years
  3. Lease: 2 month installation fee, pay to perpetuity, 10% annual price increase

- **Relative discount rate/Present value of $1 in yr. 10:**
  1. Cash: (0%-$1.00)
  2. Credit: 1 yr. (6%-$0.56), 4 yr. (13%-$0.29), 7 yr. (16%-$0.23)
  3. Lease: perpetuity (25%-$0.11) ← Preferred Option

Reasons Given By Consumers Why SHS Leasing is Preferred Over Ownership

- Familiar with incremental purchase of energy
- Equipment down payment is a large portion of savings
- Leasing:
  - relieves perceived maintenance burden
  - puts seller on hook for performance
  - permits "try and see if it is as advertised"
- Don't want to own equipment in case...
  - equipment fails, is stolen, is damaged, etc.
  - something better/cheaper may come along
  - grid may come soon

RESCO Has Many Advantages Compared to Dealer Model*

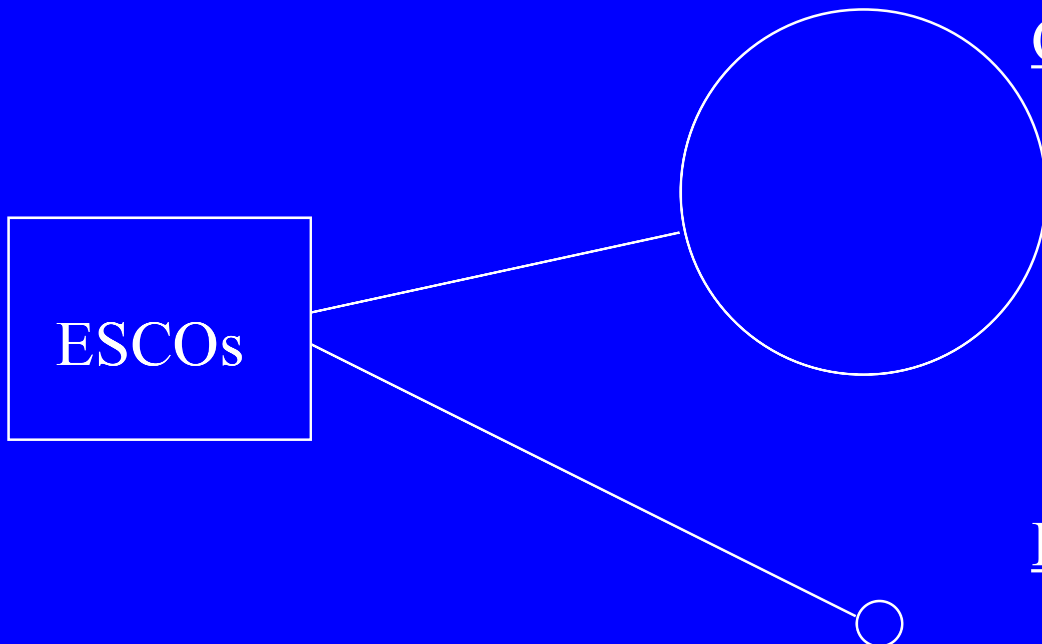
Characteristic	Leasing (RESCO)	Direct Sale (Dealer)
Market Penetration	>70%	<30%
Term of Relationship	Long	Short
Differentiating Factor	Service	Price
Maintenance Performed by	Technician	Consumer
Consumer Flexibility	Maximum	Minimum

*From consumer's perspective

Competition

- Legality?
- Grid?
  - distance
  - plans
  - connection costs
- Nearby subsidized projects?
- Nearby ESCOs?

Conventional ESCOs Are The RESCOs Major Competitors



Conventional ESCOs

– ubiquitous
– from within
– but room for improvement

Emerging RESCOs

– very few
– from outside
– but why switch?

Conventional ESCOs Have Significant Competitive Advantages

- Standard offerings, some highly subsidized
- Purchase transaction is...
  - very simple
  - quick
- Often there is a semblance of price competition
- Buyer/seller relationship exists
- Has become ingrained
- Why change?

CPC’s RESCO Strategy to Reduce Consumer’s Resistance to Change

- Make advantage apparent to user
- Make service fit with user’s current methods
- Use known words/concepts to explain idea
- Make it easy to get in/get out
- Make sure user understands the worst case
- Price for high perceived value

Getting Funded

- Credible Business Plan?
- Credible Investor?
- Mutually Acceptable Terms?
  - form of investment
  - cost of money
  - payback
- What If?

Startup

- Staffing?
- Procurement?
- Logistics?
- Installation?
- User training?

Operation

- System performance?
  - equipment
  - staff
  - processes and procedures
- Financial Performance?
  - revenue collection/defaults
  - unplanned maintenance/repair
  - theft/diddling
- Customer Satisfaction?

Uncontrollables

- Currency
- Inflation
- Stability
- Weather
- Disasters

Current Status

- Staying involved
  - customer satisfaction remains high
  - maintaining strategic relationships
- Adapting
  - pursuing high value productive uses of renewables
  - evaluating opportunities for small modular biopower
- Monitoring situation
- Preparing for recovery

Conclusions

RESCOs...

…are relatively new, but exist in many countries with large rural populations

…are a logical step in the evolution of renewable energy delivery mechanisms

…are more customer-friendly than direct sales models

…have great untapped potential for deploying renewable energy-based products and services to rural people

…can meet the challenge

GreenStar

- ✓ Village Power '98
- ► Charles F. Gay

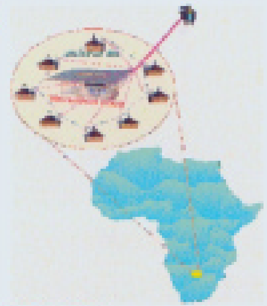
www.greenstar.org

GreenStar

- ✓ E-Commerce
- ► Solar Power
- ► Communications

Networking Communities

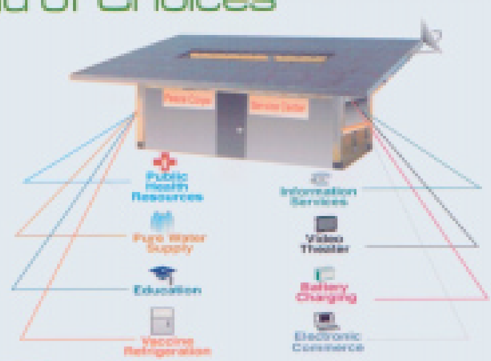
- ✓ Self-Contained Centers for Developing Regions
  - Asia
  - Mid-East
  - Latin America
  - Africa



- ✓ Economic Independence
  - Global Markets - Local Enterprise

Replicable Model

- ✓ Menu of Choices



- ✓ One Platform
  - Simultaneously Serving Social and Business Objectives
  - Putting the ".com" into International Development

First Field Test - December 1998

- ✓ Al-Kaabneh - West Bank
  - Identified by Palestine Hydrology Group
  - Supporting Presidential Visit

- ✓ Solar Array, Water Purifier, Vaccine Refrigerator
  - Internet Server for Telemedicine and E-Commerce

Collaborative Partnership Framework

- ✓ U.S. Department of Energy
  - National Renewable Energy Laboratory NREL
- ✓ United Nations Devevelopment Programme undp
- ✓ Palestine Energy Authority
- ✓ EcoPeace / Friends of the Earth

Developing E-Commerce

- Nature of networked culture, economy
- Decentralized, individual initiative, versatile, strong

- Simple elements: the smart edges
- Geodesic structure; interdependence

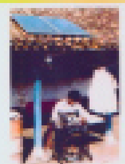
International Development

- Individual Needs:
  Knowledge, education, contacts.
- Family Needs:
  Tools not handouts.
- Community Needs:
  Locally determined and defined; professionally supported
- GreenStar catapults a community into the 21st Century with the mainstream of global commerce

E-Commerce Examples

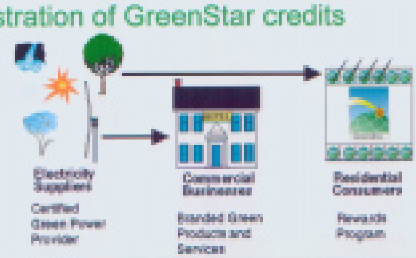
✓ Solar Coffee Processing Centers

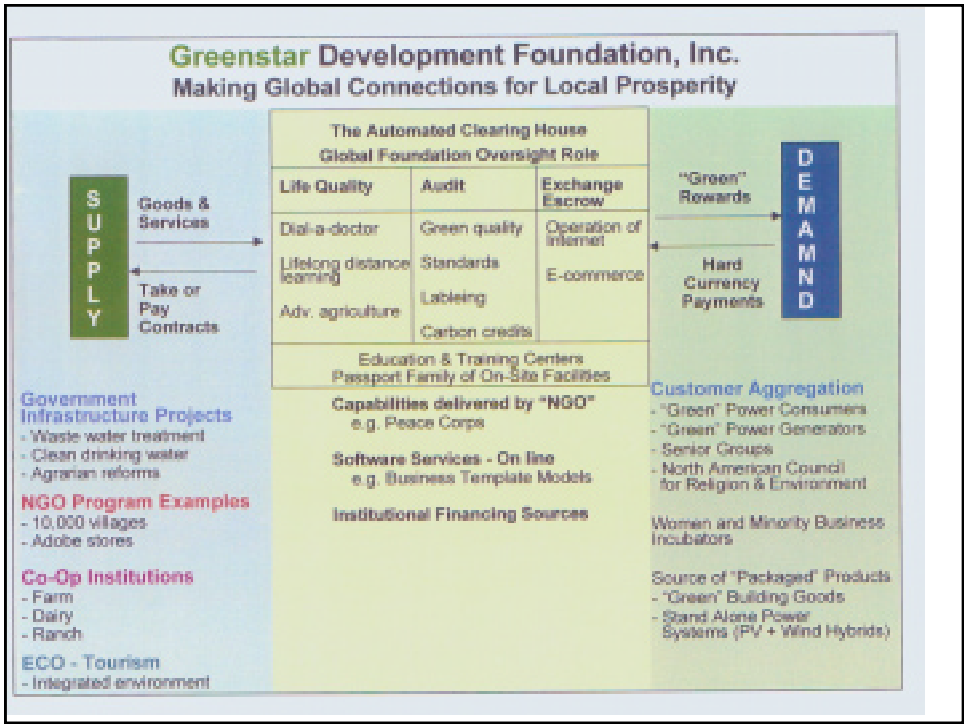
✓ Fashion Apparel



The GreenStar Global Model

- Certified Green Products and Services using Renewable Energy
  Brand recognition of the GreenStar Name and logo.
- Support of Transactional Websites Created Locally
  Global Marketplace for Earth-Friendly Products.
- Collaboration in Building Business Incubators that are financiable
- Administration of GreenStar credits





Greenstar Development Foundation, Inc.
Making Global Connections for Local Prosperity
SUPPLY
Goods & Services
Take or Pay Contracts
The Automated Clearing House
Global Foundation Oversight Role
Life Quality
Audit
Exchange Escrow
Dial-a-doctor
Lifelong distance learning
Adv. agriculture
Green quality
Standards
Lableing
Carbon credits
Operation of internet
E-commerce
Education & Training Centers
Passport Family of On-Site Facilities
"Green" Rewards
Hard Currency Payments
DEMAMND
Government Infrastructure Projects
- Waste water treatment
- Clean drinking water
- Agrarian reforms
NGO Program Examples
- 10,000 villages
- Adobe stores
Co-Op Institutions
- Farm
- Dairy
- Ranch
ECO - Tourism
- Integrated environment
Capabilities delivered by "NGO"
e.g. Peace Corps
Software Services - On line
e.g. Business Template Models
Institutional Financing Sources
Customer Aggregation
- "Green" Power Consumers
- "Green" Power Generators
- Senior Groups
- North American Council for Religion & Environment
Women and Minority Business Incubators
Source of "Packaged" Products
- "Green" Building Goods
- Stand Alone Power Systems (PV + Wind Hybrids)

Solar Lighting for the Church of Africa

A Solar Electrification Project started by the

Church of Uganda and the American Episcopal Church

And God said, "Let there be Light" and there was light.
And God saw the light, and it was good.

-- Genesis 1 : 3 - 4

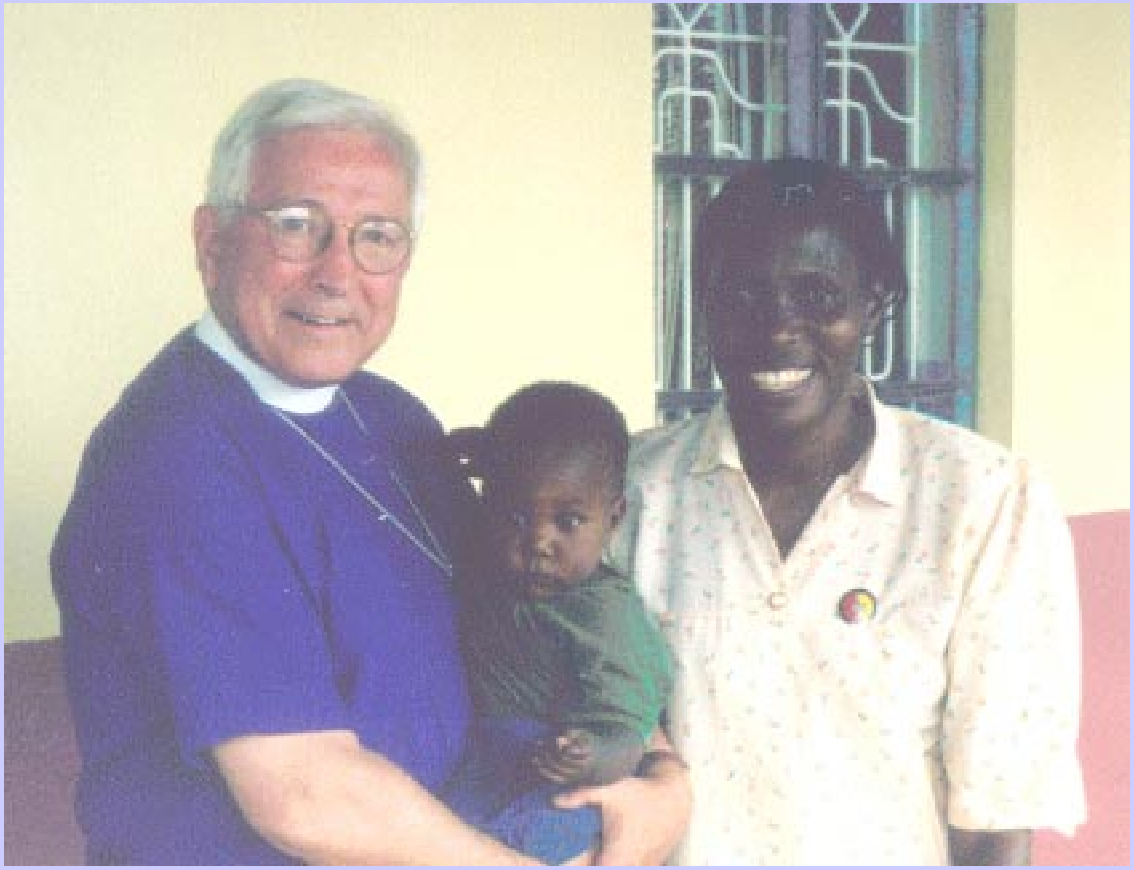
Solar Lighting for the Church of Africa

The Birth of a Program

Bishop Alden Hathaway of the Episcopal Diocese of Pittsburgh visits the Mustard Seed Orphanage, Hoima Uganda, Jan, 1997

Bishop, our orphans need light!

The Mustard Seed Orphanage Director, Evace Bitairaho explains to Bishop Hathaway how the orphans need electric light and pure water.



Solar Lighting for the Church of Africa

The Birth of a Program

Bishop Zebedee Masereka of South Rwenzori appeals to the American Episcopal Church for help - February, 1997

The Rwenzori Mountain Range can be seen from Bishop Masereka's home in the city of Kasese

Solar Lighting for the Church of Africa

The Birth of a Program

Bishop Hathaway pledges to support a program to electrify 360 churches in 6 Ugandan Dioceses - March, 1997

United Solar Systems Corp of Detroit, MI is selected to supply Solar Systems.

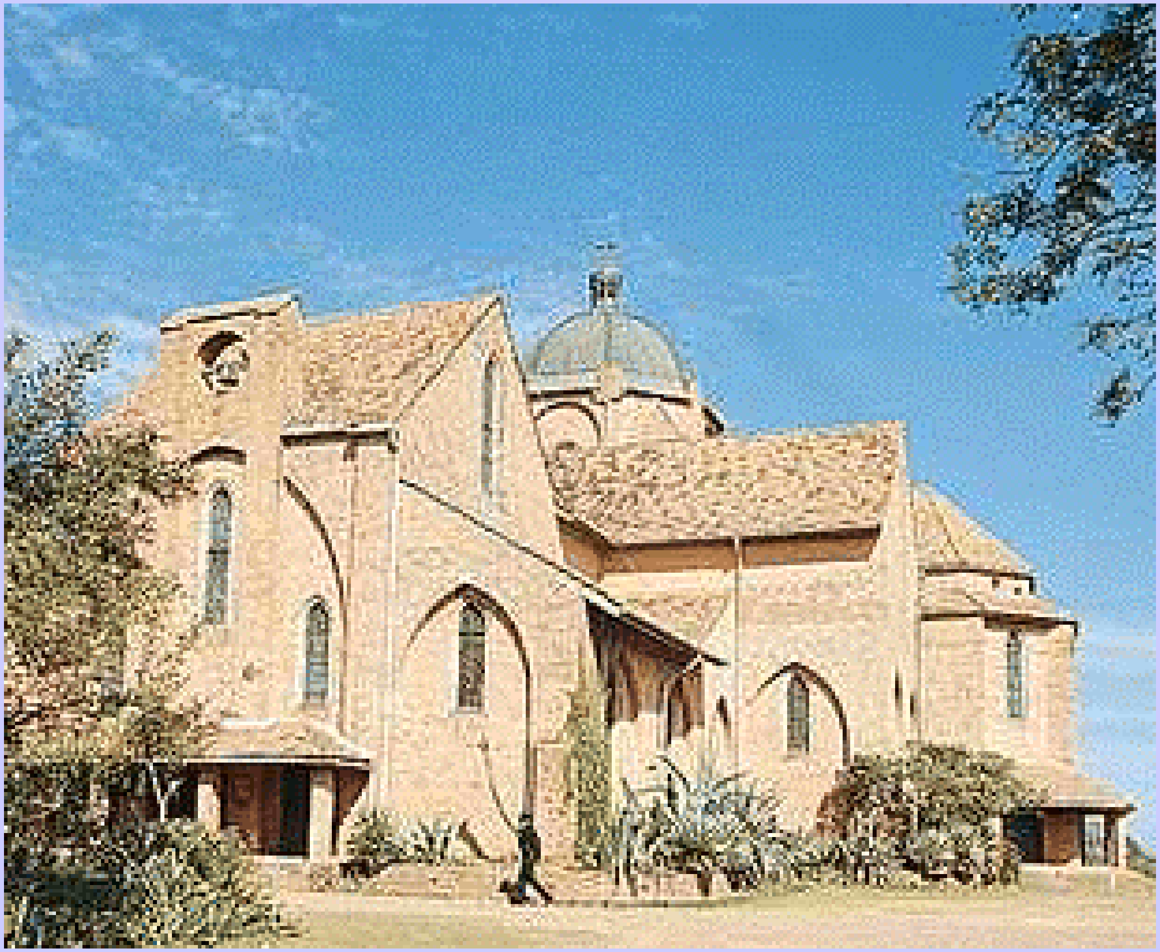
A Fund is Established in Pittsburgh to raise money.

The Diocese of Pittsburgh has become a center for the missionary activity of the Episcopal Church.

Solar Lighting for the Church of Africa

The Birth of a Program

Archbishop Nkyoyoo appeals to expand project to all 27 dioceses - July, 1997



Namirembe Cathedral in Kampala is the seat of the Anglican Church of Uganda

Solar Lighting for the Church of Africa

The Program

August - September, 1997 - 1998 more than 360 solar lighting systems are installed in 8 Ugandan dioceses

The Ugandan Dioceses deposit $100 for each system to be reserved;

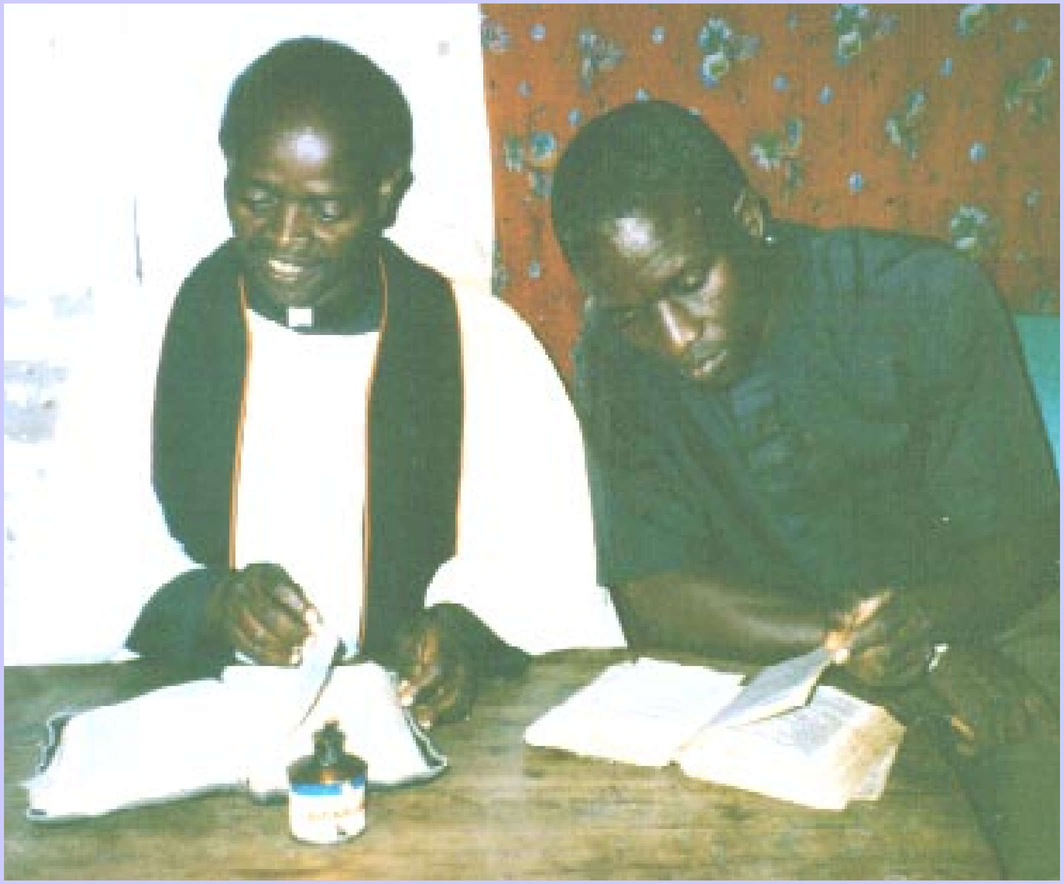
The American Church matches with a $500 contribution;

The remaining $400 is financed over 2 years at $21 per month.

Solar Lighting for the Church of Africa

Lighting without Electricity

The Predominate Source for Light in Uganda (as in most Developing Countries) is Kerosene



Solar Lighting for the Church of Africa

The Episcopal Church USA and the Church of Uganda Commitment

Helping the Priests/Helping the Community

John Ssemanda, of Solar Energy Uganda, Ltd. hands one of the first Uni-Solar Solar Lighting Kits to be installed to a Priest and his wife in August, 1997.

Solar Lighting for the Church of Africa

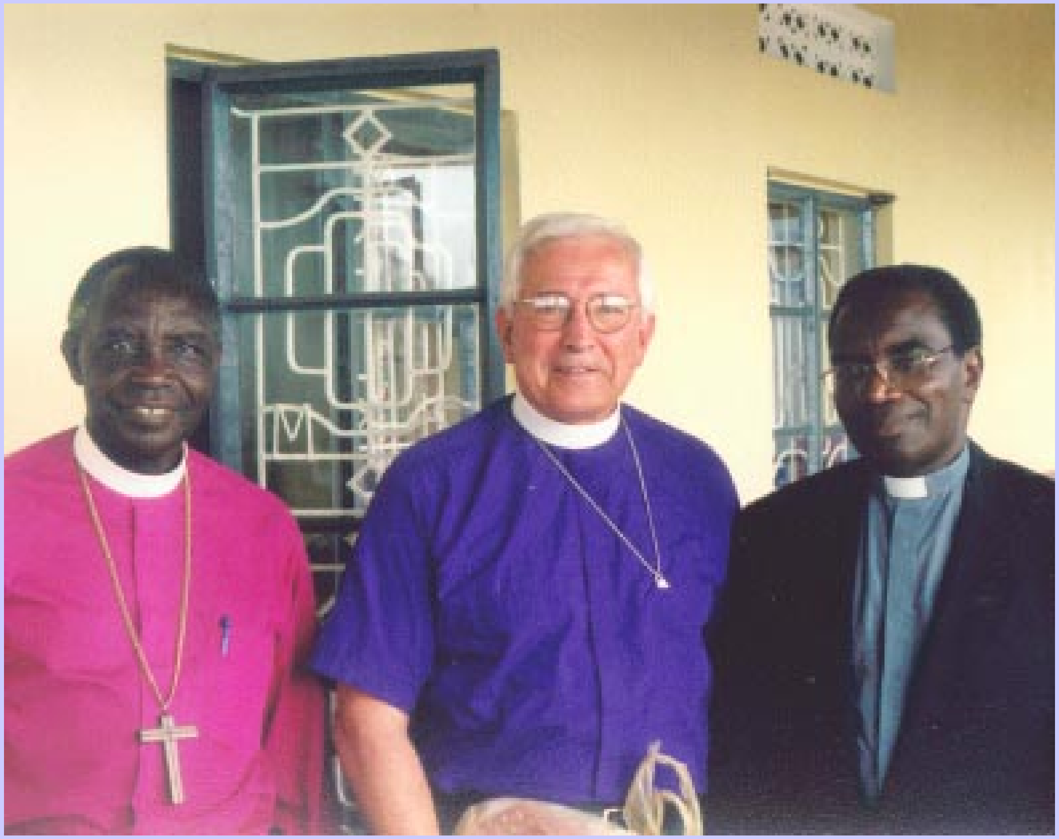
A Bishop Receives Electric Light

Officials from Solar Energy Uganda Ltd. Explain How to Operate a New Lighting System to Bishop Sinabulya

Solar Lighting for the Church of Africa

An Anglican Program becomes Ecumenical

Anglican Bishop William Rukirande, Diocese of Kibale; Bishop Hathaway; Bishop Deo Gratsi, Catholic Diocese of Hoima, at Mustard Seed Orphanage



Bishop Deo Gratsi's Diocesan home was one of several solar installations funded with assistance from Bishop Wuerl of the Catholic Diocese of Pittsburgh through the program.

Solar Lighting for the Church of Africa

A Delegation to Uganda - Konge Catholic Church, Mpigi

Bishop Hathaway, son Alden II, and grandson, Alden III, travel to Uganda July 20 - 30, 1998 to Inspect Solar Installations

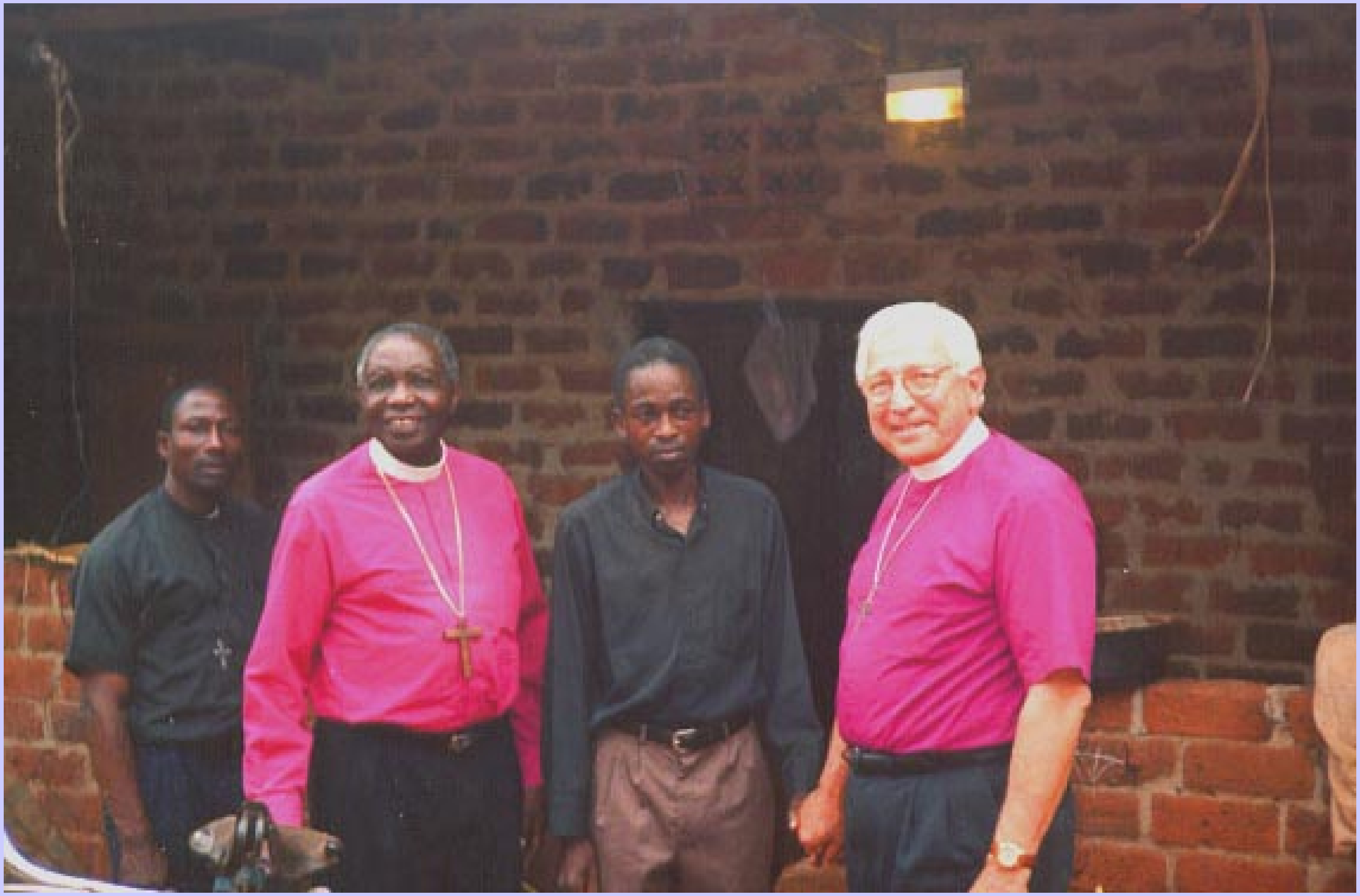
Bishop Hathaway participates with US Ambassador, Nancy Powell, at a celebration of the solar program at Konge Catholic Parrish.

Solar Lighting for the Church of Africa

A Delegation to Uganda - Central Buganda

American Churches adopt Ugandan Churches

The Reverend Male (center), Diocese of Central Buganda

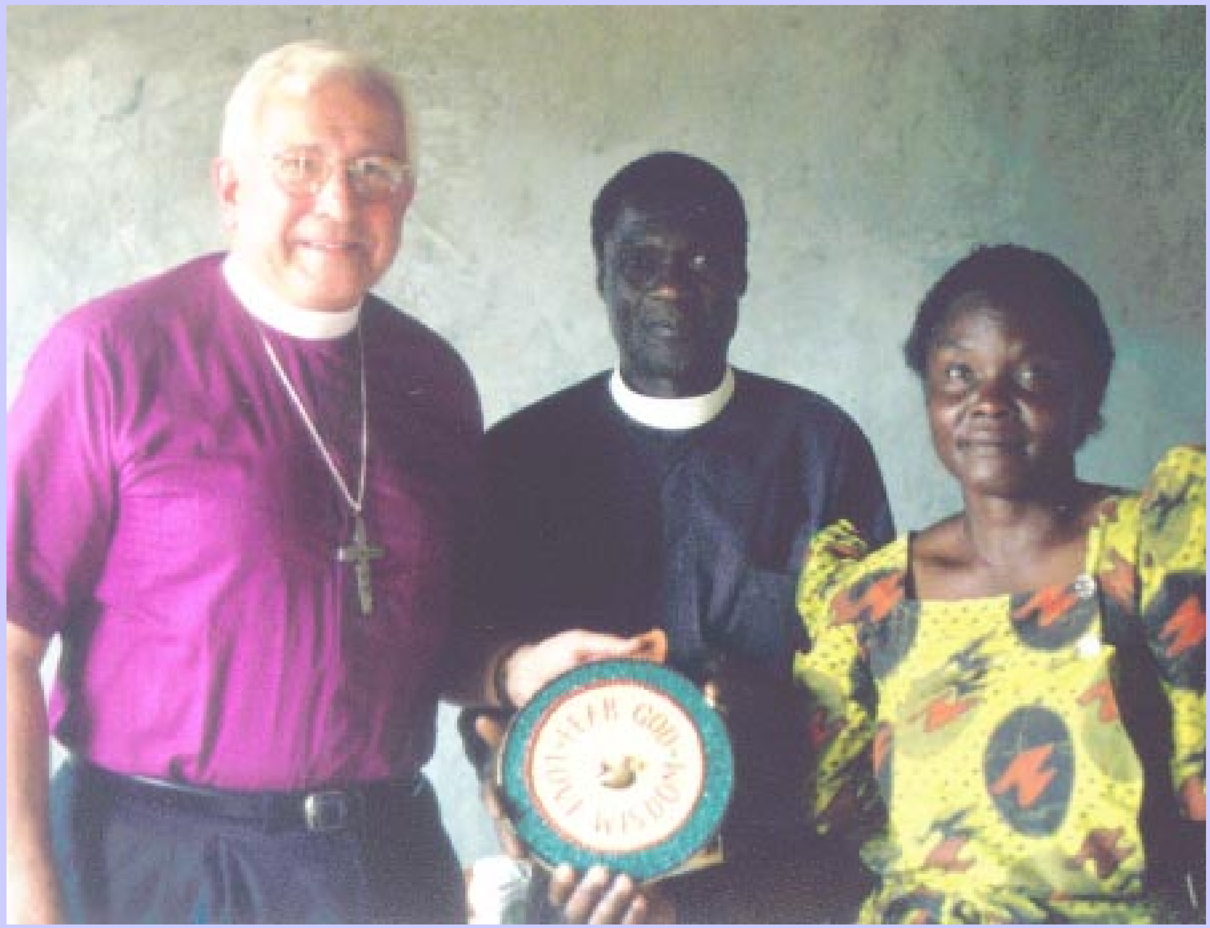


Solar Lighting for the Church of Africa

A Delegation to Uganda - Central Buganda

Bishop Hathaway, the Reverend Charles and Rebecca Male

Charles and Rebecca teach their congregants how to grow crops. They pray for enough funds to build a classroom.



Solar Lighting for the Church of Africa

A Delegation to Uganda - Diocese of Kinkiizi, Kanungu

Bishop Hathaway and delegation members at the home of Ben Kuriigamba, African Evangelistic Coordinator

This remote area in southwestern Uganda near the Congolese border is without electricity. Father Rweijungu (right of Bishop Rukirande) ministers to a Pigmy Tribe 5 km away.

Solar Lighting for the Church of Africa

A Delegation to Uganda - Diocese of Bunyaro-Kataro, Hoima

The Mustard Seed Orphanage

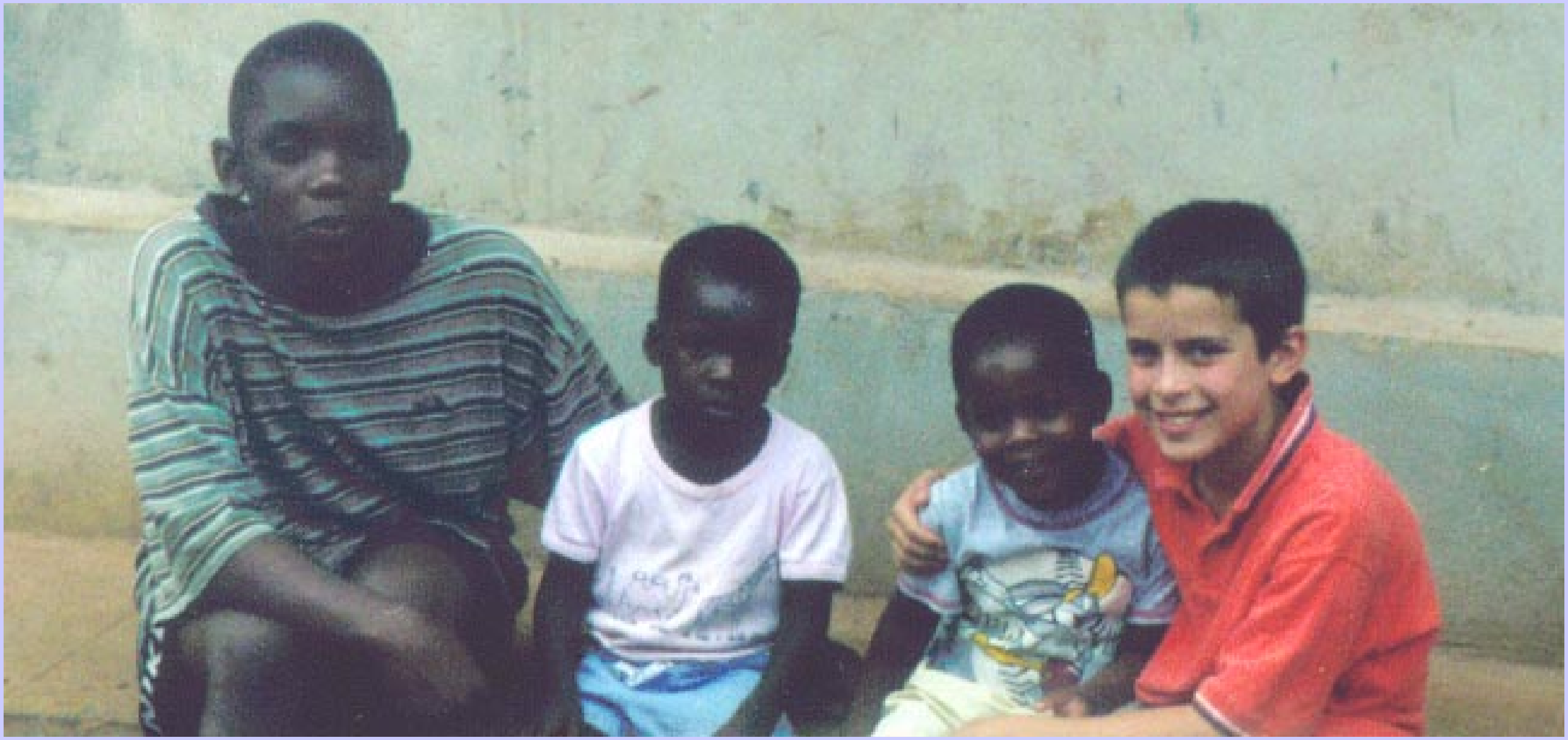
24 lights provide a beacon for the residents of Hoima.

Solar Lighting for the Church of Africa

A Delegation to Uganda - Diocese of Bunyaro-Kataro, Hoima

Two American boys; Joseph, son of Uni-Solar supplier, John Ssemanda and Tripp (Alden III), grandson of Bishop Hathaway

Visiting with orphans at Mustard Seed - "Does the light come from heaven?"



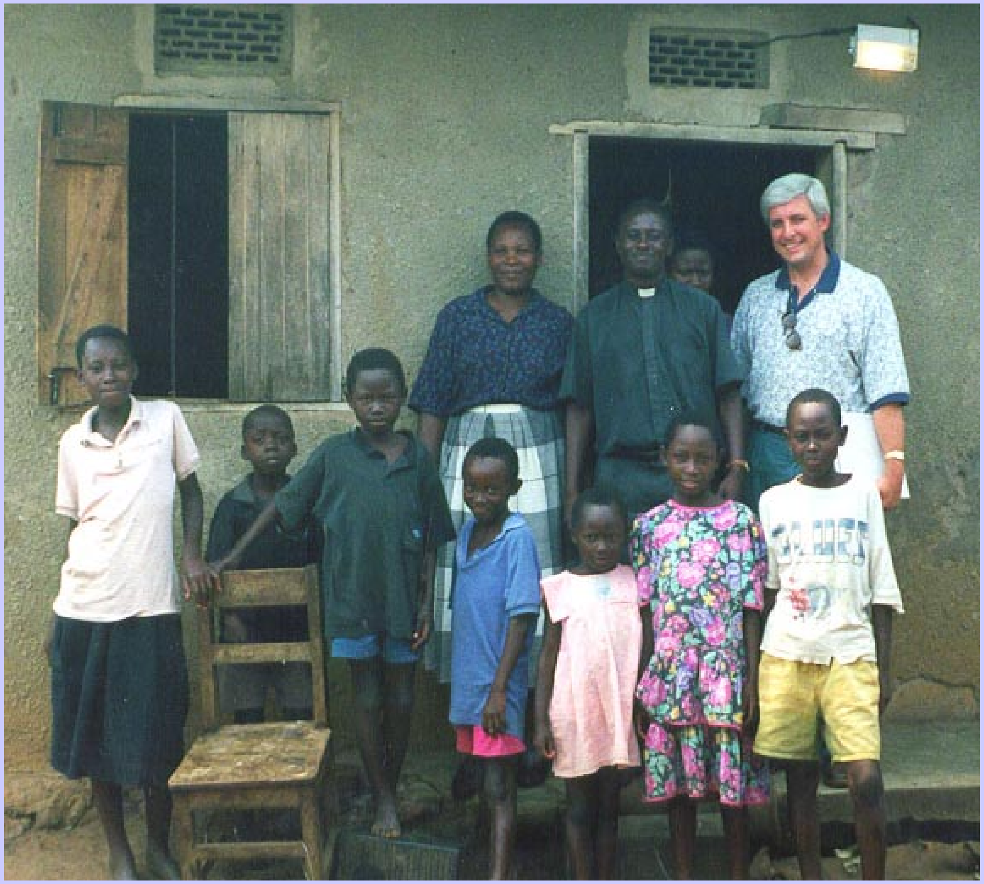
Solar Lighting for the Church of Africa

A Delegation to Uganda - Diocese of Bunyaro-Kataro, Hoima

Solar Lighting Kits Increase the Standard of Living

Reverend Solomon Tunura's Family, Hoima, Uganda

The Tunura's claim that the electric light gives chickens an extra feeding per day and increases their rate of growth and yield.



Solar Lighting for the Church of Africa

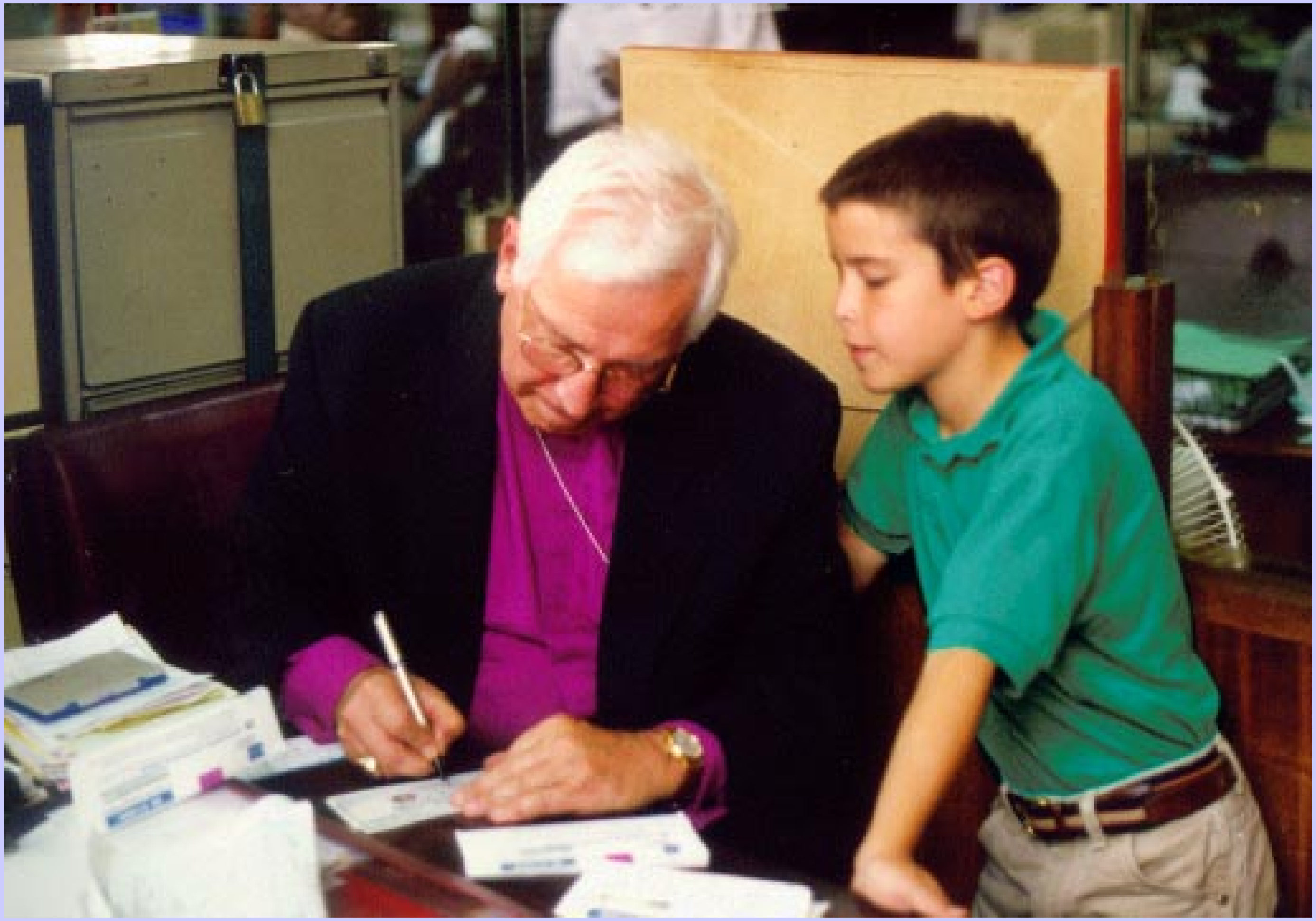
Appealing to the Government for Support

Finance Minister, and Former Energy Minister,
Gerald Ssendaula is flanked by his staff and Bishop Hathaway

Solar Lighting for the Church of Africa

Paying the Value Added Tax

Tripp looks on as his Papa pays the V.A.T. to free 200 Solar Systems from Ugandan Customs for finishing the Project.



Solar Lighting for the Church of Africa

A Delegation to Uganda - Mukono

John Ssemanda, Bishop Hathaway, son Alden II, Bishop Rukirande Inspect the 360 W PV System at Mukono Christian University.

Solar Lighting for the Church of Africa

A Delegation to Uganda - Kampala

The two Bishops with the Good Semaritan Sisters and Father Kakooza of Nalukolongo, A Catholic Home for the Disabled

Solar Lighting for the Church of Africa

The Great Commission:

"Go into all the world and proclaim the good news to the whole creation."

- Mark 16:15

Solar Lighting for the Church of Africa

Please direct your donations or questions to:

ECMC/Solar Lighting for the Church of Africa
c/o The South American Missionary Society
1013 Merchant Street
Ambridge, PA 15003
Ph:703-934-3144;
e-mail: ahathaway@icfkaiser.com

Thursday, October 8, 1998

09:00-11:00 **Financing Scale-up of Rural Electricity Access and Expanding Renewable Energy Markets**

- *Chair, Paul Hassing, DGIS, The Netherlands*

•Effective Intermediation: Experience in Asia RE Projects - *Jim Finucane, Indonesia SHS Support Group*

•Structuring and Justifying Financial Incentives - *Subodh Mathur, Consultant*

•Inter-American Development Bank Experience in Renewable Energy Financing for Rural Development - *Jaime Millan - Inter-American Development Bank*

•Financing for Private Sector Renewable Energy Projects - *International Finance Corporation (IFC)*

Financial and Capacity Building Intermediation in Asia RE Projects

Jim Finucane

SHS Project Support Group, Indonesia

October 8, 1998

Finance and capacity building for scale up of rural RE

- aim - expand access of rural households to modern energy on significant basis
- focus - market based financing to consumers or firms by banks or other financial institutions (FIs) for small energy investments, with special reference to pv systems
- result - successful pv system retail level sales and services in rural areas

Customer characteristics

- households, beyond the grid, dispersed
- high ability and willingness to pay
  - salary income or cash income from farming, fishing, livestock, small businesses
  - currently spend cash regularly to purchase energy for lighting and tv / radio - typically kerosene, used vehicle batteries, dry cell batteries
- limited access to financing for consumer durables

Local PV business characteristics

- small/medium size, entrepreneur driven, family businesses, with many exceptions
- partially in the informal sector
- main financing is savings, family, friends
- most receive some supplier credit
- few have credits from FIs for the pv business
- a few have finance and training links with suppliers and international NGOs
- some have government procurement experience

Main lines of financial interventions

- working capital and term credits
- grants for initial market development
- framework for mobilization of additional financial resources (e.g., fresh equity in existing and new companies, guarantees, increased supplier credits)

Design considerations

- affordability: market size and price points for cash and credit sales and fee-for-service schemes
- profitability, sustainable business models
- capabilities and commitment of pv businesses, FIs, technology suppliers, others
- creditworthiness of customers and pv businesses
- availability of finance, supplier support
- level of competition and consumer choice
- consumer protection - product standards, after sales service, warranties

Design tensions and trade-offs

- expand the market vs deepen the market
- strong technical specifications vs consumer choice
- the devil is in the details and banking is documentation vs keep it simple and maintain flexibility

Advance capacity building

- business planning assistance
- financial management and accounting
- best practices information and training
- product improvement design assistance
- product testing and certification
- links with financial institutions, investors, guarantee sources

Competitive financing and refinancing

- mismatch loan and subloan maturities
- competitive interest rates
- simple procedures (their's if possible)
- quick disbursement processing
- grants transparently for initial market development
  - cost share preparation expenses and initial technology improvement
  - for unit sales to increase affordability
  - cost share trials of market development ideas

Parallel capacity building

- business planning
- financial management and accounting
- technology improvement, training
- product testing, certification, quality assurance
- information to market place
- links with financial institutions, investors, guarantee sources
- market monitoring

Compliance monitoring

- end user audits (participants required to maintain customer sales and warranty records and have audited accounts)
- performance audits
- customer satisfaction surveys
- focus groups

Financing-related effects on FIs

- lower pipeline development and transaction costs of FIs
- lower risk perceptions of FIs and investors (market surveys, comparative informaton)
- lower technology related payment and market risks (training, robust specifications, after-sales requirements)
- lower FI monitoring costs (field audits, customer satisfaction surveys)

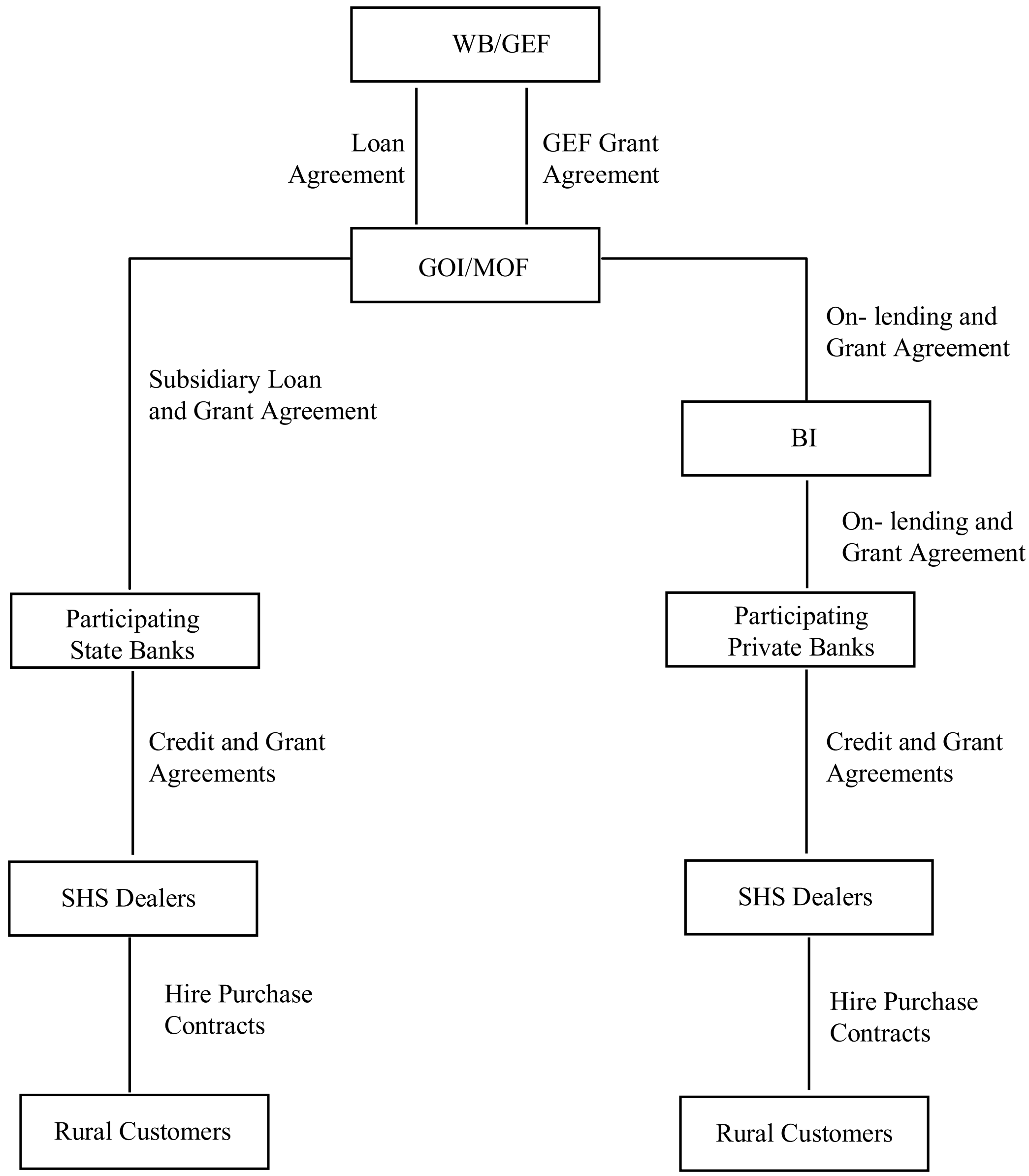
Key approvals structure

	SHS	ESD	RED
Approve company	PB, WB	PCI, WB	PMO, WB
Audit compliance	PSG	PCI	PMO
Approve grant pay	PB (after 1st audit)	AU (after 1st audit)	PMO(after audits)

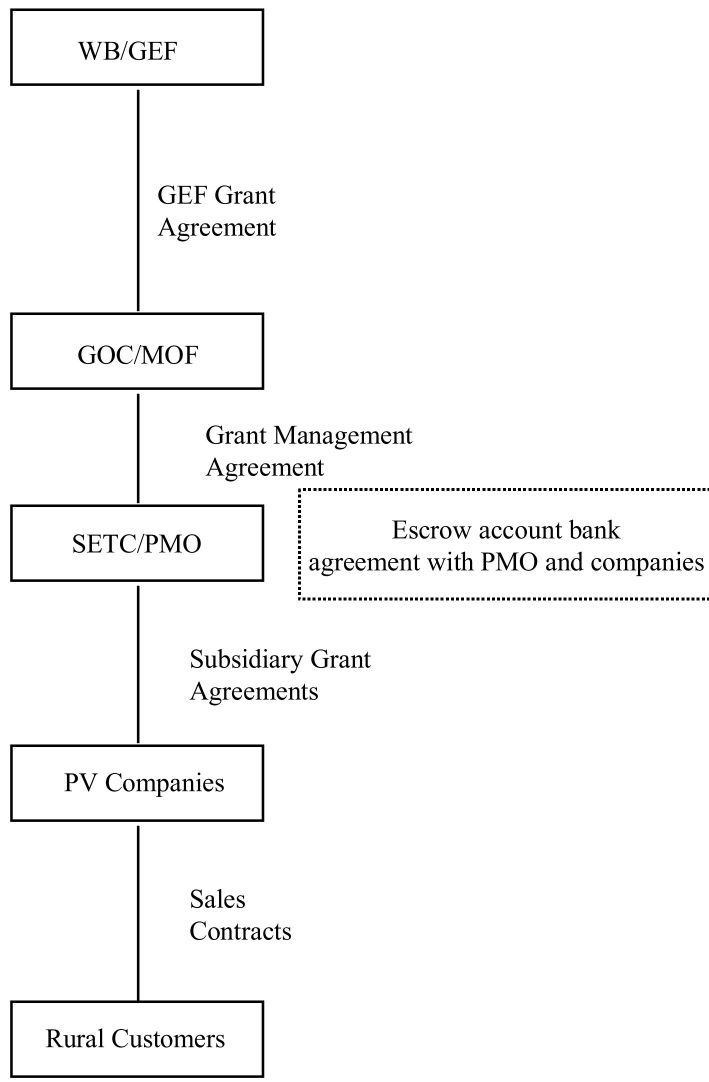
Key price, loan and grant terms

	SHS	ESD	RED
Sale or service to customers	market based pricing	market based pricing	market based pricing
GEF unit grant	For 30+Wp $60/100 – on/off Java; for 50+Wp $75/125 - on/off Java	For 30+Wp, $100	For 10+Wp, $1.5 *per Wp*
Loan to company from PB / PCI	Rupiah, market rates, up to 5 yrs	Rupees, market rates, up to 10 yrs	none
WB refinance loan to PB / PCI	80% refinance, 20 yrs incl 5 yrs grace, central bank SBI three month rate	60% refinance, 15 yrs, incl 5 yrs grace, average weighted deposit rate	none

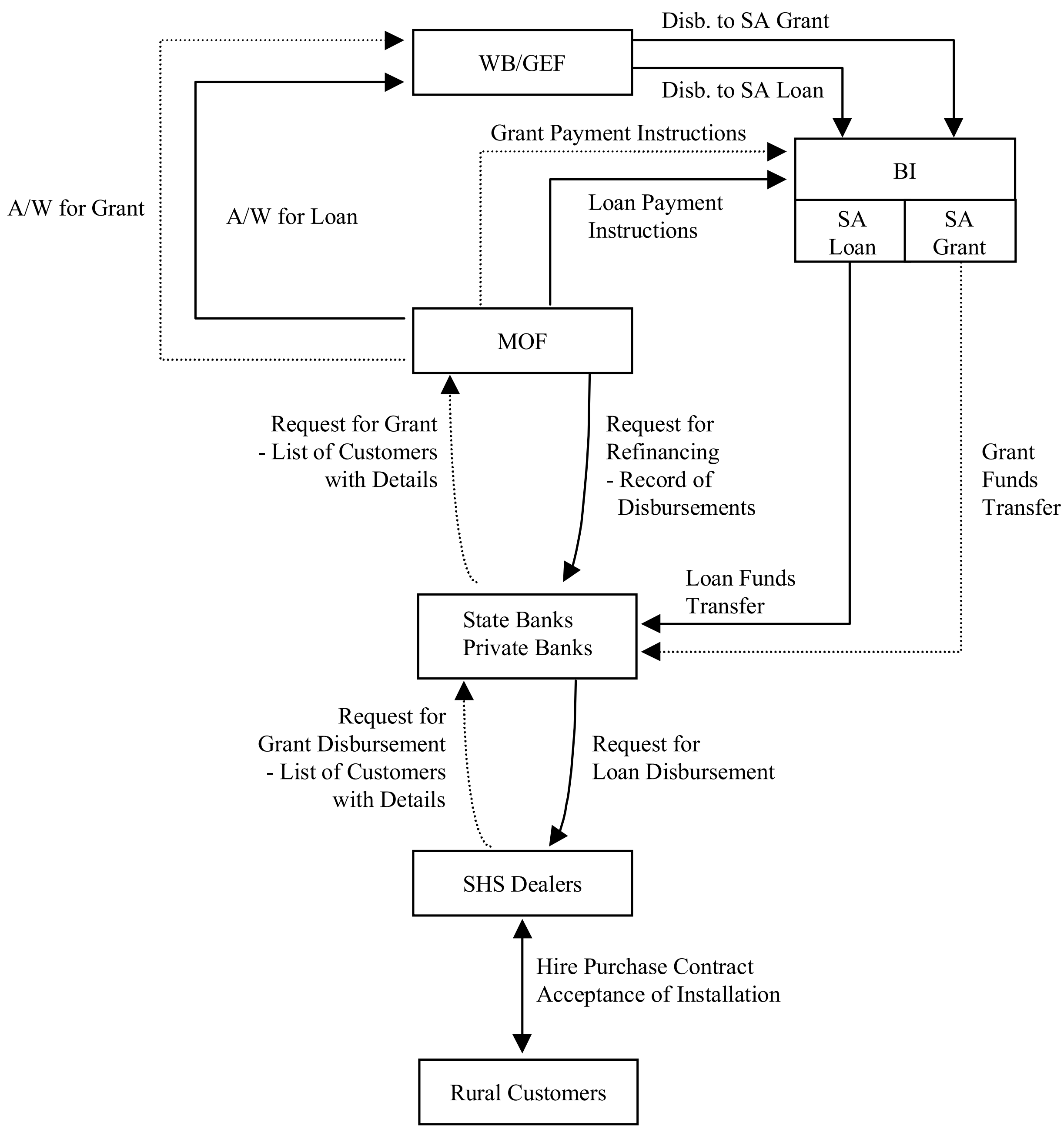
INDONESIA
SOLAR HOME SYSTEMS PROJECT
Legal Agreements



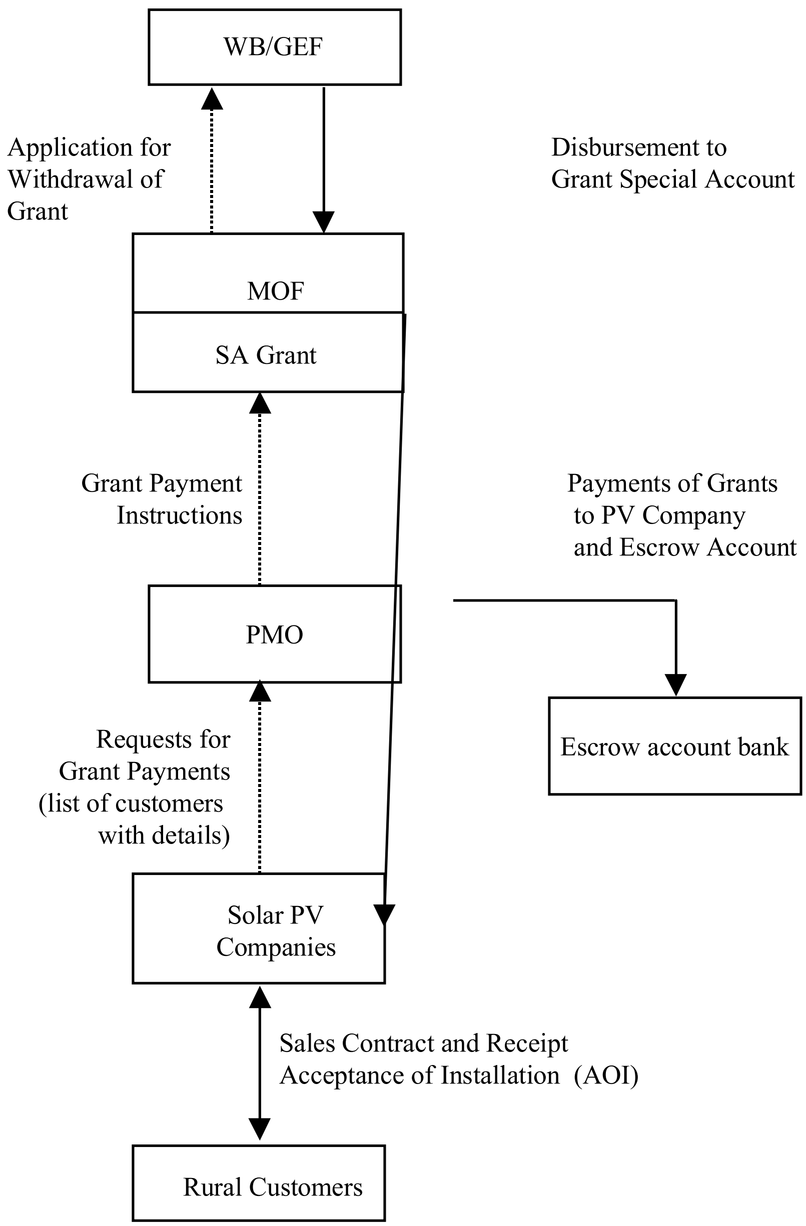
CHINA
RENEWABLE ENERGY DEVELOPMENT PROJECT
PV Component Legal Agreements



INDONESIA
SOLAR HOME SYSTEMS PROJECT
Disbursement of Grant and Loan Funds



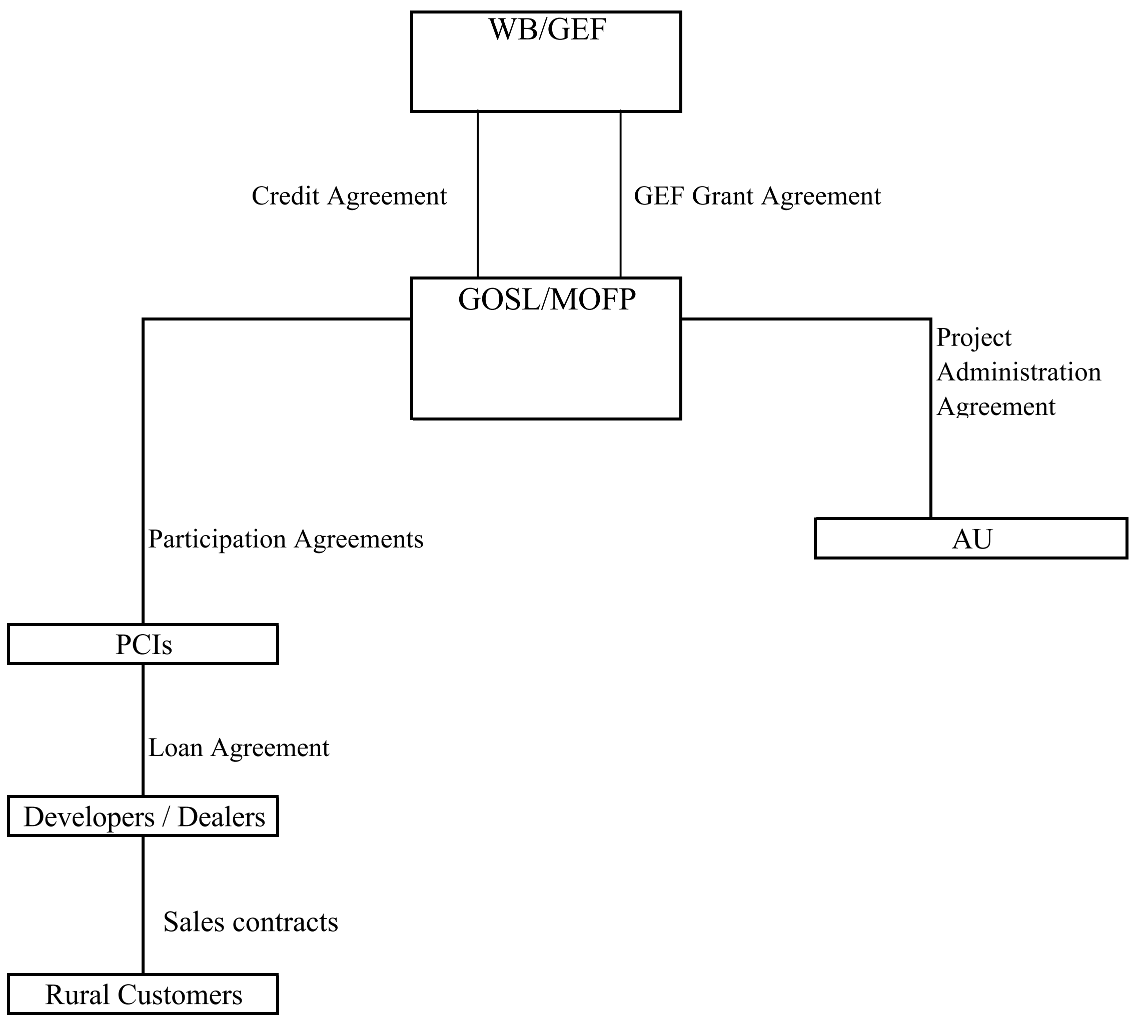
CHINA
RENEWABLE ENERGY DEVELOPMENT PROJECT
Disbursement of Grant Funds for PV Component



SRI LANKA

ENERGY SERVICES DELIVERY PROJECT

Legal Agreements for SHS Component



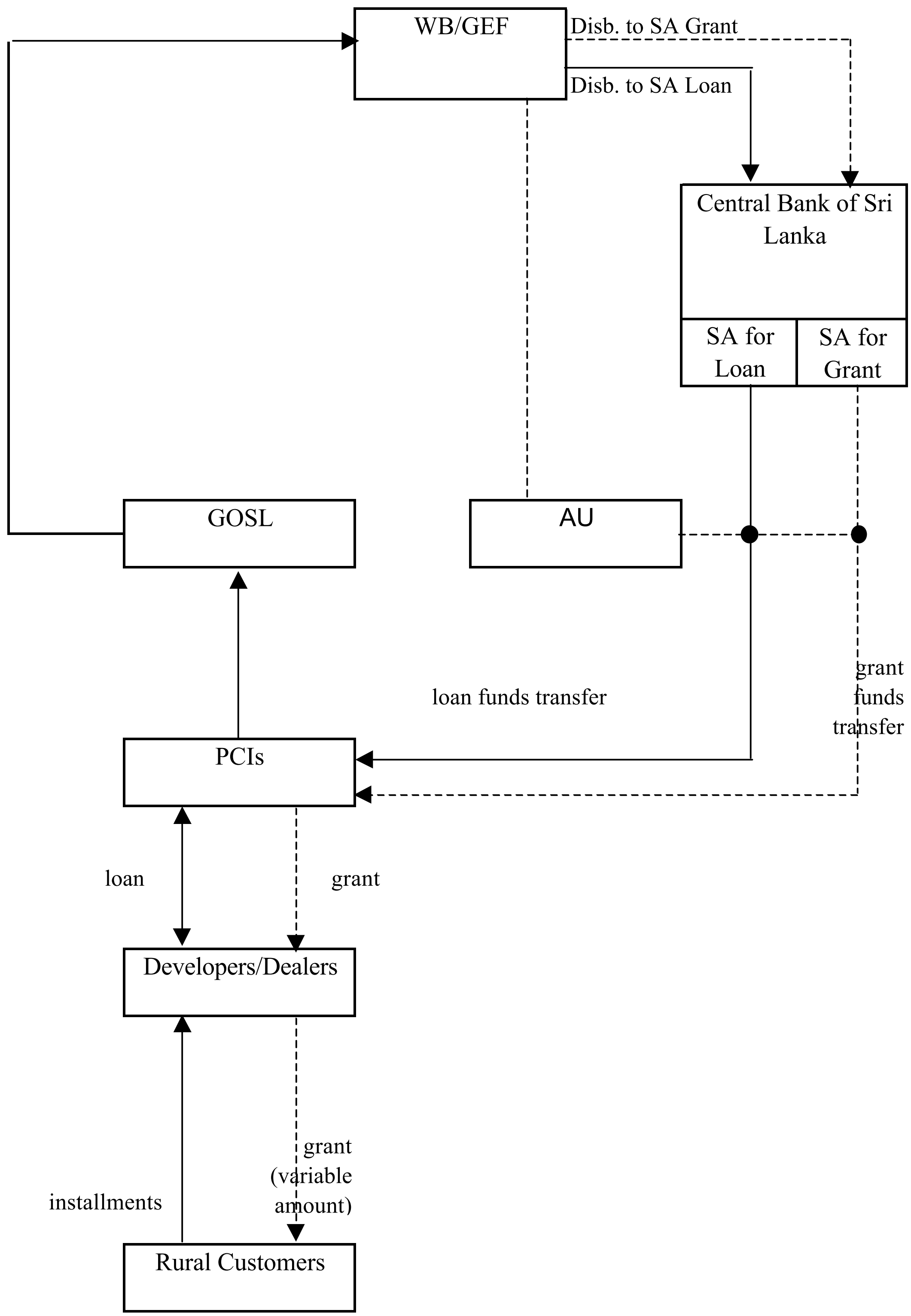
Note: As a special case PCIs may also be permitted to lend directly to rural customers

FILE NAME: LEGALAGR

SRI LANKA

ENERGY SERVICES DELIVERY PROJECT

Disbursement of Grant and Loan Funds for SHS Component



Note: As a special case PCIs may also be permitted to lend directly to rural customers

File Name: DISBURSE

Towards "Smarter" Subsidies:

Essential for Scaling Up Rural and Renewable Energy

Subodh Mathur

mathurs@cais.com

Village Power '98 Conference

October 6-8, 1998

Washington, DC.

Overview

- Ill-designed subsidies are:
  - Counter-productive
  - Waste of scarce resources
  - A key bottleneck to rapid scale-up of rural and renewable energy
- Until we can manage without subsidies, we need “smarter” subsidies

“Smarter” Subsidies: Key Issues

- Maintain cost reduction pressures
- Finance them better
- Select households judiciously
- Rethink the treatment of externalities

Maintain cost reduction pressures

- Where possible, don't stifle competition by providing subsidies to a single entity only
  - Offer similar subsidy to multiple providers
  - Fee-for-service approach (ESCOs) does not inherently require a legal monopoly; offer subsidy to multiple ESCOs
  - Consider making it technology neutral

Cost reduction … continued

- Subsidize results, not investment costs
  - Interest rate subsidies are potentially hazardous
    - → reduce incentives to use scarce capital frugally
    - → financing system may be unsustainable when subsidies are removed.
    - → "last resort", not "preferred way"
  - Capital cost subsidies provide incentives to install systems, but none to utilize them
    - → India wind capacity tax break
    - → Indonesia system expansion subsidy

Cost reduction … continued

- Catalytic subsidies for pre-investment costs may be a bargain
  - Feasibility/pre-feasibility studies
  - Information collection and dissemination
  - Training/capacity building/hand-holding
- Develop new instruments for pre-investment risks, instead of subsidies

Cost reduction … continued

- Try bidding for subsidies
  - Particularly important for “concessionaire” approach
  - If qualified bidders do not exist, make efforts to create them

Finance them better

- Fund <u>fully</u> all subsidies *ex ante*
  - Financial chaos in India power sector because of unfunded subsidies to farmers
    - → No incentive to connect rural households.
  - In Indonesia, unfunded subsidies to off-Java and rural customers threaten grid RE extension
  - Renewable energy projects vulnerable to excessively optimistic assumptions about future cost reductions

Finance them better … continued

- Consider explicit instead of implicit cross-subsidies
  - Implicit cross-subsidies work "within" the firm; no clear, separate accounts are maintained.
  - Explicit cross-subsidy is a levy or tax on some customers/technologies, used to subsidize other customers or technologies
    - → Example of 1% levy for rural electrification in Zimbabwe; NFFO in U.K.; recent Internet subsidy scheme in U.S.

Which households to subsidize?

- Tempting to subsidize modern energy for all rural households or poorest households
  - Subsidizing all rural households in a region often not financially feasible
  - Priority of poorest households may be basic commodities such as food, clean water
- Focus on households for whom modern energy is a high priority

Spending behavior shows priorities

- Basic goal is to improve quality of life of rural households
  - Subsidized prices are a practical alternative to efforts to increase income/overall expenditures
- Determine "priority" by looking at:
  - how much more would household spend on modern energy if their incomes increased
    - → at unsubsidized prices

Simple priority test

For each particular type of rural household, suppose the total annual expenditure (on all commodities) goes up by $100

How much of this $100 will go to modern energy?

Simple priority test … continued

- Compare answers across types of households to determine:

  Groups of households for whom modern energy is a high priority

- For a particular household, compare answers across commodities to determine:

  Priority of modern energy compared to other things

Simple priority test … continued

- Will this work for newer, cleaner, more convenient energy which households have not yet ever used?
  - Many techniques available in economists' toolkits for this purpose

    → used to estimate people's interest/priority in environmental protection
  - Some adaptation and testing of techniques may be needed.

Rethink treatment of externalities

- Externality: Costs of global environmental damage not taken into account by local decision-makers in developing countries
- GEF, bilaterals willing to pay to avoid greenhouse gas emissions in developing countries
- How should these payments be treated in economic cost-benefit analysis?

Rethink externalities ... Current practice

- In cost comparisons, we do not use “GEF” payments, i.e.,

Economic cost of renewables

vs.

Economic cost of conventional

Current practice ... continued

- In cost-benefit comparisons, we include "GEF" payments as a benefit, representing global willinness-to-pay

Economic cost of renewables

vs.

Local benefits of renewable + "GEF" payments

Externalities ... suggested practice

- In cost comparisons, use "GEF" payments as measure of global economic damage

Economic cost of renewables

vs.

Economic cost of conventional +

Global environmental damage cost

Externalities ... suggested practice

- In cost-benefit comparisons, do not include "GEF" payments as a benefit

Economic cost of renewables

vs.

Local benefits of renewable ~~+ "GEF" payments~~

Benefits of suggested practice

- Does not encourage projects that have limited local interest and priority
- Makes clear that “GEF” payments are not the same as “unwarranted” subsidies
- Makes it easier to show that renewables are cost competitive, taking account of environmental costs
- Conforms to economic theory

Village Power 98

Inter-American Development Bank Experience in Renewable Energy Financing for Rural Development

By Jaime Millan

Principal Energy Economist

Sustainable Development Department

IDB

October 6, 1998

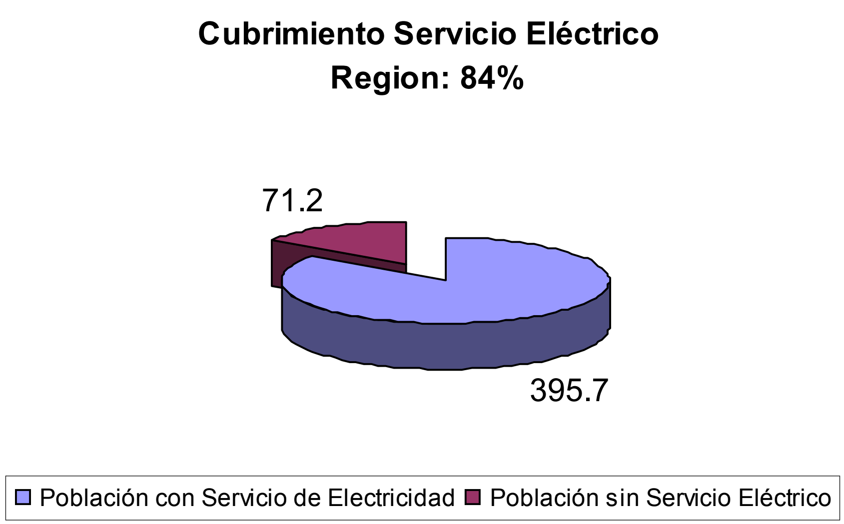
Contents

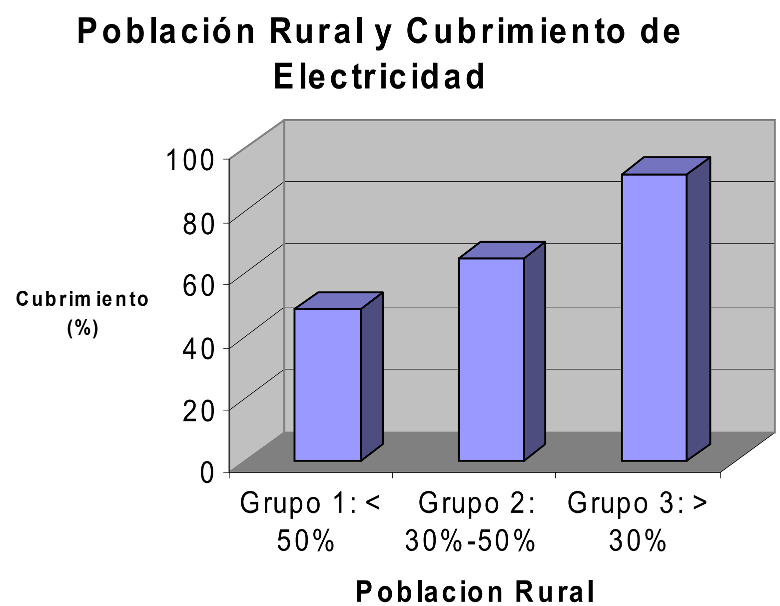
- Markets for rural energy in Latin America and the Caribbean
- The new IDB energy strategy
- Sustainable markets for sustainable energy
- Some examples
- Conclusions

Markets for Rural Energy in Latin America and the Caribbean

- Electricity coverage is high: close to 84% of population in the most urbanized (75%) region of the developing world , but
  - In some countries rural coverage is poor, less than 20%
  - In large countries with high coverage absolute numbers may be huge. Only in brazil there are 20 million people not connected to the grid
- In general rural electrification in the past was based on huge subsidies and resulted in inefficient resource allocation, but
  - Power sector reform opens the door for new participants
  - And a whole new rural energy market

Most Unserved Population is Rural. Correlation Urbanization Electrification





Fuente IDB, 1997

Unserved Population has been declining in Absolute terms in the Last 20 Years.

Cubrimiento del Servicio de Electricidad (%)	
> 90%	Argentina, Barbados, Brazil, Chile, Costa Rica, Mexico, Suriname, Trinidad & Tobago, Uruguay, Venezuela
70% - 90%	Colombia, Ecuador, El Salvador, Grenada, Paraguay
50% - 70%	Bolivia, Dominican Republic, Jamaica, Nicaragua, Panama, Peru
< 50%	Guatemala, Guyana, Haiti, Honduras

Source: IDB, 1997

	Población Rural con Servicio (Millones)		Población Rural sin Servicio (Millones)	
Region	1970	1990	1970	1990
Africa N. y Medio Oriente	11	38	66	70
America Latina	18	50	103	76
Africa	9	27	213	313
Asia del Sur	69	209	510	627
China	270	635	405	159
Asia del Este y Pacifico	233	482	697	590

Fuente: Energy Strategies for Rural and Poor People in LA, World Bank, 1997

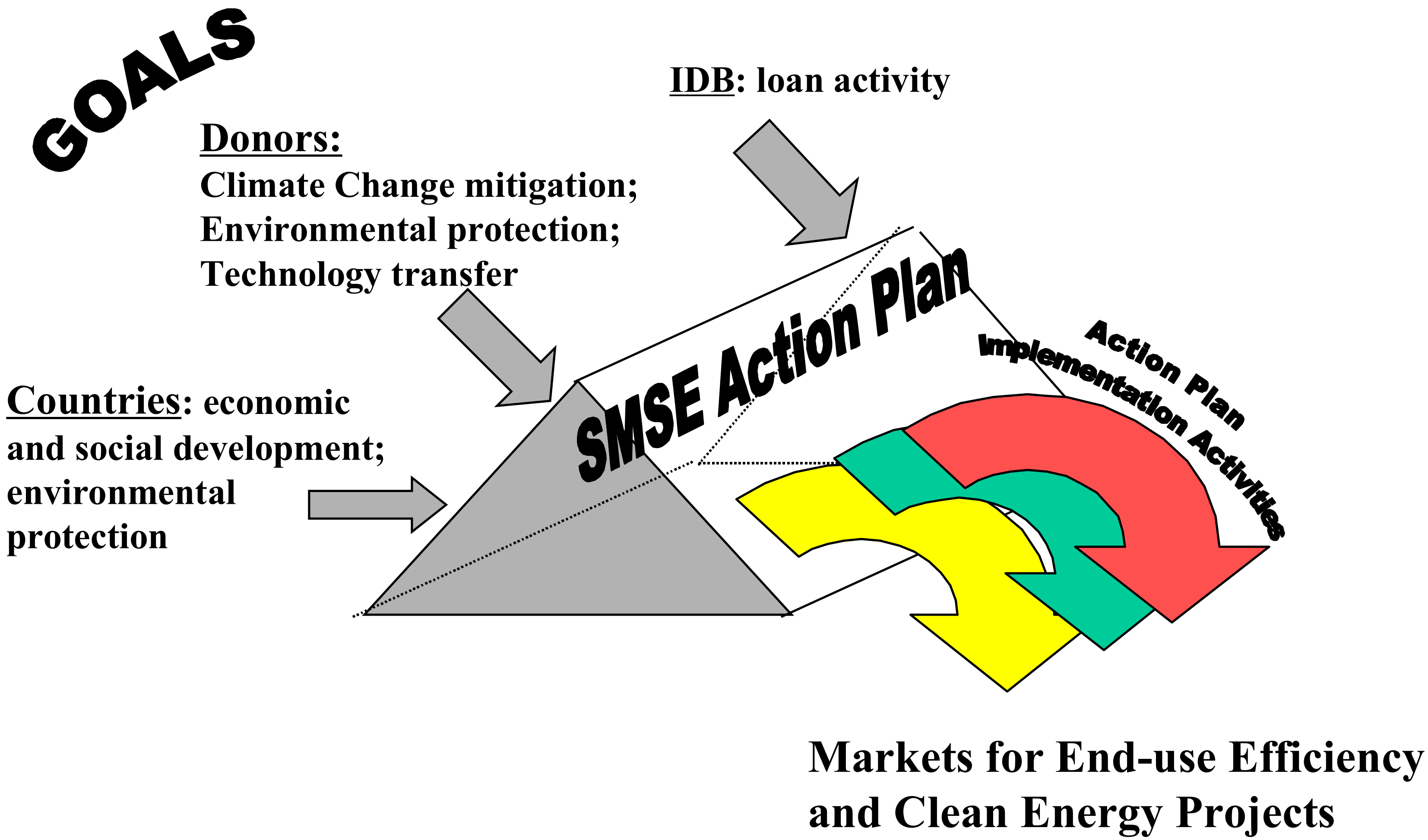
IDB Energy Strategy

- A set of complementary activities that, as a result of confronting comparative advantages and limitations with the needs of the market, help create a unique position for the bank
  - Comparative advantages in:
    - SME and micro-enterprise loans and non-lending services
    - Rural poverty strategy, and gender programs
    - Using donors funds to catalyze markets
  - Limitations in:
    - Putting energy experts to make small, time consuming loans
  - Enable markets for rural energy using our comparative advantage in business development by adjusting means to necessities

IDB….

- Enabling markets for rural energy
  - Creating the institutional and legal framework that level the playing field
  - Filling the missing links that are required to create demand for existing loans and services
    - Capacity building
    - Putting together customers and lenders
    - Innovative lending instruments
    - Non lending services
  - Experiment with many delivery models

SMSE Process Transforms Goals Into Markets for Sustainable Energy

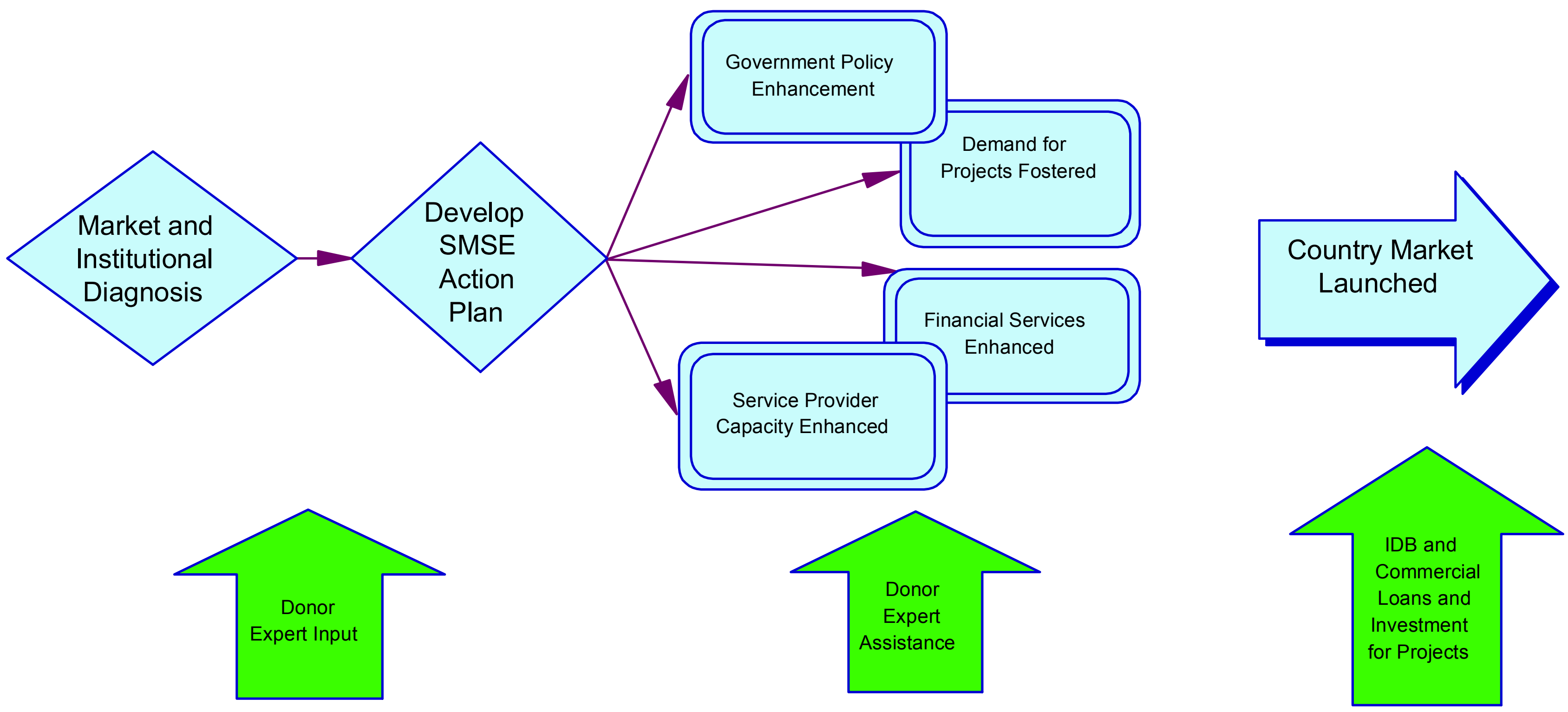


SMSE Process for Catalyzing a Market in Energy Efficiency or Renewable Energy

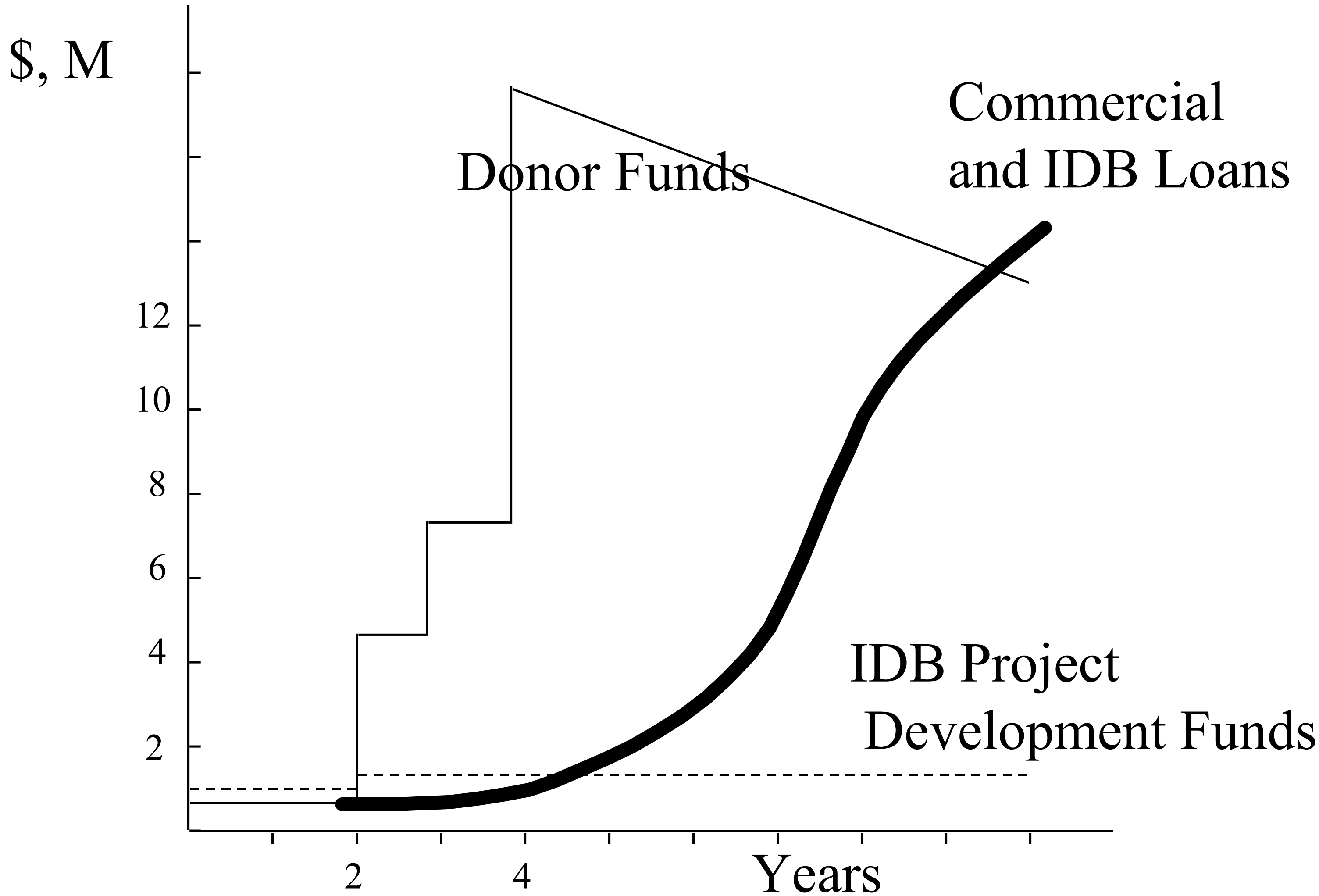
Action Plan
Development Phase:
Up to One Year

Action Plan
Implementation Phase:
One to Three Years

Market Phase



Evolution of Funds Required Over Time



Status of SMSE Activity: Results Achieved and Expected

- Brazil: MIC small project loan concluded; SMSE developed rural renewable energy services component of $400 M SME loan for northeast for 1999; action plan complete and accepted by country; probable funding for implementation by MIF and JSF and other donors
- Peru: action plan complete; probable funding for implementation by MIF and JSF and other donors
- Brazil/parana state: activity expected to be a component of $200 M urban development loan in 1999/2000
- Ecuador: activity expected to be a component of $200 M municipal development loan in 1999; probable funding from JSF
- Argentina: increased utilization of existing loan funds (science & tech, SME) and possible component of new S&T fund
- El salvador: leveraging of private sector activity through existing energy efficiency loan fund

Example for Brazil of Type of Assistance Provided in Action Plan Implementation Phase

- Demand side: market assessment
- Supply side
  - Service providers: business model development assistance
  - Financing: linking existing credit to demand; innovative finance schemes
- Institutional and regulatory: reorganization of government program to help infuse private sector initiative in place of government

Examples of Lending and Assistance Vehicles for Rural Energy in Brazil

- Expansion of markets for small & medium energy enterprises through SME Loans
- Creation of microenterprises for rural energy services in northeast Brazil
- Including components in new loans
  - Agrarian reform loan
  - Prodetur

Other Approaches:

- A comprehensive strategy for rural energy and telecommunications in Central America which, while open to any solution, is ready to replicate other’s experiences in an experimental way
- Support other’s ideas, like E&CO, follow up and be ready to scale up

Conclusions

- The bank is changing its approach seeking to adjust means to needs
- In many respects our approach is similar to that of other multilaterals
  - Driven by social concerns
  - Exploit a niche
  - Trust market mechanisms
- Our uniqueness may be found in the way we have tried to use our comparative advantages

International Finance Corporation

Financing for Private Sector Renewable Energy Projects

Village Power '98 Conference
Washington, DC
October 8, 1998

IFC

International Finance Corporation

- About IFC
- IFC Financing for RE Projects

IFC

International Finance Corporation

IFC is looking for high quality, private-sector renewable energy projects

IFC

IFC - Basic Facts

- Private sector affiliate of World Bank Group owned by 174 member governments
- Objective -- Promote economic development through commercially viable, private-sector investments
- Largest multilateral source of loan and equity finance for private enterprises in developing countries
- In FY 1998, IFC approved US$ 3.4 billion of investments in 308 projects

IFC

IFC's Role

IFC acts as a catalyst to stimulate and mobilize private investment:

IFC investments	US$ 3.4 billion
+ IFC syndications	US$ 2.5 billion
+ Other funding sources	US$ 9.8 billion
Total project cost	US$ 15.7 billion

IFC Capabilities

- Project finance
- Capital markets development
- Financial advisory work
- Project development facilities
- Special initiatives

IFC Investment Guidelines

- Maximum 25% (35%) of project cost
  - Excludes funds raised from other sources
- Market-pricing
  - But flexible on final maturity and grace period
- No Government guarantees
- Meet IFC and host country environmental guidelines

IFC's Value Added

- Direct funding with long-term staying power
- Catalyst for other investors and lenders
  (+ poss concessional funding for RE projects)
- Honest broker/neutral partner
  - Reassuring presence for joint venture partners and host Government
- Risk identification and mitigation

IFC/GEF Financing

- GEF Project Eligibility
  - Meets GEF objective of mitigating climate change
- GEF Funding Limits
  - GEF only covers incremental costs associated with meeting GEF objective

IFC

IFC/GEF Strategy

Match the type of support to the obstacles or risks blocking achievement of GEF objectives
⇨ Prefer non-grant financing

- Focus on near-commercial projects
- Minimize use of GEF resources
- Maximize leverage of GEF resources
- Where possible, co-finance with IFC

IFC

IFC/GEF Strategy

- Why work directly with the private sector?
  - Accelerate market acceptance by funding projects which are close to commercial viability
  - Leverage private capital flows
  - Technology + Management => Efficiency
- Only one of several paths to engaging the private sector

IFC

IFC Renewable Energy Projects

- IFC/GEF Small and Medium Enterprise Program (SME)
- IFC/GEF Photovoltaic Market Transformation Initiative (PVMTI)
- IFC/GEF Renewable Energy and Energy Efficiency Fund (REEF)
- + Small hydro + biomass + geothermal + EE

IFC

Small and Medium Scale Enterprise Program

- US$ 21 million program to provide contingent, concessional loans to financial intermediaries (FIs) which then on-lend or invest in SMEs
- FIs include both NGOs and commercial enterprises
- Incentives for FIs to seek repayment from SMEs
- 10 FIs selected to date - US$ 6.3 M approved

IFC

SME Program - Highlights

- RE projects approved to date:
  - 3 off-grid PV projects:
    - Soluz Dominicana (through EEAF)
    - Grameen Shakti, Bangladesh
    - SELCO Vietnam
  - + 2 FIs providing EE services -- CFL replacement in Egypt and ESCOs in north Africa and Central America
- Considering several other RE projects and still accepting applications for new intermediaries

IFC

Photovoltaic Market Transformation Initiative

- Objective: To accelerate adoption of photovoltaic technology in India, Kenya and Morocco
- Structure: US$ 30 million GEF funding to be allocated by IFC to private companies on a competitive basis

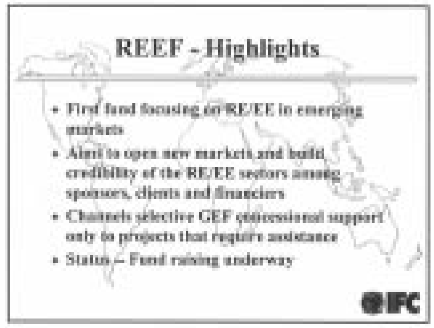
IFC

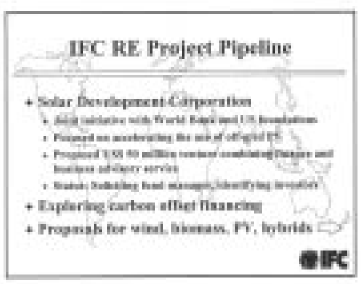
PVMTI - Highlights

- Selection criteria:
  - Meets GEF criteria
  - Innovative market development
  - Maximize leverage of GEF funds
  - Cost-effectiveness (cost/Wp delivered)
  - Local ownership by private sector
  - Use of non-grant financing mechanisms
- Status - Request for proposals issued Sept. 1998; initial deadline for submissions Dec. 1998

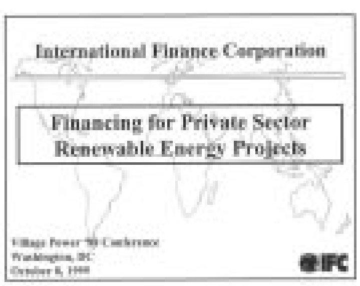
IFC


Renewable Energy and
Energy Efficiency Fund
US$ 50-200 million global investment fund providing both equity and debt
Target sectors: On-grid RE, off-grid RE and EE projects
Mid-sized projects < 50 MW
Additional US$ 10-30 million in GEF funds for co-financing of projects and incremental fund manager costs
IFC


REEF - Highlights
First fund focusing on RE/EE in emerging markets
Aims to open new markets and build credibility of the RE/EE sectors among sponsors, clients and financiers
Channels selective GEF concessional support only to projects that require assistance
Status – Fund raising underway
IFC


IFC RE Project Pipeline
Solar Development Corporation
Joint initiative with World Bank and US foundations
Focused on accelerating the use of off-grid PV
Proposed US$ 50 million venture combining finance and business advisory service
Status: Soliciting fund manager, identifying investors
Exploring carbon offset financing
Proposals for wind, biomass, PV, hybrids
IFC


International Finance Corporation
IFC is looking for high quality, private-sector renewable energy projects
Contact: Environmental Projects Unit
International Finance Corporation
Washington, DC USA
IFC


International Finance Corporation
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IFC

11:30-12:00 **Closing Statements**

- *Chair, Alistair McKechnie,World Bank*

•NREL – *Roger Taylor*

•World Bank - *James Bond*

Village Power '98

Scaling up Electricity Access for Sustainable Rural Development

Closing Remarks
by
Roger Taylor, NREL

So, what is Village Power?

Village Power '98

Scaling up Electricity Access for Sustainable Rural Development

Village Power is about:

Transitions

- from not-for-profit, to sustainable for-profit
- from a technology focus, to a needs-based focus
- from a central station, to a distributed paradigm
- from government control, to local empowerment
- from technology demos to institutional experiments to sustainable businesses
- from identifying a need to creating a market

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

Gender Issues

• ensuring women's access to credit and training
• involving women in the design, implementation, finance and maintenance of rural projects
• focusing on the needs of rural households (cooking)
• recognizing the importance of gender issues in project planning and evaluation

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

Finance

- making bankers believe (at multilateral and local scales)
- encouraging financial transparency
- minimizing subsidies
- striving for economies of scale in project implementation

Most important cost reductions are now in the transaction costs of implementation, not in technology

Village Power '98

Scaling up Electricity Access for Sustainable Rural Development

Village Power is about:

Economics

- seeking out productive uses
- seeking and engaging complementary investments
- driving toward "critical mass" projects (1000 customers per technician, 5 technicians per micro enterprise)

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

Competition

- among technologies (renewable and conventional)
- among implementation approaches (business experiments)
- for investment resources (both program and individual)
- among social priorities

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

WORLD BANK

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

Village Power is about:

Cooperation

- throughout the development community
- among the donors
- among the practitioners
- among the diversity of interests within a country
- need to share problems, as well as solutions
- need to build partnerships
- need to build joint ventures
- exploring options (technical, institutional, financing, development, implementation …)

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

Technology

- continued technical innovation
- making renewables better than diesels
- focusing on applications, not technology
- focusing on reliability of supply, quality of service
- focusing on energy, not just electricity
- building on the computer and telecom revolutions

We are no longer technology-limited,
we are institutional-limited

Village Power '98

Scaling up Electricity Access for Sustainable Rural Development

Village Power is about:

Balance

- between business creation and social obligations
- between donor interests (GHG) and country needs (development)
- between options (no silver bullet)

Village Power '98

Scaling up Electricity Access for Sustainable Rural Development

Village Power is about:

Creating new terms

- flemenstrations (failed demonstrations)
- "manufactured electricity"
- "inclusive development"
- "smart subsidies"

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

Patience

- enormous dedication over extended periods
- not getting depressed

Village Power '98

Scaling up Electricity Access for
Sustainable Rural Development

Village Power is about:

- Creating Opportunities
- Empowering People

- Running faster … so we don't loose the race

Closing Remarks

Presented at Village Power 98
Scaling Up Electricity Access for Sustainable Rural Development
Washington, D.C., October 6-8, 1998

James Bond, Director
Energy, Mining, and Telecommunications, The World Bank

Village Power '98 - an enormous success

- Over 500 participants
- A wealth of brain power
- Advertising new technologies and ideas
- Involvement of the private sector (Shell Renewables and their ESCOM project)

A.

B. Three core themes:

- The technologies: *What are the new possibilities? How is the cost-benefit ratio improving?*
- The financing: *How best can we finance rural energy access?*
- The organizational structures: *How best to put financing and technologies into practice?*

C.

- The news on technologies has been good, but not good enough: the costs are still too high.
- The news on financing has also been heartening: the Bank's LILs, microfinance initiatives, Shell Renewables' card-based fee for service system.
- But the challenge of scale-up will be met most effectively on the institutional level: a great deal of encouragement here, from our 1998 Village Power Road Warrior to NRECA. Utilities do not look like the answer - working from the poor's own organizational arrangements will likely succeed best.

D.

E. Three central challenges:

F.

1. To the industry: bring down the costs of the technologies.

2. To the financiers: defeat the institutional impediments to innovative financing.

3. To all of us: to realize that we are in a stiff competition for scarce resources, not just with

- Other strategies for RE (grid extension, distributed generation); and
- Other priorities for national energy policies (e.g. better urban electrification);

But also with

- Other potential receptacles of financing for economic and social development: from schools and hospitals, to roads and water.

This is the bottom line we must confront: we must work together to make renewables a competitive option for RE, and to make RE a competitive option for development and, even more importantly private sector financing.

Appendix A
Poster Session

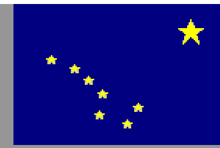
NREL Handouts
Project Briefs
Bibliography
Renewables for Sustainable Village Power by Larry Flowers
Lessons Learned from the NREL Village Power Program by Roger Taylor

Village Power '98 Attendees

Photographs

Alaska

Richard Emerman (Alaskan State Energy Office)
and Mari Shirazi (NREL)



Rural Alaska population: 76,000, communities: 200, utilities: 100

Alaska's Renewable Energy Program

MWh(s) sold	363,783
% Diesel generation	98%
Gallons of diesel fuel	27,540,292
State subsidy	about US$18 million

General: no roads or interties, bulk fuel storage

Purpose of renewables programs: cost-effectiveness

Developments programs:

- Small Hydro
- Wind:
  - Turbine performance (AOC 15-50 in Kotzebue)
  - High penetration wind-diesel system development

Wales High-Penetration Wind-Diesel System

- High-Penetration, Wind-Diesel System
- Begin first phase of installation in the Fall of 1998
- Wales is a remote Inupiat Eskimo village of about 160 people
- Primary funding by EPA Environmental Technology Initiative and Alaska Science and Technology Foundation
- Estimated $600,000 to retrofit the existing diesel plant with two AOC 50-kW wind turbines, distributed dump load, system controller, and energy-storage subsystem
- Partners are National Renewable Energy Laboratory, Alaska Department of Community and Regional Affairs, Kotzebue Electric Association, and Alaska Village Electric Cooperatives.

KEA Wind Farm

- Wind-diesel system
- Three AOC 50-kW turbines installed, seven additional turbines to be installed beginning in the fall of 1998
- Kotzebue is a predominately Inupiat Eskimo village of about 3000 people
- Initial funding by State of Alaska, additional funding by DOE
- Project goal to eventually include up to 2 MW of wind power and to become a center of excellence for wind power in Alaska
- Kotzebue Electric Association (KEA).

Tazimina Hydroelectric Project

- The 800-kW Tazimina hydroelectric project, completed in 1998, serves the Iliamna region in rural Alaska. There are no roads or transmission lines connecting the region and its 600 residents with the outside world.
- Tazimina is a run-of-river project—there is no dam or impoundment.
- Water is diverted around Tazimina Falls—a small fraction of the available flow is diverted in summer and most of the flow in winter. Because the falls are a natural barrier to fish migration in summer and are frozen in winter, the diversion does not affect fish populations.
- Project capacity exceeds peak demand. As a result, the utility's diesel generators can be completely idled most of the year.
- The project cost US$11.7 million to construct. State and federal grants totaling US$8.4 million accounted for 72% of the cost, supplemented by US $3.3 million of low interest debt. Initially, the cost of power from the hydro project is about the same as the avoided cost of diesel power generation
- The utility's average residential rate is about US$0.46/kWh.

Tazimina River in August of 1996

Argentina

Peter Lilienthal (NREL)

Unelectrified population = 2,388,351 people or 556,999 households

Argentina's Renewable Village Power Activities are:

- Rural concessions in Salta and Jujuy
- Wind-diesel retrofits in Patagonia
- Wind mapping and water pumping in La Rioja
- Solar Home Systems in Missiones
- Rural schools in Santa Fe and Buenos Aires.

Rural Concessions

- Salta and Jujuy are the first provinces to award concessions to private utilities for the supply of energy services through stand-alone renewable systems.
- Working with the Secretaria de Energia, NREL has developed models that estimate the cash flow and profitability of private companies operating rural concessions for use throughout Argentina.
- NREL is continuing to collaborate with Ente Regulador de los Servicos Publicos in Salta.

A wind/PV hybrid in Jujuy

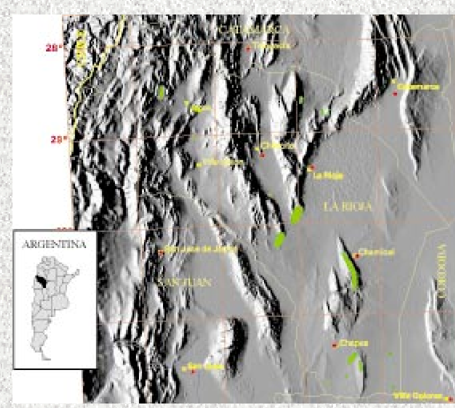
An isolated diesel plant in Tres Lagos, where a wind-diesel retrofit is under development

Wind-Diesel Retrofits in Patagonia

There are dozens of diesel plants in the provinces of Patagonia serving isolated communities. The fuel supply and maintenance requirements for these diesels can be reduced by utilizing Patagonia's abundant wind resource and integrating wind turbines and new controls into the diesel plants. A project is under development for the community of Tres Lagos in Santa Cruz.

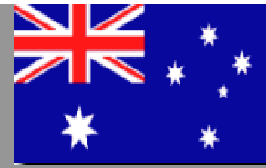
Wind Mapping in La Rioja Province

- NREL and the Government of La Rioja Province are collaborating on a program to assess the wind resource in the province and to create wind-energy maps of La Rioja.
- The province will conduct a wind measurement program, using 10 60-m towers and 19 24-m towers.
- NREL will provide training and technical assistance to the province, and will perform the final analysis and wind mapping.



La Rioja Province of Argentina and Surrounding Areas- Future Wind Resource Exploration Areas

Australia: Country Overview



Stephen J. Phillips (Advanced Energy Systems)

Australia's Renewable Energy Program

Australia's renewable energy program has a long and active history and is gaining strength all the time. Renewable energy is commonly used for powering remote ranches and communities in the Australian Outback and is actively promoted and supported by the major utilities and state and federal ministries of energy. Australia's renewable energy industry includes award-winning manufacturers of most major renewable energy technologies including wind turbines, solar panels and concentrators, power conditioning equipment, batteries, fuel cells, and biomass. Major universities around Australia conduct renewable energy research in cooperation with industry through ACRE, the Australian Cooperative Research Centre for Renewable Energy.

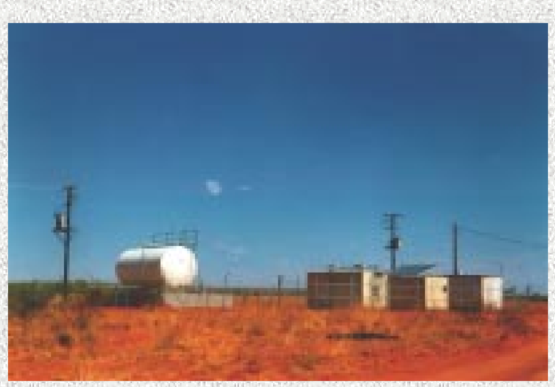
Wilpena Pound, South Australia

Commissioned in July of 1998 for the ETSA Corporation of South Australia, the Wilpena Pound hybrid system incorporates a 100-kW Solar Array, 100, 150, and 300-kVA generators, a 400-kWh battery bank, and a 125-kVA Static Power Pack from Advanced Energy Systems. The system has a peak capacity of over 500 kW and is expected to reduce emissions of CO_2 by approximately 300 tonnes per year. The system cost AU$2M and was installed in favor of extending the utility grid. The system was designed, manufactured, and commissioned by Advanced Energy Systems and powers the Wilpena Pound Tourist Resort and accommodations for the park personnel.

The Wilpena Pound solar/diesel hybrid system

Eppennara, Northern Territory

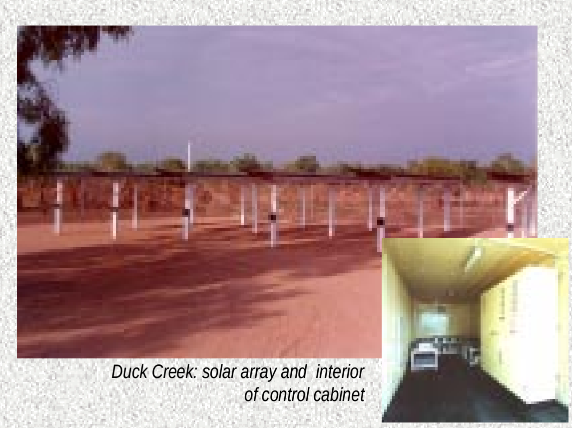
Powering a village, pastoral station, and school; the Eppennara power system was commissioned in 1994 and incorporates a solar array, AES inverter, two diesel generators and a battery bank. The system operates under a "Build/Operate/Transfer" contract between the Power and Water Authority of the Northern Territory and Advanced Energy Systems. With a current peak capacity of 130 kW, it is slated to be upgraded with an 80-kW wind turbine by the end of 1998. Too remote to ever be considered for grid extension, the renewable energy hybrid system was chosen over stand-alone diesel generators.



Eppennara power station

Duck Creek, Northern Territory

Powering a village and school, the Jilkminngan (Duck Creek) power system was commissioned in 1992 and incorporates an 18-kW solar array, 60-kVA AES inverter, two diesel generators (40- and 80-kVA) and a 100-kWh battery bank. The system is owned by the Power and Water Authority of the Northern Territory. With a current peak capacity of 144 kW, the system is also used for testing different solar technologies. As with most AES systems, the Duck Creek power station incorporates a remote dial-in monitoring and control package which is used to access and analyze solar data via a computer link.



Duck Creek: solar array and interior of control cabinet

Bangladesh

April Allderdice (NREL)

Unelectrified Population = 96 million

Renewable Energy Development in Bangladesh

Bangladesh has seen the parallel development of private and public sector renewable energy rural electrification. Grameen Shakti is a not-for-profit rural power company whose purpose is to supply renewable energy to unelectrified villages in Bangladesh. While the Rural Electrification Board has electrified a remote island with solar PV, Grameen Shakti has developed a solar home system sales business. Grameen Shakti is also developing a wind powered microenterprise zone pilot project.

Rural Electrification Board Solar Program

- The Bangladesh Rural Electrification Board (REB)
- Solar PV electrification of island village using home systems and battery charging stations.
- The project was installed in September 1996
- Narsingdi District, Bangladesh
- The project used the existing infrastructure of the REB that is responsible for rural grid extension in Bangladesh
- Customers pay a monthly fee between US$2.30 and US$4.80

Narsingdi Island people enjoy TV powered by solar energy

A solar-powered store offers longer hours for sales

Grameen Shakti Solar Home Systems

- Solar home system sales network
- Sales began September 1996 in four initial zones in Bangladesh
- Grameen Shakti technicians work out of rural unit offices to ensure local sales and maintenance availability
- Solar home systems range in price from US$3000 to US$600
- Grameen Shakti offers a two-year credit term for sales.

Grameen Shakti Wind-Powered Micro-Enterprise Zones

- Grameen Shakti
- Micro-enterprise Zones for enterprises that require more power than a solar home system can provide
- Installations scheduled the Fall of 1998
- Coastal area of Bangladesh
- Enterprises will operate out of Grameen Bank cyclone shelters, many of which already have Grameen Bank offices in them.
- End user payments are yet to be determined.

Installation of 1.5-kW wind turbine in Chokaria, Bangladesh

Bolivia Electrification Program

Granville (Pete) Smith (NRECA/South America)

Unelectrified Population= 3.5 million ++

Renewable Energy Program
Bolivia Electrification

- Solar PV electrification in altiplano and Santa Cruz
- Biomass generation program in lowlands
- Local government support for renewables
- Partnership with CRE
- GIS planning used to identify targets
- Local assembly of equipment
- Training.

Riberalta Biomass Power

- Cooperativa Eléctrica de Riberalta/NRECA
- Brazil nut biomass generation plant
- Installed in 1996
- Amazonian region of Bolivia
- Funding from USAID, Cooperative, E&Co
- 1-MW plant, US$2.2M with grid.

Riberalta biomass 1-MW power plant

Typical solar home system installed in the altiplano

Altiplano and CRE Solar Electrification Program

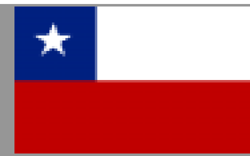
- Cooperative in Santa Cruz and Municipalities in Oruro and La Paz
- Solar PV electrification programs
- Initiated in 1994, on-going
- Various communities in the altiplano and San Julian, Santa Cruz
- Financed by local government funds
- Over 2500 systems installed and growing.

Bolivia Wind Water Pumping Program

- Altiplano and Cochabamba valleys
- Water supply program using wind and solar electric pumping systems
- Initiated by NRECA in 1993, ongoing
- Llasaraya, Oruro, and Cochabamba
- Funds provided by USAID coordinated with CARE
- 25 systems installed to date.

Wind water pumping station installed in Llasaraya, La Paz

Chile



E. Ian Baring-Gould (NREL)

Unelectrified Population = 861,000, primarily in the southern regions

Villa Las Araucarias Pilot Project

- Inland community supported by forest industry
- Health post, school, and 17 homes electrified
- 9.8-kWh daily load with significant load increase expected
- System supplies 24-hr power
- System includes 7 kW Bergey turbine, 3-kW TRACE inverter, 33.6-kWh battery bank of Trojan L-16s, 5.4-kW autostart Honda generator, and 220 volt, and 50 hz AC distribution grid
- Contributing organizations: CNE, NREL, NRECA, and Frontel/SAESA.

Island of TAC, Region de los Lagos, Chile

Chiloe Islands Project

- Electrification of 36 islands in the Chiloe Sound using a mix of wind hybrid and individual home wind systems
- Planned installations for 1999 and 2000
- Islands located throughout the Chiloe Sound in Region X
- Public request for proposal to provide electrical service issued by the regional government with technical assistance provided by CNE, NREL, and NRECA
- Over US$12 Million in power system equipment planned
- Contributing organizations: CNE, Intendencia de los Lagos (Region X), NREL, and NRECA.

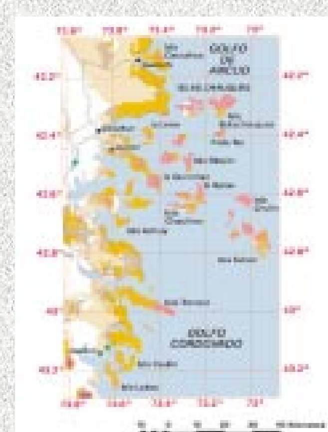
Chile's Renewable Energy Program

- Chile's Comisión Nacional de Energia (CNE) is evaluating the applicability of renewable energy for rural power development
- Installation of pilot power systems is occurring in Region IX and X to demonstrate the use of renewable energy technologies
- Training of integrators, engineers, and utility representatives in the design, operation, and maintenance of hybrid power systems
- Wind resource mapping in regions with large rural populations.

Village of Villa Las Araucarias and the installed power system

Isla Tac Pilot Region X

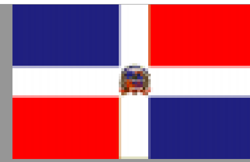
- Wind-hybrid power system to provide 85 kWh per day of electrical power for the Chiloe island community of Tac
- Installation planned for December of 1998
- Pilot system to demonstrate wind renewable power systems for the electrification of island communities
- US$210,000 for the power and distribution systems funded jointly between U.S. DOE, the regional government, and a local utility
- Contributing organizations: CNE, Intendencia de los Lagos (Region X), NREL, NRECA, and SAESA
- System to introduce technology to be used in Chiloe Islands Project.



Isla de Chiloe Area of Region X; Preliminary map of favorable wind resource areas

Dominican Republic

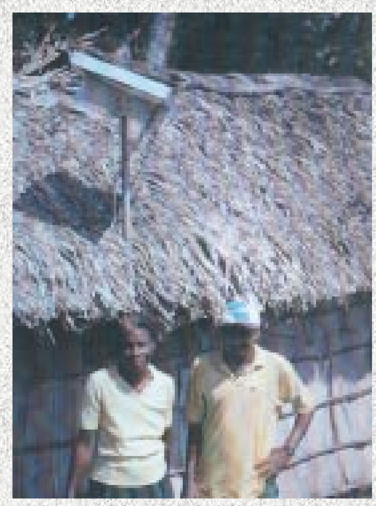
John Rogers (Global Transition Group)



Total population = 7.5 million
400,000 unelectrified homes, significant need for clean water and power land area = 45,000 km^2

Dominican Republic Rural Energy Delivery

- Since the mid-1980s, the Dominican Republic has experienced various initiatives employing renewable energy, primarily photovoltaics, for rural energy delivery.
- Rural energy delivery is strongly market-oriented.
- The emphasis has been on the creation of sustainable commercial infrastructures for the delivery of products, services, and financing.



Soluz Dominicana technician with a PV fee-for-service customer

PV Fee-For-Service Operation

- Soluz Dominicana, s.a.
- PV fee-for-service operations are offering stand-alone PV systems and serving 1,620 as of 9/98
- Began in 1994
- Affects over 160 communities in two northern provinces
- Individual households contract PV service and Soluz installs and maintains all systems for set monthly fees
- US$1.3M invested to date.

Installation of REGAE financed wind-electric water pumping system

Electrical Energy Sector Restructuring Project (EESRP)

- Winrock International/REGAE
- Promotion and commercialization of small wind-hydro power generators for village power and other applications under USAID are financed by EESRP
- Began October 1996
- Countrywide
- Providing technical assistance and loans to project developers, companies, NGOs, and individuals
- US$3.0M ($700,000 loan/lease fund).

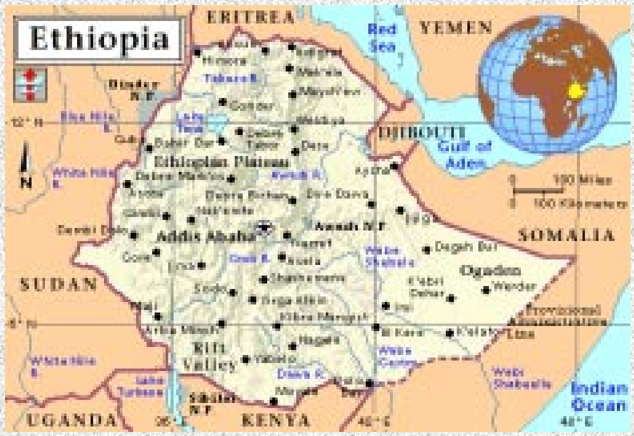
Renewable Energy Community Water Delivery

- ADESOL (Solar Energy Development Association) and Inc./Enersol Associates, Inc.
- PV, wind-electric community water systems
- Began in 1993
- Countrywide: six communities—over 1,200 people
- Donations cover civil works; ADESOL finances commercially supplied RE water systems with revolving loans
- US$200,000 to date.

Typical ADESOL financed systems supply 2,000 gallons of water per day for 200 people

Ethiopia - PV Program

Neway Argaw (NREL)



Unelectrified Population = 85% (50 Million)

Organizations Actively Involved in Renewable Energy Program in Ethiopia

- Ethiopian Science and Technology Commission (ESTC)
- Ethiopian Energy Studies and Research Center (EESRC) Ministry of Mines and Energy
- Ministry of Health (MOH)
- Ministry of Education (MOE)
- Rural Technology Promotion Programme (RTPP), Ministry of Agriculture (MOA)
- Addis Ababa University (AAU)
- NGOs: UNICEF, Christian Relief and Development Association (CRDA), Oxfam UK.

Melkassa PV Pump Irrigation Demo Program

- This demonstration project is owned by Addis Ababa University (AAU) which was financed by the Swedish Agency for Research Co-Operation with Developing Countries (SAREC).
- AAU is administering the research part of the demonstration program which is operated by eight local farmers.
- The system is 600 W_p and was installed in 1990 by AAU.
- The site is located at Melkassa in the eastern part of Ethiopia.
- AAU is monitoring the system and eight households are beneficiaries of the system to irrigate 4.5 hectares of land.
- The project costs US$8,185.

Work-Amba PV Pumping System

- This system was installed in 1994 under the UNICEF-assisted rural water supply programme.
- The system was administered by the water committee directly voted in by the community.
- The system is 1.6 kW_p and serves 3000 people.
- The system is located at the northern part of Ethiopia.
- The system is operated by the water committee and maintained by the Ministry of Water Resources.
- The system has a distribution system with four water points.
- The project costs US$40,550.

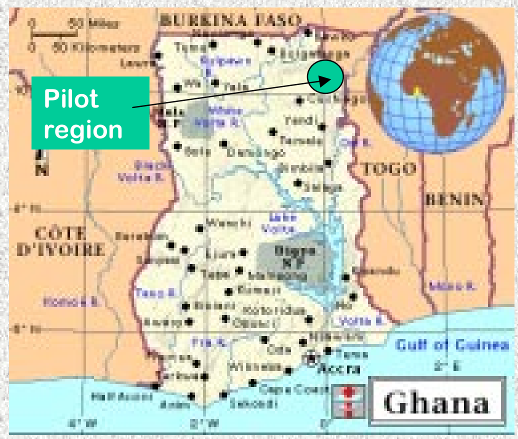
Debre Zeit Area PV-Water Pumping System

- This system was installed in 1988 by the Rural Technology Promotion Programme, Ministry of Agriculture.
- The system was administered by the local farmer's association.
- The system is 1.2 kW_p (M55) and serves 2000 people.
- Users pay US$0.36/month/household.
- The system is located 70 km south of Addis Ababa, Ethiopia.
- The system is operated by the farmer's association and maintained by the Rural Technology Promotion Programme, Ministry of Agriculture.
- The system functions properly except for the inverter (a Grundfos SA1000) which broke a few times.

Ghana

Renewable Energy-based Rural Energy Services Company (RESCO)

Jerome Weingart (Weingart & Associates) and Roger Taylor (NREL)



Unelectrified Population = 11 million people

A UNDP/GEF Path-Finding Initiative

- US$3 million cost-shared project (UNDP/GEF, Government of Ghana, and U.S. DOE/NREL)
- Sub-Saharan Africa's first renewable energy-based rural energy services company (RESCO)
- The goal is to demonstrate bankability and sustainability, and the supply of priority energy services to communities willing and able to pay
- Photovoltaic and other technologies will be used to provide energy services on a cost-recovery fee-for-service basis
- An independent corporation will implement the pilot project.

Renewable Energy for Rural Social and Economic Development in Ghana

- Execution: Ministry of Mines and Energy
- Implementation: A new corporation not tied to the existing electric utility infrastructure
- Timetable: Fall 1998, for three years
- Pilot region: Mamprusi East district
- Unelectrified population in pilot region: tens of thousands of people in over 70 villages
- NREL is the principal collaborating international scientific institution, participating in project design, implementation, training, and technical support.

Working to Ensure Sustainability

- RESCO is designed to be profit-making, with services provided on a *willingness and ability to pay* basis.
- RESCO will own and maintain the equipment, including selected end-use equipment (e.g., grain mills, cold storage, and water supply systems).
- Three service centers spanning the pilot region (service territory) will be established.
- Use of traditional and effective system of bonded cashiers for revenue recovery.

Renewable Energy Applications for the Rural Communities

- **Community applications** - potable water supply, power for health clinics, schools, public lighting, community halls, churches and mosques, and telecommunications and entertainment
- **Productive uses** - small-scale irrigation, post-harvest processing, grain grinding, cold storage, guest houses, shops, bars, dress makers, artisans, and video stores
- **Household applications** - lighting, entertainment, and new high-efficiency low-emission cooking
- **Government services** - lighting, fans, and communications for government facilities.

Ghana's Unelectrified Communities

- 4,000 unelectrified communities with several million people.
- Water supply by advanced hand pumps, with round-the-clock pumping by women in many villages during dry season.
- Water-borne disease is a leading source of death and disability.
- Unelectrified health posts and schools limit health services and education.
- Lack of electricity constrains economic productivity and growth.

Guatemala

Fundación Solar and Winrock International

55% - 65% of the urban population is electrified;
45% of the rural population is electrified.

Renewable Energy in Guatemala

- There is no explicit policy on rural decentralized energy services or for the role of renewable energy.
- The government of Guatemala is promoting the development of feasibility or pre-feasibility studies for rural grid interconnection and some village electrification using renewable energy.
- The interconnection rate has increased to 50% - 55% of the population, but it is expected that in the rural areas the electrification index may be lower.
- Privatization has spurred significant investment in fossil fuel generation.
- Recent policy developments have not been very supportive of renewable energies, for example; new tax legislation has removed import benefits formerly accorded to imports of renewable energy equipment.
- In Guatemala, privatization has been passed, but it is only part of the equation: a comprehensive energy policy still needs to incorporate all aspects of renewables in the planning equations and support mechanisms for decentralized rural energy services.

- Stand-alone PV systems are the most common technical solution for rural projects.
- Solar PV is economically sensible if communities are 5 km away from the national grid and have less than 100 houses.

- Not all of the people can afford to be farmers: productive uses of RE is a must in Guatemala.
- Scaling up technologies allows for economic gain, as well as for financial profits in small rural businesses.
- Small hydro-electric systems (15-100 kV) are feasible in a country with over 4,000 MW of untapped hydro potential.

- If a village has more than 30 houses, 4 m/s wind speed, and is located 7 km away from the national grid, wind power is the right choice.
- Fuel wood continues to be the main source of energy for cooking in Guatemala.
- Renewable energy is not an ultimate solution in Guatemala, but it is a means to accomplish other social, economic, and environmental goals.

INDIA

Winrock International

Although 85% of the villages in India are deemed to have been electrified, 71 million rural households still do not use electricity.

Renewable Energy Program Government of India

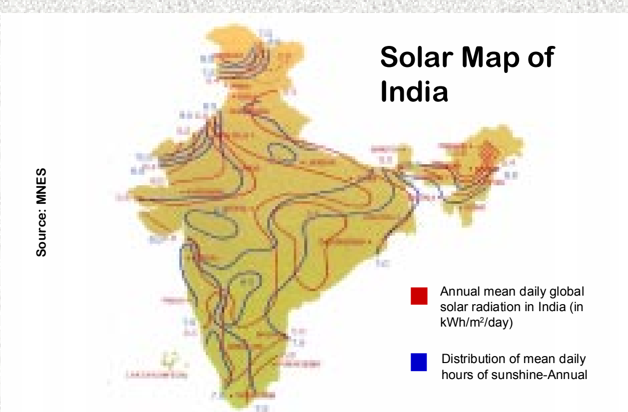
- The Indian Renewable Energy Development Agency (IREDA) was set up by the Ministry of Energy in 1987 to provide assistance to manufacturers and users of renewable energy systems.
- In 1992, the Ministry of Non-Conventional Energy Sources (MNES) was established as a department in the Ministry of Energy.
- The Ministry implements the Integrated Rural Energy Program transferred to it from the Planning Commission.
- A National Program on Biogas Development is a major program of the Ministry.
- Cogenerated power: GOI policies include wheeling and banking, third-party sales, and buyback.
- Wind power: The major source for power generation among renewables, with 1.4 billion units of electricity being supplied to the grid so far.

Cogeneration in the Indian Sugar Industry

- Indian sugar industry
- Exporting power to the grid
- Initiatives began in 1995
- Uttar Pradesh, Tamil Nadu, Maharashtra, Karnataka, and Andra Pradesh
- Installing high-pressure boilers and superior turbines, making condenser modifications, and utilizing bagasse as fuel
- Existing and planned: 310.8 MW.

Bagasse plant equipped with an 18-MW turbo-generator set with 66 kg/cm^2 pressure and 485°C temperature boilers

Gathering sugar cane trash to make bagasse



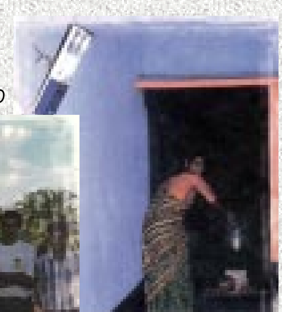
Commercialization of Solar PV Powered Dryer

- Dr. Rao Associates
- Commercial solar cabinet dryers of natural convection or “forced circulation” type to enable larger quantities of hygienic and good quality food products to be dried faster and generate additional income for rural women and men engaged in this activity
- Began in 1998
- Andhra Pradesh
- Designed and developed by the Society for Energy, Environment, and Development under sponsorship of UNDP-GEF’s Small Grant Program, through Development Alternatives, a New Delhi NGO
- Two sizes, 2' x 2' and 2' x 4', using dry materials ranging from 4 kg to 15 kg per charge.

Solarizing Rural India

- SELCO Photovoltaic Electrification, Pvt. Ltd.
- Provide electricity to the rural population and integrate PV into the mainstream of the local culture
- Began in 1995 in Southern India
- Developing and marketing small-scale solar PV power systems to rural households and institutions
- Prices varies.

A branch office of SELCO



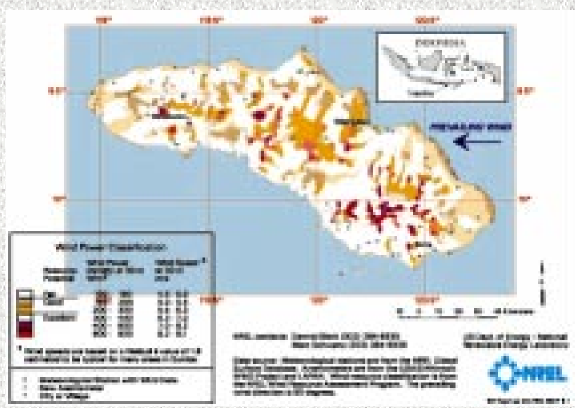
For rural families, an investment spread over a two- or three-year period can make a basic home PV system a possibility.

Indonesia

E. Ian Baring-Gould (NREL)

Wind Project

- Installation and financing of wind-based power and water pumping systems in remote communities
- Wind measurement and resource mapping
- Eight systems installed; 40 to be installed
- Projects located in eastern islands, West Timor, and Sumba focus
- USAID funded; contributing organizations include Winrock International - project manager; and NREL - technical assistance.



Sumba, Indonesia-Favorable Wind Resource Areas

Solar Home Systems

- Provide basic electricity to rural customers
- Facilitate private sector participation in renewable energy commercialization
- Promote sustainable development and reduces the energy sector's dependence on fossil fuels
- Strengthen Indonesia's institutional capacity.

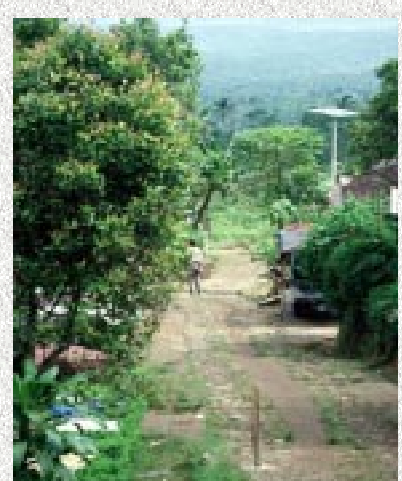
Indonesia's Renewable Energy Program

- Large geothermal power systems in populated areas
- Retrofitting of remote diesel power plants in the eastern islands using wind power systems
- Installation of small community based power and water pumping systems using wind technologies
- Development of financing mechanisms for leasing small wind power systems for rural electrification
- Market development for individual solar home systems to supply power in remote unelectrified communities.

Wind hybrid power system in West Timor

Diesel Retrofit Study

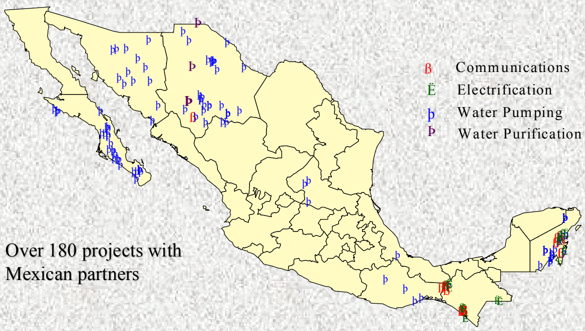
- Assessment of the diesel retrofit market using wind technology for the eastern islands
- Focused on the region of NTT and the Maluku Islands
- Analysis data include wind-resource maps, diesel plant operational data, and maps of the plant distribution, and transmission networks to determine sites with diesel retrofit potential
- NREL technical assistance; funding from U.S. DOE, USAID, and the World Bank. Assistance from Winrock International and PLN.



Individual PV home system

Mexico Renewable Energy Program

Charles Hanley (Sandia National Laboratories)



Unelectrified rural population is more than 5 million people

DOE/USAID Mexico Renewable Energy Program

- Program has multiple objectives
  - Increase sustainable markets for U.S. and Mexican industries
  - Demonstrate renewables in combating global climate change
- Focus on off-grid productive uses
- In-country partners have established and funded programs
  - Training and technical assistance provided by Sandia team
  - Pilot projects to institutionalize renewables within existing programs
- Phase 2 focusing on replication and greater in-country management.

Colonia Modelo Ranch
Mpo. Ascención, Chihuahua

450-W_p PV Water Pumping:

- Siemens SP-75 Modules
- Grundfos SP2A-4/90 Pump
- Grundfos SA-400 Controller

Water Pumping for Productive Uses (Through Several Partnerships)

- Primary partner is FIRCO - a technical organization under the Secretary of Agriculture
- Chihuahua RE Working Group - government and private organizations (including FIRCO, DGDR, and CFM)
- Water pumping applications include livestock, irrigation, domestic, and community water systems
- 115 water pumping projects (61.5 kW) in eight Mexican states
- Focusing on nationwide replication as part of an established $1.8 billion agricultural development program.

Chajul Biological Station
Montes Azules Reserve
Chiapas

1.4-kW_p PV Electrification:

- Siemens SP-75 Modules
- 5.5-kW Trace Inverter
- Condumex Controller
- Exide E125-19 Batteries
- 6.3-kW Onan Propane Generator

Protected Areas Management

- Partnerships with World Wildlife Fund, The Nature Conservancy, and Conservation International
- Demonstration of RETs to facilitate reserve management and sustainable development programs
- Working with 14 non-government organizations
- 25 projects (total of 19.8 kW) in 10 reserves
- Working with the Mexican Secretariat of Environment to identify future applications and provide technical assistance
- Demonstrate feasibility and application of renewable technologies for eco-tourist facilities in Chiapas and Quintana Roo.

Other Partnerships Create a Broad Base

- National Solar Energy Association (ANES)
- Federal Electricity Commission (CFE)
- Center of Energy Research (CIE-UNAM)
- National Energy Savings Commission (CONAE)
- Universities of Chihuahua (UACH), Sonora (UNISON), and Quintana Roo (UQROO)
- U.S. and Mexican RE companies, SEIA, and AWEA
- Key SNL team partners: SW Technology Development Institute - New Mexico State University, Enersol Associates, Ecoturismo y Nuevas Tecnologías, Winrock International, and National Renewable Energy Laboratory.

Costa de Cocos
Ecotourist Hotel
Xcalak, Quintana Roo

10-kW Wind Electrification:

- Bergey Windpower EXCEL Module
- 5.5-kW Trace Inverters (2)
- Bergey VCS Controller
- Trojan L-16 Batteries

Philippines

Preferred Energy Inc. and Winrock International

39% of the population (2,917,000 households) remain without access to the power grid

Renewable Energy in the Philippines

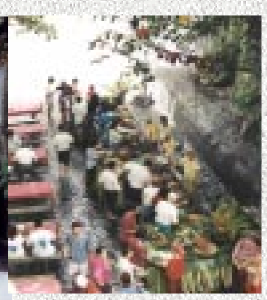
- The Philippine Energy Plan 1996-2025 predicts that over the plan period, total energy requirements of the Philippines will increase to an annual average of 6.6%.
- The Philippine Department of Energy projects that by 2025 renewable energy will account for 15% of the total energy mix.
- In 1996, geothermal and hydropower provided 9.5% and 14%, respectively, of the electricity generating capacity in the Philippines.
- Preferred Energy, Inc. (PEI), a Philippine NGO, is working to promote renewable energy development, support project development, and provide and facilitate debt and equity financing for RE projects.
- PEI, Sibol ng Aghan at Teknolohiya (SIBAT), and other partners are developing a Village Power Fund to provide loan financing for village electrification and productive projects employing renewable energy.

Panels installed by Solar Electric Company generate electricity to power a radio repeater station at the Regional Health Center of the Department of Health in Ormoc, Leyte

Solar PV Dissemination Project

- Solar Electric Company, Inc.
- Solar PV Dissemination Project
- Began in 1997
- Offices in Metro Manila, Iloilo, Pangasinan, Palawan, Cebu, Bacolod, La Union, and Davao
- Solar home systems, PV powered water pumping projects, refrigeration, telecommunications, and electrification for municipal buildings and offices
- P$4.6 million.

A view of the micro-hydro plant



Tourists wade in ankle-deep water as they enjoy meals in the soothing ambiance of water cascading from the dam.

Rehabilitation and Expansion of a Micro-Hydro Facility

- Villa Escudero Plantations & Resort, Inc. (VEPRI)
- Rehabilitation and expansion of its micro-hydro facility, increasing capacity from 75 kW to 172.8 kW
- Began in 1997
- Villa Escudero, one of the most visited tourist spots in the country, is two hours from Metro Manila
- Added two micro-hydro plants of 62 kW and 35.8 kW, which enabled them to maximize exploitation of hydro resources within the estate with no negative environmental results
- P$10.5 million.

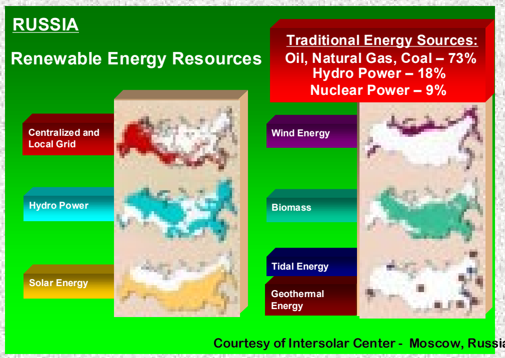
Rice-Husk Fired Grain Dryers

- Pasig Agricultural Development & Industrial Supply Corp.
- Continuous-flow rice-husk fired grain dryer
- Began in 1994
- Being used by medium- and large-scale commercial grain processing centers all over the Philippines
- The furnace creates a cyclonic motion of the rice husk fuel inside the combustion chamber while burning, separating ash that can be sold while mitigating against traditionally-used, environmentally damaging fuel oil
- A typical 8-t/hr grain-drying plant: about P$5,275,000.

Traditional and value added: rice-hull waste that formerly had to be burned or dumped can be transformed into reduced electricity expenses and a new income stream for rice millers.

Russian Federation

Vahan Gevorgian (NREL)



U.S. DOE/Russian Ministry of Fuel and Energy: Joint Collaboration for Renewable Energy Resources in Russia

- Agreement by Joint Committee of Economical and Technical Cooperation between Prime Minister Chernomyrdin and Vice President Gore (September 1993) to examine options for Russia's energy future (including EERE)
- Memorandum of Cooperation signed by Russian Minister of F&E Yuri
- Shafrannik and U.S. DOE Secretary Hazel O'Leary (October 1993)
- Establishment of EERE Joint Coordinating Committee by Russian Deputy Minister Vitaly Bushuev and U.S. DOE Assistant Secretary Christine Ervin (October 1994)
- Meeting between NREL and Russian Ministry of F&E representatives to establish Renewable Energy working group and prepare program implementation plan (November 1994).

NREL's Participation in the U.S./Russia Cooperative Program for Renewable Energy Resources

- Technical assistance in design, installation, and operation of 21 wind/diesel hybrid systems in Russia's Northern Territories (40 BWC wind turbines with related equipment had been purchased and shipped to Russia in 1996 using USAID CIP funds)
- Feasibility study and installation of a 1-MW biomass power plant in Arkhangelsk region
- Assistance in the start-up operation of a 2-MW/yr triple junction a-Si manufacturing facility in Moscow using U.S. technology
- Explore possibilities of financing large-scale wind/diesel hybrid and biomass power systems for the Russia's Northern Territories (900 sites)
- Develop the strategic plan for electrification of Russian Northern Territories
- Feasibility studies done for large utility-scale wind farms in Southern Russia (Krasnodar/Novorossisk) and Russian Far East (Nakhodka).

Wind/diesel hybrid system at Krasnoe Village, Arkhangelsk Region

Installation of Wind/Diesel Hybrid Systems in Russia's Northern Territories

- Three systems in Arkhangelsk and Murmansk are fully operational.
- Fourteen more wind turbines are being installed in Chukotka.
- NREL has provided training for Russian specialists in using of Hybrid2 computer model and operation of DAS for remote hybrid systems.
- Five sets of monitoring equipment have been purchased by NREL to be installed on operational hybrid systems.
- Remaining systems are expected to be installed by the end of 1998.
- Wind/diesel test facility will be established with NREL assistance in Istra, near Moscow.

Feasibility Study for 1-MW Biomass Power Plant in Arkhangelsk Region

- Several site visits were made in 1996-1997 to the village of Verkhne-ozerski, in the Onega Region of Arkhangelsk Oblast, to evaluate the feasibility of building biomass-combustion electric power plants, using waste forest products.
- A detailed pre-feasibility study was completed for a 470-kW power plant in Verkhne-Ozerski in 1998, that showed the economic viability of such a power plant. The plant will use 13,000 tons of wood waste, available near the village.
- The design is being expanded to include three more villages. The power plant's capacity is being increased to 1 MW. The feasibility study should be complete by the Spring of 1999. The MFE has been authorized by the World Bank to allocate up to US$3M towards the construction of the power plant.
- The U.S. Trade and Development Agency is planning to fund a comprehensive study that will include four 1-MW biomass electric power plants in the Arkhangelsk region in FY99.

Site for a 1-MW Biomass Power Plant in Verkhne-Ozerski village, Arkhangelsk Region that will burn nearby wood waste.

South Africa

Gabrielle Seeling-Hochmuth

South African Progress in RE Systems

- PV, few hybrids in clinics and schools
- SHS/BCS projects, Wind, PV powered water pumping
- PV/diesel hybrids: farms, resorts, telecommunications
- Hybrid demo systems planned

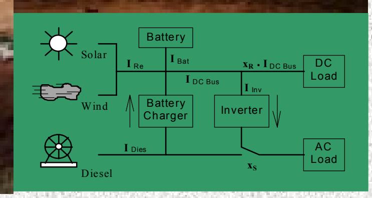
Still Needed
- Training, participation, and entrepreneur selection
- Clustered projects for sustainable O&M
- Integration of activities and services
- Access to financing and markets, competitive products
- Monitoring and evaluation.

Government Policy

Nelson Mandela in 1995:
- Eliminate poverty - create employment in rural areas
- Government committed to integrated rural development
- 73% rural households not electrified by the end of 1996

Social equity framework:
- PV/off-grid electrification of rural households

Economic development framework:
- PV/off-grid electrification of rural centers of productive activities.



Income/Employment Generating Activities

Businesses that use PV/off-grid electricity
- Mainly in retail
- PV/hybrid grid electricity to improve output and quality
- Irrigation for farms and agricultural processing

Business creation through PV/off-grid infrastructure
- Trained PV electricians
- Franchises with local shops (e.g., PV Battery Charging), equipment is marketed
- Good PV/off-grid industry infrastructure in South Africa.

PV School and Clinic Programmes

- Education, healthcare, meeting facilities create empowerment and contribute long-term to productivity
- **Schools program** is Eskom driven (RDP/donor funds)
  - 1200 PV systems for schools installed so far
- **Clinic program** is IDT driven
  - 150 PV and PV-hybrid electrified clinics so far
  - Lights, vaccine refrigerators, and 2-way radios
  - Progress slow, but O&M sustainable.

Thailand

Debbie Lew (IIEC)

Unelectrified Population = less than 2% of total population

Thailand's Renewable Energy Programs

- DEDP PV Battery Charging Stations
- PWD PV Battery Charging Stations and PV powered water pumping stations
- EGAT PV, wind, geothermal, and fuel-cell demonstration and testing facilities
- EGAT PV rooftop program
- PEA PV rural electrification program
- NEPO Energy Conservation Program has a Voluntary program which provides RD&D for renewable energy technologies (e.g., biogas and PV).

DEDP PV Battery Charging Station Program

- Department of Energy Development and Promotion (DEDP)
- PV Battery Charging Stations
- Five-year program; began in 1995
- In rural villages where grid connection is not foreseen
- DEDP and its regional energy centers identify sites, install stations, and train local technicians
- 300 3-kW stations are planned; 176 are installed at 750,000 Baht (Thailand currency) each.

PWD PV Battery Charging Station Program

- Public Works Department (PWD)
- PV Battery Charging Stations
- Started in 1988
- In rural, unelectrified villages, mostly in the northern region
- PWD identifies sites, installs stations
- 1100 795-W stations installed at 225,000 Baht each.

Promthep Alternative Energy Station

- Electrical Generating Authority of Thailand (EGAT)
- Grid-connected wind/PV hybrid
- Started in 1990
- Phuket Island, Southern Thailand
- EGAT is demonstrating and testing different wind and PV technologies at this site. The DC power generated by the small wind turbine and PV power is converted to AC and connected to the grid
- 10-kW PV; two 10-kW and one 150-kW wind turbine.

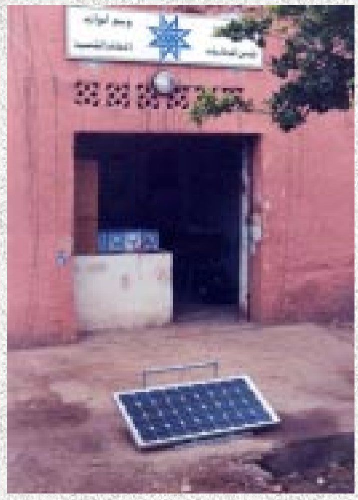

Solar Battery Charging Stations

Stephen Graham (SGA Consulting Ottawa,Canada)

Brazil

- **W = 1000-1500** , **HH/Stn - 50-70** , **# national - 40**
- **Outlets** - 12 , **W_p/Outlet** - 85-128 , **Battery Charge Reg -** Bus Series 13.5 V
- **LVD -** yes**, Battery Type -** solar, SLI, 54-100 A-h **Est Life** - 4 yrs
- **Capital Cost -** \$9.18/W_p, **Av Charge Time -** 2 days/battery
- **Subsidy -** (5%), **Fees -** \$10/mo (4x + bat)
- **Implementing Agency -** national NGO (FTV)
- **Problems/Issues -** Collection, loan repayment

12 outlets with LED SOC indicators and batteries lvd protected



A SBCS franchise- note batteries for sale

Morocco

- **W = 1320** , **HH/Stn - 200** , **# national - 30**
- **Outlets** - 12 ,**W_p/Outlet -** 110, **HV Reg -** Shunt
- **LVD -** no**, Battery Type -** DD, SLI 70-100 A-h **Est Life-** 2 yrs
- **Capital Cost-** \$9.35/W_p, **Av Charge Time -** .8 day/battery
- **Subsidy** - (50%), **Fees -** \$1/charge
- **Implement Agency -** private (Noor Web franchise)
- **Problems/Issues -** subsidy, profitability

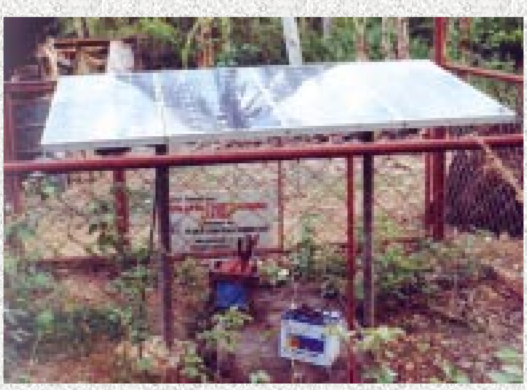
Thailand

- **W = 800 and 3000**, **HH/Stn - 30 and 80**, **# national - 1,350**
- **Outlets** - 5 and 20,**W_p/Outlet** - 155, **HV Reg -** series and none
- **LVD -** no (indicator), **Battery Type -** solar, DD, SLI 32-120 A-h **Est Life**- 2 yrs
- **Capital Cost -** \$11.90 to 5.50/W_p, **Av Charge Time -** 1 day/battery
- **Subsidy -** (100%), **Fees-free to** \$0.04/charge
- **Implement Agency -** government (Public Works and Energy)
- **Problems/Issues -** subsidy removal

20-outlet SBCS self-regulating - note connector plugs

The Philippines

- **W = 300**, **HH/Stn - 20**, **# national - 225**
- **Outlets** - 2 ,**W_p/Outlet -** 150 , **HV Reg -** none
- **LVD -** no**, Battery Type -** DD, SLI 70-150 A-h **Est Life-** 2 yrs
- **Capital Cost** - \$6.455/W_p, **Av Charge Time-** 1 day/battery
- **Subsidy** - (80% -100%), **Fees -** \$0.35 - \$0.75/charge
- **Implement Agency -** various government and NGOs
- **Problems/Issues -** service level at station competing programs



Two-outlet self-regulating SBCS

Health Clinics

Tony Jimenez (NREL)

Types of Rural Medical Facilities

Health Post
- Facility may or may not be wholly dedicated to health services
- No full-time staff, except possibly a public health worker
- Offers only the most basic services.

Health Clinic
- Typically staffed with one or more full-time nurses who may live on site
- Provides wider range of basic services
- May have one or two beds for in-patient care.

Referral Hospital
- Staffed with one or more doctors
- Provide in patient care
- Equipped to do abdominal/OB/gynecological surgery
- Provide radiological and laboratory services.

Health clinic in West Bengal, India

Health Clinic Showing RE Applications

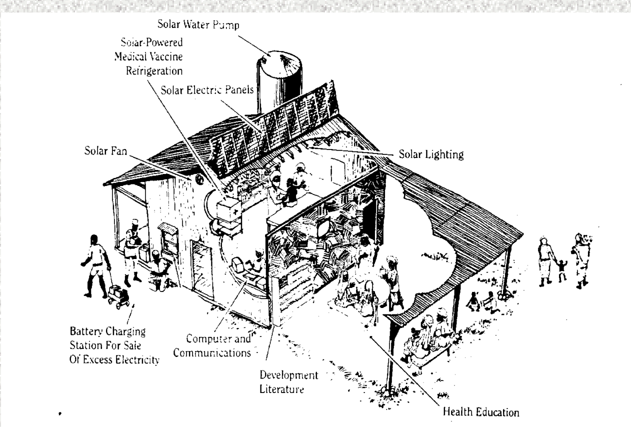


Diagram courtesy of John R. Boone and Solar Electric Specialties, Inc.

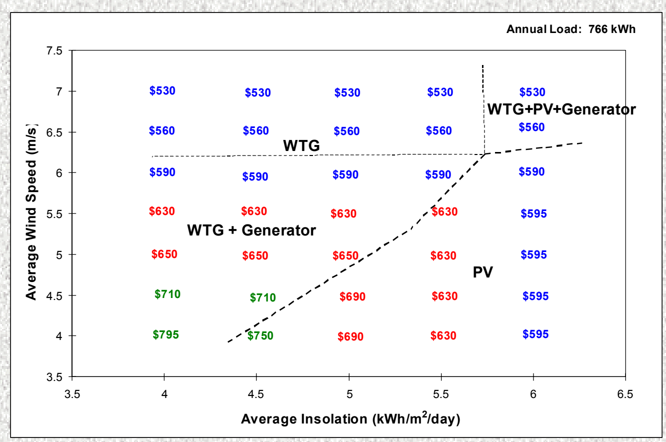
Health Facility Applications

Application	Power (Watts)	Duty Cycle (Hr/day)	Energy Use (Wh/day)
Vaccine Refrigerator	60	6 - 12	410 - 720
lights (each)	20	2 - 12	40 - 240
VHF Radio			
Stand by	2	12	24
Transmitting	30	1	30
Microscope	15	1	15
Vaporizer	40	1 - 4	40 - 160
Oxygen Concentrator	300	1 - 4	300 - 1200
Overhead Fan	40	4 - 12	160 - 480
Water Pump (1500 l/day @ 40 m)	100	6	600
12” B&W TV		15	1 - 4
15 - 60			
19” Color TV		60	1 - 4
60 - 240			
VCR	30	1 - 4	30 - 120
AM/FM Stereo	15	1 - 12	15 - 180
Electric Sterilizer	1500	0.5 - 2	750 - 3000

Services Offered at Health Clinics

- Inoculations
- Treatments:
  - Respiratory Infections
  - Venereal Diseases
  - Parasitical Diseases
  - Malaria
  - Diarrheal Diseases
  - Skin Disease
  - Eye Disease
- Pre-Natal/Post Natal Care & Child Birth
- Traumas: Burns, Simple Fractures, Wounds
- Dental
- Referral to Hospitals
- Public Health Education
- Family Planning
- Surgery (abdominal and OB/gynecological) (Hospital)
- Radiological (Hospital)
- Laboratory (Hospital)

Health Clinic Annualized Cost



The above graph indicates how power system configurations and annualized costs vary with the available resource. The costs are for a power system capable of supplying 2 kWh/day. The results assume a particular economic scenario and are indicative only.

Micro-Enterprise

April Allderdice (NREL)

Introduction

The micro-economy is thriving in the developing world. It needs energy and has an income to pay for it, but until now there has been no direct conduit through which to target this population with renewable energy resources. With the advent of the micro-credit banks and their associated micro-enterprise development programs there are now local organizations that serve as an interface with this sector.

Domestic Lighting Systems for Micro-Enterprise

Small household lighting systems increase the capacity and profitability of micro-enterprise through longer working hours, longer selling hours and the use of small motors or appliances. In Bangladesh, Grameen Shakti targets micro-entrepreneurs as part of their solar home systems marketing program.

Grameen Shakti customers include a hardware shopkeeper, a saw mill owner, and an electronics repairman

Micro-Enterprise Zones

Many income generating activities require more power than a typical solar home system can provide. To supply these higher quality energy services, Grameen Shakti is developing the micro-enterprise zone concept, creating an electrified center where rural villagers can come to establish workshops and businesses with the benefit of AC power.

Bangladesh Rice Mill

The Renewable Energy for Micro-credit and Micro-enterprise Applications Guidebook

NREL and Global Transitions Consulting are teaming up to create a renewable energy applications guidebook for micro-credit banks and micro-enterprise development organizations. The guidebook will take a critical look at the opportunities and challenges in bringing renewable energy to the micro-enterprise sector.

A Grameen Bank branch office

Renewable Energy for Schools

Tom Lawand (Brace Institute) & Tony Jimenez (NREL)

School Applications

School energy needs include:

<u>Electricity</u> for lighting, communication, water pumping teaching aides and appliances.

<u>Thermal energy</u> for cooking, water heating and space heating

- Communications - radio-telephone, fax, short-wave radio
- Computer
- Teaching aides - VCR, TV, film projector, slide projector
- Water pumping and water treatment
- Cooking and food preparation
- Refrigeration
- Space heating and cooling
- Water heating
- Washing machine
- Kitchen appliances

Lessons Learned

A prerequisite for a technically sound installation is a thorough analysis of a school's energy needs and the energy-system knowledge base of the individuals living in the area.

User training and the establishment of a good service infrastructure are equal in importance to a technically sound system installation.

Teacher turnover is often high in remote schools. The importance of involvement, input, and training the teachers about the installation of the system will increase the likelihood of success, acceptance, and soundness of the energy system.

- Undertake a thorough preliminary analysis of a school before installing a system.
- Provide detailed instructive literature to accompany installed equipment.
- Involve the caretaker in all activities concerning the renewable energy system.
- Provide every new teacher with detailed instruction concerning the proper operation and maintenance of their RE system.
- Give every new teacher explicit instructions on what to do in case of a technical difficulty that they are unable to repair themselves.

Boys at play in front of the PV powered Ipolokeng school in South Africa

The interior of a classroom at the Ipolokeng school in South Africa, showing one of the computers that is powered by the PV panels on the roof

Water Projects and Lab Research

Ron D. White (NREL)

Wind-Electric Water Pumping

- Quintana Roo, Mexico
- Bergey 1500 on Rohn 25 m tower
- 1.0-HP Grundfos submersible
- Expect 10 m^3 per typical day
- Connects to existing water distribution system
- Design by Ecoturismo y Nuevas Technologias s.a.
- Installation Assistance by NREL and Sandia (September 1998)
- Funding from USAID.

Pump house and turbine provide clean water in Quintana Roo, Mexico

Wellhead, Panels, and RO Unit

PV-Powered Pumping and Desalination

- Sadous (near Riyahd), Saudi Arabia
- 1680 W_p for Reverse Osmosis (RO); 980 W_p for submersible pump
- 600 liters/hour of drinkable water
- Installed in the Fall of 1994
- Design and performance papers presented December 1995 (available on request).

Analysis of Water Treatment Systems

- Matching energy needs and usage patterns
- Current research on UV disinfection units
- Cycle testing of UV bulb lifetime/output
- Evaluation of system integration issues: small wind turbines and electrodialysis reversal water desalination and UV water works disinfection unit.

Reports Available

- An Overview of Water Disinfection in Developing Countries and the Potential for Solar Thermal Water Pasteurization (NREL/TP/550-23110)
- Opportunities for Renewable Energy Technologies in Water Supply in Developing Country Villages (NREL/SR-430-22359)
- Overview of Village Scale, Renewable Energy Powered Desalination (NREL/TP-440-22083)
- Other Technical Papers available as well.

NREL Water-Related Technical Contacts

- Wind: Ian Baring-Gould (ian_baring_gould_@nrel.gov)
- PV: Byron Stafford (byron_stafford@nrel.gov)
- Solar Thermal: Mary Jane Hale (mary_jane_hale@nrel.gov) or Jay Burch (jay_burch@nrel.gov)
- Renewable Chemical Technologies and Materials:Dan Blake (daniel_blake@nrel.gov).

Biomass Systems

Small Modular Biomass Systems

Raymond Costello (DOE), Rich Bain (NREL), and Tom Mancini (SNL)

Objective: To develop small modular biopower systems

Fuel flexible:
- Efficient
- Simple to operate
- Minimum negative impacts on the environment
- Power range: 5 kW - 5 MW.

Multiphase Project:

- Phase 1: Feasibility Studies
- Phase 2: Prototype Development and Testing
- Phase 3: Integrated Systems Demonstration

Individual Households to Institutions (hospitals, schools) Less Than 100 kW_e

• **Sunpower**	Gasification/Stirling Engine
• **CPC**	Gasification/IC Engine
• **STM**	Gasification/Stirling Engine
• **Reflective Energies**	Gasification/Gas Turbine

Small Villages and Industries 100 kW_e - 300 kW_e

• **Reflective Energies**	Gasification/Gas Turbine
• **Bechtel**	Gasifier/Engines/Gas Turbine

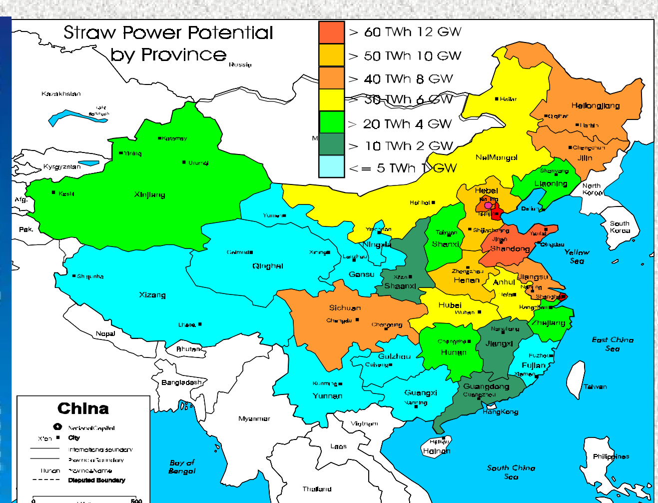
Industries, Mini-Grids, and Grid Support Greater Than 500 kW_e

• **Agri-electric**	Fluid-Bed Combustor/Steam Turbine
• **Bioten**	Direct-Fired Combustor Turbine
• **Carbona Corp**	Gasification/Steam Turbine
• **EERC**	Fluid-Bed Combustor/Steam Turbine
• **Niagara Mohawk**	Gasification/IC Engine/Gas Turbine

NREL's molecular beam mass spectrometer helps industry partners define process conditions in real time and minimize process emissions

China Village Power Concept

PR China Ministry of Agriculture and NREL



Concentrating Solar Power

Gray Lowrey (Sandia National Laboratories)

Dish/Engine Technology

- Solar energy is concentrated through mirrored array onto a thermal receiver
- Heat is converted to three-phase 480-volts electricity by a Stirling engine
- Solar-to-electric conversion as high as 30%, significantly higher than any other solar technology
- 5-kW to 25-kW systems ideal for rural applications
- Multiple dishes can be connected for increased power needs.

SAIC's 2nd Generation 25-kW Hybrid Dish/Stirling System at Golden, Colorado

Trough Technology

- Solar energy reflected by parabolic troughs onto the heat collection element
- Circulated synthetic oil absorbs the sun's energy and is used to create steam for the generation of electricity with conventional turbines
- 30-MW to 80-MW systems provide a wide range of applications
- 354 MW of trough fields are currently operating in the United States
- Commercial plant operations have optimized performance, reduced costs, and improved efficiencies.

SEGS Troughs at Kramer Junction, California

Power Tower Technology

- Solar energy is reflected by a field of mirrors (heliostats) to a receiver atop a centrally located tower.
- Molten salt, the heat transfer fluid, flows through the receiver to absorb the sun's energy, and is used to create steam for the generation of electricity with conventional steam turbines.
- The ability to store heat in the form of molten salt makes it possible to generate electricity at any time of the day, not just while the heliostats are receiving solar energy.
- Solar Two, a 10-MW demonstration project, is currently operating successfully in California.
- 30-MW to 200-MW systems are projected to offer the lowest cost electricity produced from solar energy.

Solar Two at Daggett, California

Concentrating Solar Power Technology Status and Projected Cost

Type of Techonolgy	Technology Status	Unit Capacity	Capital Costs (US$/kWh)	O&M (US¢/kWh)	Levelized Energy Cost (US¢/kWh)	
					Year 2000	Year 2010
Dish/Engines	Early Technical Feasibility	5 kW to 50 kW	$2,900	2.0	8.6 – 13.0	4.0 – 6.0
Troughs	Early Commercial Evolution	30 MW to 80 MW	$2,900	1.0	6.8 – 11.2	5.6 – 9.1
Power Towers	Demonstrated Technical Feasibility	30 MW to 200 MW	$2,400 To $2,900	0.7	5.2 – 8.6	3.3 – 5.4

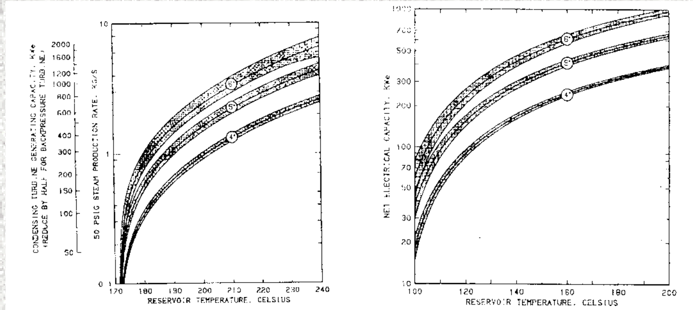
Concentrating solar power (CSP) technologies (previously referred to as solar thermal electric technologies) use mirrors to concentrate the sun's energy up to 10,000 times to power conventional turbines or heat engines to generate electricity. This clean, secure, environmental friendly power has the potential for major impacts in international markets and diversifies our options for domestic electricity production. Energy from CSP systems is high-value renewable power because energy storage and hybrid designs allow it to be provided on-demand—even when the sun is not shining.

Mini-Geothermal for Village Power

John Finger (Sandia National Laboratories) & Jim Combs (Geo Hills Associates)

One Slim Hole can Supply Enough Working Fluid for a Small Power Plant

- Small diameter (< 6″) holes can provide enough steam or brine for power plants ranging from 100 kW to several MW.
- Slim holes require smaller drill rigs, which have less environmental impact, lower costs, and provide easier access to remote locations.
- If large-scale production is a subsequent possibility, slim holes also give reliable predictions of a reservoir's productivity.



These curves show power production from different hole sizes and temperatures for both flash and binary plants.

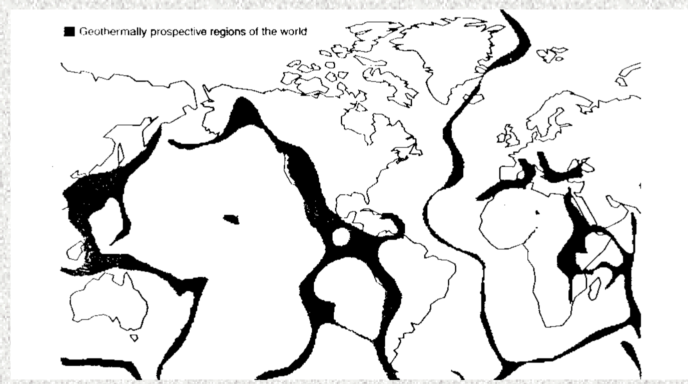
A 300-kW geothermal binary plant has operated for four years in Fang, Thailand.

Small Power Plant Technology Exists

- Small power plant technology exists in modular form, and has been demonstrated in sizes as small as 100 kW.
- Geothermal power plants are extremely reliable, with an average load factor over 90%.
- Geothermal power plants require much less surface land area than wind or solar plants.

Economic Highlights

- Power from small geothermal plants is usually not considered for a developed grid, but can be highly competitive compared to other options for remote locations. It is especially suitable for base-load generation.
- Cost of power will be highly site-specific, but analysis for a representative example gives a rate less than US$0.15/kWh
- The analysis above does not consider cost savings from using slim holes.
- Most geothermal resources in Africa, Central America, and around the Pacific Rim are in emerging economies.



World-wide prospective geothermal areas based on volcanism, seismicity, and plate boundaries.

GEOTHERMAL OFF-GRID POWER WORKSHOP

This workshop will be held in Reno, Nevada, on December 2 - 4, 1998. It will be directed at anyone involved with reducing the costs and increasing the availability of geothermal base-load, small-scale electrical power installations.

Brochures are available from John Finger, Sandia National Laboratories, (505) 844-8089 or jtfinge@sandia.gov or the Geothermal Resources Council at (530)758-2360.

Hybrid Power Systems

E. Ian Baring-Gould (NREL)

Rural Power Development

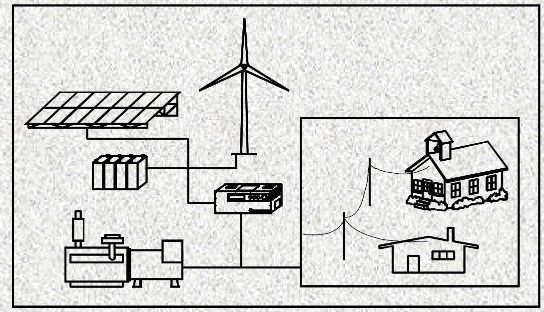
- Conventional rural electrification relies on grid extension or diesel power plants.
- Hybrid systems are often a less expensive alternative for remote communities.
- Economics depend on the renewable resources, the load profile, and the cost of the conventional alternatives.
- Hybrids range from less than 1 kW to greater than 1 MW.

Xcalak hybrid power system - diesel retrofit completed in 1995

Alaska/Kotzebue Project

- Owned by Kotzebue Electric Association
- Wind-diesel system for predominantly Inupiat Eskimo village of 3000 people
- Three 50-kW AOC wind turbines installed; seven additional 50-kW AOC turbines to be installed
- Several large diesels including 3-MW diesel
- Initial funding by the State of Alaska, additional funding by U. S. DOE
- System reduces life-cycle cost of energy by displacing diesel fuel consumption.

Costa de Cocos 11-kW wind-diesel hybrid system



Schematic of potential components in a hybrid power system

Retrofit of Existing Diesel Power Plants

- Use of renewable technologies and advanced system control to enhance the economic efficiency of existing diesel gensets
- Applicable to diesel gensets of all sizes
- Five basic system topographies from the installation of more efficient diesel engines to advanced hybrid-system designs.
- Cost of capital equipment is offset by the savings in diesel fuel, systems operation, and maintenance expenses
- Decrease in polluting emissions and reliance on plant personnel because of the use of clean technologies and controls.

Atlantic Orient Corporation 50-kW wind turbine provides power to the Alaska Kotzebue Project.

Costa de Cocos, Mexico, Wind-Diesel System

- Wind-diesel hybrid system with 7-kW Bergey wind turbine, two 5.5-kW Trace inverters, 50 kwh of Trojan L-16 batteries, and associated hardware
- System supplies 24-hour power for small scuba diving and fishing resort; loads include refrigeration, water desalination (reverse osmosis), kitchen appliances, workshop tools, fans, and lights
- System reduces life-cycle cost of energy primarily through displacement of diesel fuel, but also lowers air and noise pollution associated with diesel
- Turbine retrofitted with complete corrosion-proof package to reduce effects of salt water corrosion.

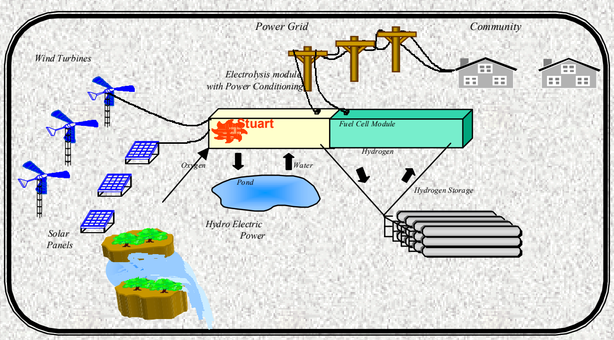
Hydrogen for Rural Electrification

C.E. Gregoire Padró (NREL) and M.J. Fairlie (Stuart Energy Systems)

Clean Air Now! (CAN!) Renewable Hydrogen Project (El Segundo, California, U.S.A.)

- 40-kW (nominal) photovoltaic array
- Alkaline electrolyzer
- Compressor for high pressure (5,000 psi) storage of hydrogen
- 14,000-scf storage at 5,000 psi; with 80,000-scf supplemental storage at 2,200 psi
- Hydrogen dispensing station for Xerox Corporation maintenance fleet.

Aerial view of a CAN! facility near the Los Angeles airport



Hydrogen Village concept

Hydrogen Village

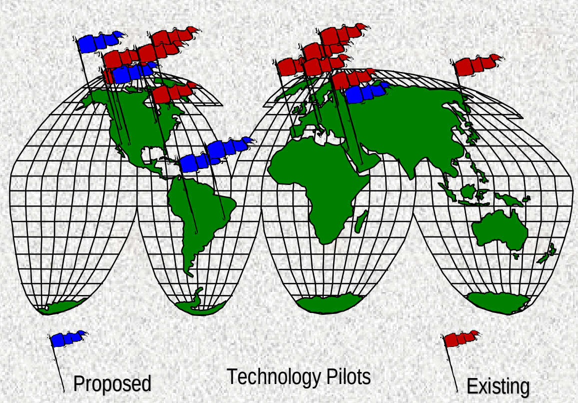
- Stand-alone integrated power system
- Overcomes renewable energy gap by using hydrogen energy storage
- Flexible, renewable resources can be used, such as wind, solar, and hydro
- Hydrogen for electricity and motive power
- Can displace diesel power generators in remote communities
- Promotes use of indigenous resources for clean fuels.

International Energy Agency Annex 11 Modeling Efforts

- Seven countries participated in a 3-year effort to develop design guidelines and an analysis tool for evaluation of hydrogen demonstration projects.
- Data were collected on existing hydrogen demonstrations.
- Twenty-four component subsystem models were developed for hydrogen production, storage, distribution, and end use.
- Integrated systems were designed using component models.
- Numerous publications on this work are available in the literature.

International Energy Agency Annex 13 Analysis Effort

- Cost models will be developed for the 24 existing and any additional component models.
- Technical and economic evaluations will be performed on proposed or existing hydrogen demonstrations.
- Life-cycle assessment will be performed to quantify the environmental benefits of hydrogen energy systems.
- Activity will begin in November 1998. Participation is open to all IEA countries; non-IEA countries are also encouraged to participate as observers.



Photovoltaics

Byron Stafford (NREL)

Photovoltaics (or PV)

- PV is the direct conversion of sunlight to DC electricity using a semiconductor effect—there are no moving parts.
- PV cells—the basic building block—are made from either silicon (single-crystal, polycrystalline, and amorphous), cadmium-tellurium, or alloys of copper indium selenium.
- Single-crystal and polycrystalline silicon modules are the most common worldwide, followed by amorphous silicon. Cadmium tellurium and copper indium selenium modules are being introduced.
- PV cells are interconnected to increase the output voltage and current. The PV cells are packaged into a PV module to protect the cells from water, humidity, physical damage, and to provide electrical safety.

Single-crystal silicon PV cell shown above.

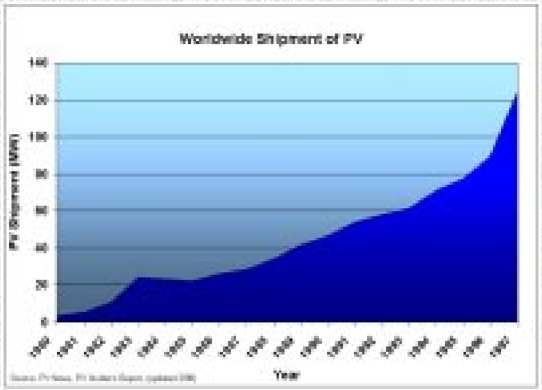
PV cells are series-interconnected in a PV module.

PV is Modular and Reliable

- International standards cover module power ratings and reliability. Many companies offer 10 - 20 year warranties on their modules.
- Modules can be mounted on the ground, on roofs, on poles, or on floats on lakes. Modules can be interconnected for higher voltages or currents. Most modules are made for charging a 12-volt lead-acid battery.
- PV systems can power DC equipment or, with an inverter, AC equipment. PV systems can be used in hybrid systems with wind turbines or generators.

PV Economics

- Module prices are US$4.50 - $6.00/W for all PV technologies. The price in other countries will depend on quantity, available supply, taxes, tariffs, and shipping.
- The solar resource and electrical loads are the primary factors in determining the size, and hence cost, of a PV system. Reducing electrical loads will result in lower cost PV systems.
- International reliability standards include testing for wind loading, hail impact, thermal cycling, and electrical isolation. Modules that meet the standards will last longer in the field, resulting in a lower system life-cycle cost.



Worldwide PV shipments continue to increase.

PV modules generally range in size from from 50 W to120 W and can be installed by one to two people. Several modules can be interconnected for more power.

Village Power Wind Applications

David Corbus (NREL)

Kotzebue Wind-Diesel System

- Owned by Kotzebue Electric Association
- Wind-diesel system for predominantly Inupiat Eskimo village of 3000 people
- Three AOC 50-kW wind turbines installed; seven additional 50-kW AOC turbines to be installed
- Several large diesels including 3-MW diesel
- Initial funding by State of Alaska, additional funding by DOE
- System reduces life-cycle cost of energy by displacing diesel fuel consumption.

50-kW turbines in Kotzebue, Alaska

7-kW Turbine in Villa Las Araucarias

Villa Las Araucarias Hybrid System

- Inland village community supported by forest industry
- Health post, school, and 17 homes electrified
- 9.8-kWh daily load with significant load increase expected
- System supplies 24-hour power
- System includes 7-kW Bergey turbine, 3-kW TRACE inverter, 33.6-kWh battery bank of Trojan L-16s, 5.4-kW autostart Honda generator, and 220-volt, 50-hz AC distribution grid.

Wind-electric Water Pumping in Indonesia

- 1.5-kW wind turbine directly connected to an off-the-shelf 3-phase Grundfos centrifugal water pump
- Variable voltage and frequency output of wind turbine results in variable speed water pumping
- Low head (4-6 m) high volume (up to 150 m^3/day) small plot irrigation application
- More efficient than conventional mechanical wind water pumping systems
- Installed at the Small-Scale Irrigation Management Project - Oesao Demonstration Farm, Timor.

10-kW turbine directly coupled to a water pumping system

300-W turbine in the Dominican Republic

Micro-Turbines for Electrification of Remote Schools, Health Posts, and Homes in the Dominican Republic

- 300-W Southwest Wind Power Air Turbine used for remote electrification of small loads in the Dominican Republic
- Turbines are inexpensive and easy to install
- Turbine package includes batteries, a charge controller, and a small inverter.

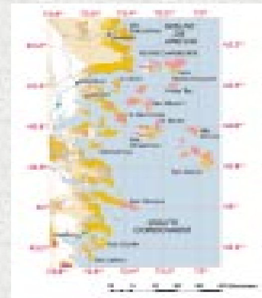
National Renewable Energy Laboratory's Village Power Program

Lawrence Flowers (NREL)

Pilot Projects

Village of Villa Las Araucarias and the installed power system

Russia: Assists the Russian Ministry of Fuel and Energy in the deployment of 21 wind-diesel systems in Russia's Northern Territories and feasibility studies for construction of a 1-MW demonstration biomass power plant in Arkhangelsk region
Mexico: Provides technical assistance to wind projects including village electrification, eco-tourism, and water pumping projects
Chile: Provides full range of assistance on small wind electrification projects including resource assessment, training, and pilot project development and installation
Brazil: Multi-faceted approach to renewable energy implementation and commercialization including solar home lighting pilot projects as well as two large hybrid wind/PV/diesel pilot projects
China: Works with in-country partners on renewable energy projects and training including resource assessment, pilot project and O & M plans, project identification, financial analysis, and pilot project implementation.



Isla de Chiloe Area of Region X; Preliminary map of favorable wind resource areas

Resource Assessment

NREL's regional wind resource map of the Chiloe Region of Chile was produced using Geographic Information System software. Meteorological data from NREL's global database combined with digital terrain data helped determine the distribution of the wind resource shown on the map.

. The purpose of the wind resource map is to highlight regions in Chiloe where the level of the wind resource is sufficient to make rural wind energy projects feasible.

. NREL is also providing technical assistance to Chilean organizations in siting potential wind monitoring stations and wind energy projects on these islands.

SunWize Wind-PV-Diesel system at the National Wind Technology Center

Applications Development/Testing

Approach:

- Important village power applications are identified and integrated renewable energy solutions are designed and developed to power those applications.
- Commercial systems are tested to ensure compatibility with specific village power applications (e.g. ice making and water desalination).

Example:

SunWize commercial hybrid system includes 1.8-kW PV, 5.8-kW diesel, two 4 kW inverters, and 535-ah battery bank at 48 volts with a connection for a wind turbine up to 6 kW . The system has been tested at the NWTC and will be deployed in a pilot project in the Dominican Republic. It is ideally suited for productive use applications such as ice making or water desalination (e.g. reverse osmosis).

Andrew McAllister of NRECA provides a training course on renewable energy to the villagers of Isla Nahuel Huapi as part of the village training program in Chile.

Training

Russia:
- Trained analysts in hybrid systems
- On-site training of system installation/commissioning/monitoring

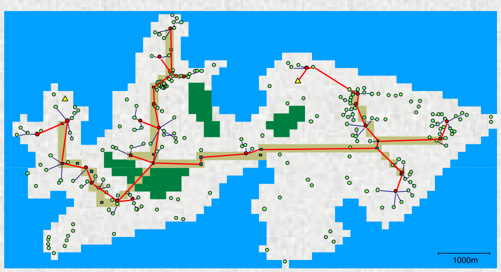
Mexico:
- Workshops on wind water pumping and village hybrids
- Installation training on water pumping, and ecotourism wind systems

Chile:
- On-site training of utility engineers and villagers on hybrid systems
- Training of rural electrification engineers in analysis of options

China:
- Training of analysts on hybrids and resource assessment

Brazil:
- Training of analysts and middle managers on wind hybrids analysis
- In-country workshops on wind and PV applications

Philippines:
- Trained SPUG and private sector analysts in hybrid systems.



A small island in the Chiloe Region of southern Chile.

Analysis and Model Development

NREL has developed a suite of Village Power analytical models:

- Hybrid2 is a detailed engineering model for technical and economic performance of hybrid systems.
- HOMER is an optimization model for quick and easy screening, economic comparisons, and conceptual design of hybrid systems.
- ViPOR is a grid optimization model that lays out village mini-grids and uses HOMER to compare mini-grids to individual household systems.
- NREL is developing a Regional Planning Model (RPM) that will use both HOMER and ViPOR to identify the conditions under which grid extensions, mini-grids, and individual systems have the lowest cost. RPM will interface with ARCInfo to exchange information on the existing grid and resource and demographic data and display its results geographically.

RSVP Home Page

Renewables for Sustainable Village Power (RSVP) Web Site (www.rsvp.nrel.gov)

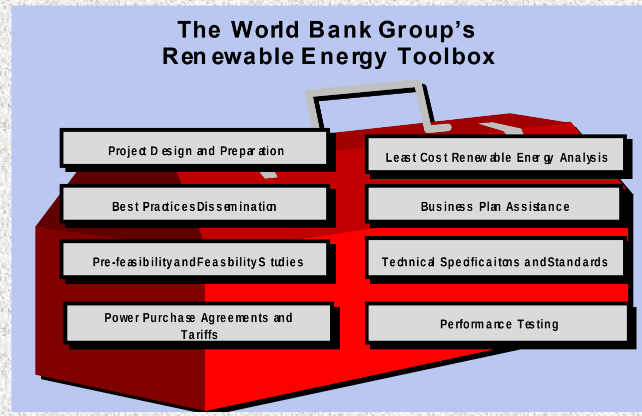
- Dedicated to village power
- Provides information on applications, contacts, and development of renewable energy projects
- Provides a database of village power projects with information from more than 150 international village power projects from over 20 countries.
- Projects can be searched by technology (e.g. wind and photovoltaics) application (e.g., lights and water), sector (e.g. residential and commercial), and geographical region.

The World Bank :

Investing in Renewable Energy for Rural Development

The World Bank Group is Gearing Up in Renewable Energy

- ✦ Asia Alternative Energy Program (ASTAE) and Energy, Mining, and Telecommunications Sector Unit (EMT) support project preparation
- ✦ Solar Development Corporation (SDC) promotes PV development
- ✦ IFC-New Products Group promoting renewable energy business (REEF, PVMTI, and SME)
- ✦ GEF/Bank Strategic Alliance for Renewables forming
- ✦ Dedicated trust funds support renewable and rural energy project preparation.



Renewable energy: making a difference in India

<u>The India Renewable Energy Development Loan</u> promotes the commercialization of renewable resources technologies; creates marketing and financing mechanisms for system sale and delivery; encourages private-sector investment in small-scale power generation; and promotes environmentally sound investments.

<u>Small Hydro -</u> To date, 22 small hydro power plants are in various stages of implementation (125 MW) with another 30 MW in development.

<u>Wind -</u> Thirteen wind farms (41 MW) have been financed. 900 MW of private wind capacity have been installed.

<u>Solar Photovoltaics -</u> The PV project pipeline consists of over 1200-kW_p capacity valued at over US$13 million. Applications include lighting, hybrid systems, and grid-connected pumping.

Total World Bank/GEF support for the renewable energy components is US$141 million.

<u>The Sri Lanka Energy Services Delivery Project (ESD)</u>

ESD encourages grid and off-grid energy services using renewable energy and demand-side management. The project includes a credit component to help finance private sector investments; NGOs and cooperatives in off-grid photovoltaics and village hydro schemes; rehabilitation of grid-connected, mini-hydro sites, and other applications. The project also includes a grid-connected pilot wind farm conducted with the local utility, the Ceylon Electricity Board (CEB). Expected results include installation of up to 26 MW of renewable energy capacity, including up to 30,000 solar home systems; annual update of the small power purchase tariff; signing of at least 12 small power purchase contracts; and CEB-generation planning models.

Total World Bank/GEF support is US$30 million

Micro-hydro electric power station provides clean, safe energy in Sri Lanka.

<u>Argentina RE for Rural Markets (FY 1999)</u>

This project will provide electricity to rural areas in Argentina in a sustainable manner using renewable energy sources by the private sector. The project supports consolidation of power sector reform.

Total World Bank/GEF support is US$60M

<u>Brazil Rural Electrification Project (FY 2000)</u>

The proposed project aims to provide electricity to disperse rural populations in Brazil, based on renewable energy supplied from the private sector.

Total World Bank/GEF support is US$70M

Projects in the pipeline: Latin America and the Caribbean

<u>China RE Promotion (FY 1999)</u>

This stand-alone renewable energy project will support the accelerated development of renewable resources of energy (190 MW of wind, 200,000 solar home systems, plus technical assistance).

Total World Bank/GEF support is US$135M

Projects in the pipeline: Asia

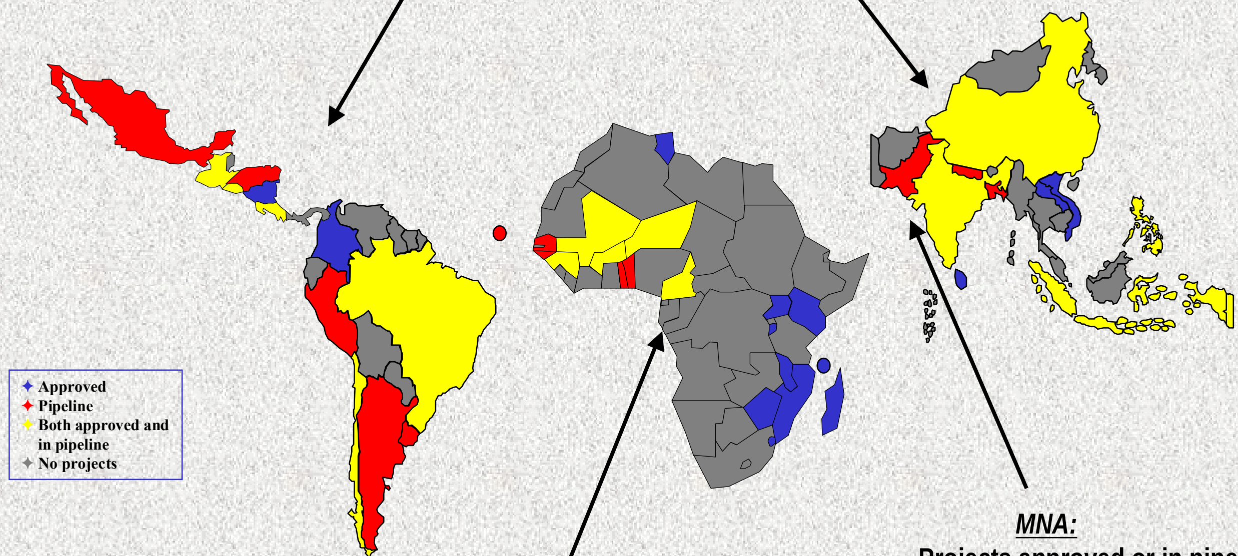
The World Bank :
Investing in Renewable Energy for Rural Development

Latin America/Caribbean:

- Projects approved or in pipeline in 13 countries
- Grid and off-grid projects involving PV, wind, hydro, biomass, and geothermal

Asia:

- Over US$1.2 billion in WB/GEF loans, credits, and grants in 12 countries
- Projects include renewable energy, efficiency
- Total project costs of US$2 - 3 billion
- Avoided fossil fuel capacity of 1.6 gigawatts



MNA:

- Projects approved or in pipeline in five countries

Africa:

- Renewable energy projects/studies in 19 African countries
- Bank-approved renewable energy activities underway in 13 countries

Winrock International

Long-term field presence and cultural sensitivity allows WI to respond to those we serve.


Hydro-power training in the Amazon, wind turbine in Indonesia, and PV used in Guatemala


Hydro power in the Philippines and wind-powered refrigerators inIndonesia


Brazil: Osvaldo Pereira


Central America: Ivan Azurdia


Philippines: Grace Yeneza


India: Shyamala Abeyratne


Indonesia: Lolo Panggabean

Strategic in-country presence: The REPSO Network and Managers

Winrock International (WI), a private, nonprofit institution, was formed in 1975 by friends of Winthrop Rockefeller. It merged in July 1985 with the International Agriculture Development Service and the Agricultural Development Council to become the current Winrock International.

With projects in over 40 countries, Winrock is a decentralized global team of staff and volunteers dedicated to *working with people to build a better world by increasing agricultural productivity and rural employment while protecting the environment.*

WI's support comes from grants and contracts from national and international agencies, foundations, corporations, and gifts. Winrock is committed to ensuring that more of the world's development resources are used to improve the lives of rural people.

Winrock's Renewable Energy Strategy focuses on four areas of activity that will bring electricity to rural people while establishing long-term mechanisms to promote and support the use of renewable energy.

1. Building Local Capacity: Local problems require local solutions. WI is training local organizations so they can maintain and expand sustainable energy programs. WI also integrates renewable power concepts with other rural development programs—water and forest management, agricultural production, human resource development, rural employment and enterprise development—which will make rural regions healthy and economically productive places to live.

3. Financing and Credit: WI works to mobilize capital to assist private developers prepare and structure privately-funded RE projects. In 1991, WI helped launch Environmental Enterprises Assistance Fund, which has attracted over $20M to developing world environmental businesses. WI works with the World Bank and other financial institutions to increase financial access to local businesses, NGOs, and end users. WI helped establish project funds to finance systems in the Philippines, India, Indonesia, and the Dominican Republic. These finance systems provide limited loan and equity funds. In national programs, WI and its International REPSO Network help establish revolving loan funds with local NGOs and provided working capital to local renewable energy businesses. At the village level, revolving RE loan funds offer individuals credit to purchase equipment.

The International REPSO Network: Renewable Energy Project Support Offices (REPSOs) are part of WI's strategy to help local people find appropriate and environmentally sustainable solutions to their energy and income needs. Staffed with in-country RE professionals, REPSOs are an effective vehicle for matching the global interests of the RE industry with the needs of rural populations without electrical services in the developing world.

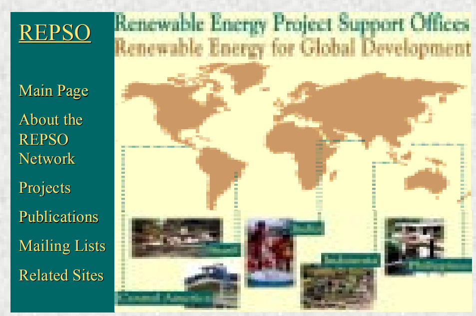
REPSOs provide technical and financial support services to small businesses, NGOs, communities, and others to promote development of renewable energy programs, equipment, and services.

The network functions as a conduit between local project developers and commercially proven technologies and services. It serves industry by identifying new markets and development opportunities, sharing information, and promoting local expertise.


Building a better world


Sugar cane (bagasse) as a supplemental fuel; solar-powered pest control; wind-powered irrigation


The mix: developing market expertise plus knowledge of technologies



The REPSO Network home page

In 1995 WI restructured to enhance delivery of services and technical support in five key areas:

- **Agriculture:** Increasing sustainable food production
- **Forestry and Natural Resources:** Building capacity for integrated natural resources management and community development
- **Leadership and Human Development:** Providing innovative training and educational opportunities critical to preparing leaders, especially women
- **Renewable Energy and the Environment (REEP):** Improving income generation, business development, and economic growth
- **Rural Employment and Enterprise Development:** Strengthening rural communities through off-farm business development.

2. Innovation: Winrock brings relevant new technology to rural areas and helps rural markets become more visible to companies developing the next generation of technology. Targeted innovations combined with people who know how to apply them can transform rural communities.

Winrock brings its experience and approach to the attention of potential sources of public and private resources. Working with local partners to implement model projects that illustrate the potential synergy between the development of new products, improved rural services, and private profits—Winrock creates positive momentum and attracts capital to the rural energy sector.

4. Markets & Commercialization: Unelectrified areas of developing countries are the present and future market for renewable energy technologies. As these technologies evolve and prove themselves in international markets, prices will drop, making them competitive with other energy sources that supply power grids in both emerging nations and developed countries. WI identifies markets and matches them with technology providers.

Improved Dissemination of and Access to Information will result in increasing knowledge and awareness of RE technologies. WI creates synergy among different countries' activities and experiences in meeting energy needs through the application of renewables through its web site, other communications, and outreach activities and projects, including facilitating communications between the REPSOs and with industry, government, and utilities; promoting dialog between development professionals; and exploring opportunities for collaboration and information exchange with organizations in USAID-assisted countries. Visit the Winrock Web site at *www.winrock.org* and peruse the REEP and REPSO Network home pages.

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Renewables for Sustainable Village Power (RSVP) Web Site

by Julie Cardinal 7/98

Background

The RSVP Program supplies information to both private and public stakeholders through a World Wide Web site at *http://www.rsvp.nrel.gov*. The information provided on the Web site is regularly updated to maintain its usefulness and to help develop and foster working relationships with those interested in village power projects around the world.

Scope

The RSVP Web site provides a variety of information on topics such as applications, contacts, and the development of renewable energy projects.

Database. The RSVP database has information on more than 140 international village power proj- ects from more than 20 countries. The database is searchable by technology (e.g., wind, photovoltaics), application (e.g., lights, water), sector (e.g., residential, commercial), and geographical region (see Table 1). Each project entry contains information on economic, financial, institutional, and technical aspects. Host country, project participants, and lessons learned are also included.

Analytical models. The site contains descriptions of analytical models developed and used by the RSVP program. The models include the Hybrid Optimization Model for Electric Renewables (HOMER), theVillage Power Optimization model for Renewables (ViPOR), and *Hybrid2*.

Discussion forum. The forum site provides a platform for sharing experiences and opinions on issues related to village power through e-mail. Here you can find announcements of new village power services, requests for information, requests for proposals, Internet resources, project opportunities, and updates on the RSVP Program. The discussions provide networking opportunities and address topics such as new technologies, social and cultural issues in village power, economics and financing, and working with various development institutions. Past discussions can be viewed on the site's archives link.

Village Power event calendar. The calendar provides information on upcoming meetings and conferences.

Library. The site library has publications information from NREL and other rural development organizations such as the World Bank and the National Rural Electric Cooperative Association (NRECA). It also contains the RSVP team publications, masters theses and doctoral dissertations, and links to related Internet libraries.

The RSVP Web site also contains links to other Internet resources on renewable energy, excerpts on issues in village power, renewable energy contacts, and information on the annual Village Power Conference.

Status and Planned Activities

Since its inception, the RSVP Web Site has undergone several changes. The password-protected database has been replaced with a registration page. This allows the site to be monitored and evaluated to serve its users better. New users are not required to have a password to see RSVP information. The projects were converted into a Microsoft Access 97 Database, allowing instan-taneous access to new information. An electronic system was established which allows project leaders to easily update their information. The Asian section of the database also was expanded.

NREL plans to expand the database and continue to regularly update the project information. Other activities include increasing the number of site users, monitoring and updating Web site links, and continuing to offer useful, easily accessible information.

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NREL/FS-520-24632

Partial Matrix of RSVP Database Projects

Count of Region		**Technology**										
Region	**Application**	*****	**Biogas**	**Biomass Combustion**	**Diesel**	**Geothermal**	**Hybrid System(s)**	**Micro Hydro**	**Photo-voltaics**	**Solar Thermal**	**Wind**	**Grand Total**
Caribbean	Battery charging							1			1	**2**
	Ice maker								1			**1**
	Lights								6			**6**
	Mini grid										1	**1**
	Refrigerator								1			**1**
	Water pump								4		1	**5**
Caribbean Total		**4**						**1**	**12**		**3**	
Central America	Battery charging										3	**3**
	Computer								1			**1**
	Lightrs								6		2	**8**
	Power tools								2			**2**
	Productive uses							1				**1**
	Sewing machine								3			**3**
	Stores							1				**1**
	TV								1			**1**
	Village power							1				**1**
	Water pump							1	2			**3**
Central America Total								**4**	**15**		**5**	**24**

Table 1. *The matrix cross-tabulates projects' technologies by their applications. For example, if a project has two technologies listed and one application, it is counted twice and so forth.*

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Argentina: Concession for Rural Electrification Services

by Peter Lilienthal 7/98

Background

Province-by-province, Argentina is privatizing its electric power sector using two process tracks: grid-connected service and off-grid service. The Secretaria de Energia, in collaboration with provincial authorities, has identified the maximum grid extension region for the near future. All areas outside that region are eligible for regulated nongrid-connected service. The concession to provide this service as a regulated monopoly is being allocated through a competitive auction. Though details differ in each province, a consistent part of the program is the maximum tariff that the private company can charge. Two auctions in 1996 and a third, held in 1997, will serve as the pilot for a nation- wide program funded by the World Bank.

Scope

The National Renewable Energy Laboratory (NREL) has provided technical assistance to the Argentine concessions program. NREL staff helped in the design of the subsidy and tariff structure and in estimating the costs of the program. The subsidy and tariff structure provides the concessionaire with a revenue stream sufficient to maintain a sustainable operation and gives the end-users appropriate incentives to ensure efficient use of the electri-city. These two features are often absent in rural electrification programs and result in substantial burdens to the government and limit the expansion of rural electrification services. NREL, with assistance from NRECA-Bolivia, reviewed the Secretaria de Energia's estimates of the expected costs of a business supplying solar home systems. They then made recommendations about the estimated costs and the methods used to calculate the likely success of such an enterprise dependent on the size of the business. NREL also provided information on the costs and applicability of hybrid powered, collective mini-grid systems and on the design of systems for the electrification of rural schools.

Status

Using different business plan scenarios, a metho-dology was developed to identify the cost of service and the required tariff and subsidy as a function of the number of customers the business might have. The methodology can be easily adapted to different regions where the business costs and infrastructure requirements may be different. It has been used in two provinces, Salta and Jujuy, where concessions have already been granted. Proceeds from funding of $120 million from |the World Bank and the Global Environmental Facility will allow additional provinces to participate in the concession. Wind resource mapping is also being added to the methodology in the concession program's third province, La Rioja.

Planned Activities

NREL continues to assist in the development and application of the tariff methodology for additional provinces. The methodology may be used as a template in other regions and countries where renewable energy is being considered in rural electrification systems. We are working with the private concessionaire on alternative system designs and wind resource maps will be created for other provinces in the concession program.

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NREL/FS-520-24627

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

NREL Wind Technical Assistance to Mexico Renewable Energy Program

by David Corbus 7/98

Background

The Mexico Renewable Energy Program helps expand the use of renewable energy, primarily PV and wind, in rural, off-grid applications. The program is co-sponsored by the U.S. Department of Energy (DOE) and USAID and managed by Sandia National Laboratories, with the National Renewable Energy Laboratory (NREL) providing technical assistance for wind projects. The project approach emphasizes sustainability and the development of in-country institutional capacity.

The NREL program team is working with Mexican organizations within established and funded programs to incorporate the use of renewable energy technologies where they are the best technical and economic solution. The team provides training and technical assistance to the pilot project staff to help to institutionalize the use of renewable energy technologies in Mexico.

Scope

Program goals are to increase the demand for the appropriate and sustainable use of renewable energy technologies, thereby expanding markets for the U.S. renewable energy industry, and to increase the use of renewable energy technologies as a mechanism for combating global climate change, specifically by reducing greenhouse gas emissions.

More than 200 photovoltaic systems and several wind energy systems have already been installed, including a 10-kW wind-diesel system for an eco- tourism resort. Significant near-term replication of these projects is under way with the Fideicomiso de Riesgo Compartido (FIRCO, a federal, shared-risk trust fund that is under Mexico's agriculture department), the major program partner. FIRCO is working to set in motion one of Mexico's largest agricultural development programs, and Sandia and NREL are providing technical assistance as FIRCO begins to install hundreds of renewable energy projects (mostly for water pumping).

The Mexico program is divided into specificprogram areas and crosscutting activities that include work with FIRCO at both the state and national levels. The program also has projects with several state agencies in Chihuahua, Sonora, Baja California Sur, Quintana Roo, Oaxaca, Veracruz, and others. In addition, cooperative projects are underway with Conservation International, the Nature Conservancy, World Wildlife Fund, and several local organizations to incorporate renewable energy into ongoing activities for protected-areas management in Mexico. The program's crosscutting activities include solar and wind resource assessment, training, technical and economic analysis, financing mechanisms, industry interactions, project monitoring and evaluation, and environmental assessments.

NREL's approach is to *emphasize sustainability and infrastructure* by

- working with established Mexican organizations
- working within established and funded programs
- providing training in technologies, applications, and project implementation
- providing technical assistance and cost-shared funding for pilot projects.

Emphasis is on productive uses such as water pumping for livestock or crop irrigation, lighting for commercial or business activities, and ecotourism. Such uses

- provide economic and social benefits
- have a high degree of sustainability and replicability because they provide a mechanism for paying for renewable energy systems
- compete with subsidized renewable energy programs in Mexico.

NREL Activities

NREL is helping Mexico in site identification and providing technical assistance to their wind project teams.

Oaxaca Workshop and 1.5-kW Turbine Instal-lation. NREL participated in the Mexico/AID Renewable Energy Workshop held in Oaxaca in August of 1996. Besides presenting material on wind-powered water pumping and hybrid system design, NREL trained others in the installation of the 1.5-kW wind-powered water pumping system.

10-kW Costa de Cocos Wind-diesel Installation. The work at Costa de Cocos consisted of prefeasibility and economic analyses, preliminary design, preparation of bid specifications, evaluation of bids, coordination between the vendor and owner on project implementation, participation in project implementation, and follow-up evaluation of the project, including analysis of monitoring data.

San Juanico Analysis. Working closely with Arizona Public Service (APS), NREL has done extensive economic and performance modeling of a proposed hybrid system for the village of San Juanico. Their activities include: tariff structure definition; assessments of ability to pay; loads analysis; site visits and dialogue with villagers; preliminary design studies based on Commission Federal de Electricidad (CFE) and APS cost requirements; extensive meetings with APS and CFE and other interested parties; and time-series modeling of system performance using estimated hourly loads and hourly anemo-meter data from the site. The installation of this projeact should be complete by January 1999.

Wind and Solar Resource Assessment. The NREL resource assessment team analyzed both wind and solar data for Mexico and is producing a catalog of Mexico wind data from various sources. They also are producing wind resource maps for several regional areas. Two important activities were the acquisition of digital terrain data for all of Mexico and the analysis of satellite data on ocean wind speeds near the Gulf, Caribbean, and Pacific coasts.

Besides these activities, NREL conducted assessments of a wind/PV/diesel hybrid system in Quintana Roo for the fishing lodge of Casa Blanca, analysis of several wind-powered water pumping sites in Quintana Roo, and analysis of potential protected-areas management projects in the states of Quintana Roo and Yucatan.

Planned Activities

San Juanico Hybrid System. NREL will continue technical analysis for the San Juanico Hybrid power project. The work will include technical system design assistance and design of a monitoring system for the project. Technical Assistance in the Yucatan. NREL is providing technical assistance to several small wind projects in the Yucatan Peninsula, including small wind/PV system installations at the Isla Contoy and Pez Maya nature reserves.

Replication of FIRCO Water Pumping Activities. NREL will continue to support the FIRCO water pumping projects with the goal of replicating wind-powered water pumping systems in an area with a good, homogenous wind resource such as Oaxaca.

Wind Resource Assessment. NREL will produce a catalog of all wind monitoring activities under the program. Researchers have completed a set of detailed, computerized wind resource maps of two regions of Mexico: the Yucatan Peninsula and Baja California Sur. These maps were generated using automated wind mapping systems.

NREL will continue technical assessments, prefeasibility analysis, and site visits for wind projects that pass initial screening by project team members in the field. Several small wind projects are being evaluated in the Yucatan Peninsula.

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NREL/FS-520-24638

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Hybrid Power System for Xcalak, Mexico

by David Corbus 7/98

Background

Xcalak is coastal fishing village located at the southern tip of the Yucatan peninsula in Eastern Mexico. The village has about 300 residents in 60 homes that have never been connected to the national utility grid because the small size and remoteness of the village made grid extension too expensive. However, there have been attempts to bring electricity to Xcalak. In fact, it has been electrified five times-four times with diesel-electric generators and the last time with a hybrid wind and photovoltaic system.

In 1992, after nearly a decade without diesel power, Xcalak received a 71-kW renewable energy power system consisting of six wind turbines and a photovoltaic array. Other components in the hybrid system included a 400-kWh battery bank and a 40-kW inverter. The system was designed around a 220-V direct current (DC) electrical bus. Condumex S.A. installed the system. Condumex, located in Mexico City, has been the preeminent supplier of solar energy equipment in Mexico for many years. The new system was funded by the State of Quintana Roo and the federal PRONASOL rural development program.

The Xcalak hybrid system was energized in August 1992 and has been producing between 120 kWh and 250 kWh of AC power per day, depending on the wind resource. Any electricity generated by the system that is not needed satisfy the immediate electrical load is stored in the battery bank for use during times of low wind and solar output. System performance has been slightly better than expected, primarily because the wind resource has been greater than was originally predicted. However, because the village load has grown substantially the system often cannot meet the demand. The Xcalak system performance is monitored by the Southwest Technology Development Institute (SWTDI) and the National Renewable Energy Laboratory (NREL).

Over the last five years, several problems have surfaced. Several wind turbine alternators have been replaced and the PV array has been out of operation twice due to regulator and wiring failures. Problems with the inverter have caused prolonged system downtime. Many of these technical problems were not severe, however, and could have been fixed in a timely manner had there been an appropriate infrastructure in place for system maintenance. Salt corrosion has proven a problem on the wind turbines, necessitating the replacement of turbine parts and tower guy wires.

The Xcalak project has taught us some important institutional lessons, principally things to avoid. The system was installed before a local electrifi-cation committee (patronate) was formed leaving the ownership and responsibility for the system largely undefined. The Governor of Quintana Roo, who championed the project, was voted out of office in 1993. The utility company was never involved with the project and the locals have lacked the cohesion to organize themselves into a regulating body. In addition, the users were not originally charged for the electricity, which naturally caused consumption to balloon. There has been difficulty in getting the users to pay once a method for charging them was implemented.

Status

NREL began analysis of the system performance data in 1994 and has provided technical assistance to the project since then on an ad-hoc basis. To date, there have been no institutional changes with the Xcalak project, hence, the system is in danger of falling into disrepair. Technical challenges, although significant, are not the primary problem. Lack of system administration is the major impediment.

In August of 1997, a Canadian contract was awarded to SWTDI to investigate the institutional and technical problems posed by the project. Since then, with assistance from NREL, Sandia National Laboratories, the University of Quintana Roo, and Bergey Windpower Company, the turbine alternators have been repaired and significant maintenance performed on the wind turbines. Solutions to the institutional problems are being pursued under the SWTDI contract, including the installation of electrical meters, tariff analysis and implementation, repair of the distribution grid, and formation of a local administrative body that will be responsible for system administration.

Planned Activities

NREL and SWTDI will continue to monitor the performance of the system and analyze the data, particularly noting that the battery in the system is already five years old.

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NREL/FS-520-24637

PROJECT BRIEF

Battery Charging Stations

by David Corbus 7/98

Background

Getting their electrical service by charging 12-volt, 50–100 Ah batteries from diesel grids is common for residents in some areas of the developing world. However, a few examples of renewable energy-powered battery charging stations also exist in such areas. For example, GTZ installed a photovoltaic (PV) battery charging station in the Philippines and NREL is deploying a PV-powered battery charging station in India.

Transport of the batteries to and from the household is either the responsibility of the resident or a service provided by the station. The batteries can be individually owned, or leased from the station. The batteries are charged either on a set schedule, or as the batteries need a recharge. While such logistical variables provide a challenge, battery charging stations have the major advantage that they can bring affordable electric service to very low income populations.

Status

NREL has studied the institutional arrangements for battery charging stations, and conducted research, both design and testing, on their architecture and controls. As part of the deployment of a PV-powered battery charging station in India, NREL has tested a PV powered battery charging station (identical to the one in India) provided by Applied Power Corporation. Initial testinghas been completed and results are available (see contacts).

Significant research has also been conducted on wind power for battery charging stations. Because of the variable voltage DC bus typical of small wind turbines, the design of a wind-powered battery charging station can be complex. Yet, there is potentially a greater economy of scale for a wind-powered station when compared with a PV station.

Testing at NREL on wind-powered battery charging stations has focused on a low cost method for charging 12-volt, deep cycle batteries from a small wind turbine. Three alternatives were evaluated. The first option has four batteries, with a common state-of-charge, in series with many strings in parallel and voltage control for the entire DC bus. The second has individual charging control for each 12-volt battery using a DC to DC converter/charger for each battery. The third option is AC minigrid system comprising batteries and an inverter under which the battery charging load is only one of many various village loads on the system.

NREL has completed feasibility testing of a wind-powered battery charging station using the second alternative and has awarded a contract to Ascension Technology for the production, design, and fabrication of a commercial prototype based on the testing.

Issues with wind-powered battery charging stations

NREL held an online Internet discussion with researchers and renewable experts worldwide. The discussion dealt with several key issues including the operational, technical, financial, environmental, and safety aspects of battery charging stations.

In response to the operations issues, the discussion group proposed that batteries can either be owned by the station and leased to the user or be owned by the user. The lease system has several benefits:

- standardization of the batteries
- cost leverage from bulk purchase
- weekly maintenance at a station.

On the other hand, an individual ownership system has one, very key, benefit. The individual is responsible for their own battery maintenance and, therefore, less likely to over discharge the battery.

The group also expressed concern that batteries could be easily mishandled if the end user was responsible for transport. Such mishandling could result in shortened battery life and possible battery acid spills resulting in personal injury. An alternative is to have a transportation service such as a donkey cart, a truck, or another mode of local transportation. While this option is more expensive, it may be more economical in the long run because of better battery handling, battery throughput control, and increased business generated by a larger service territory.

The environmental and safety issues revolved around recycling and packaging. Recycling is a vital component of all battery programs. A station can probably facilitate recycling as it is a single facility to collect batteries and deal in bulk with battery recyclers. Safe packaging of batteries has started in South Africa and Brazil. Replication will be necessary for new battery charging schemes.

Concerning financing, the group response suggested a centralized business scenario. A centralized business can provide credit history and is more likely to be approved for a loan than several hundred individual PV users; cost recovery is with a single point of contact. High up-front costs are the limiting factor for complete solar home systems in some communities. In these cases battery charging stations hold a critical advantage because there is low or no capital expenditure for the end user.

Planned Activities

Activities for the future include testing of a commercial prototype battery charging station built by Ascension Technology and installed at the National Wind Technology Center.

References

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NREL/FS-520-24628

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Hybrid Power Systems for Russia's Northern Territories

by C. Dennis Barley and Vahan Gevorgian 12/97

Background

In the northern areas of Russia (including the Kola peninsula, the Arkhangelsk region, the Chukotka peninsula, and other locations), a number of lighthouses, small industrial villages, and meteorological station facilities receive electric power from one of two sources. An existing grid serves a portion of the area and small, local diesel power plants serve the remaining locations. In some cases, the reliability of the grid service is deemed unacceptable and local independent power stations are desired. As for the small diesel plants, diesel fuel prices in northern Russia range from about $0.36/liter to $1.30/liter, and the demand for electricity often exceeds available fuel supplies.

These conventional power issues are helping to open up a market for renewable energy sources. The wind resource in northern Russia is very good, particularly in the Murmansk and Ark-hangelsk regions. The estimates of the annual average wind speed for those regions range from 7 to 9.5 m/s for the coastal areas and from 4 to 7 m/s inland. Most of the territories lie near or north of the Arctic Circle, so icy conditions and permafrost ground are concerns.

Scope

The United States Agency for International Development (USAID) has provided $1.4M for the purchase of 40 Bergey Windpower wind turbines (10 rated at 1.5 kW and 30 rated at 10 kW), batteries, solid-state power converters, and other equipment for retrofitting hybrid systems with existing diesel plants. Candidate project sites were selected on the basis of the infra-structure necessary to maintain the systems, the wind resource at the site, the fuel price and availability at the site, and a variety of applications to serve as pilot projects. The U.S. team provided systems designs, equipment and training of local technicians in installation and maintenance.

Status

Based on a preliminary assessment of loads, wind speeds, and fuel prices, analysis at National Renewable Energy Laboratory (NREL) indicated that optimally cost-effective hybrid retrofits for roughly six villages and ten smaller projects could be fashioned from the set of equipment provided with the USAID funds. During the summer of 1997, two Russian engineers spent two months with the NREL team using the *Hybrid2* simulation model for the analysis of hybrid systems for northern Russia. Upon their return to Russia, they became key members of a Russian team that consists of specialists representing the Russian Ministry of Fuels and Energy, the Federal Center of Small and Nontraditional Energy, and the Intersolarcenter.

Two hybrid systems, both in the Arkhangelsk region (two 10-kW turbines at Krasnoe village and one 10-kW turbine at Bolshie Kozli village), were installed from September to December 1997. Two more 10-kW turbines are being installed in the Arkhangelsk region at Megra village, four 10-kW turbines are going in at Chukotka and sites for four 10-kW turbines are under preparation in the Murmansk region.

The Bergey team provided a two-week installation and operations and maintenance training seminar for local engineers and technicians in October and November of 1997. Planned activities for the project team and partners include continuing to gather information, perform analysis and system design, and install and monitor systems.

Team/Partners

- Russian Ministry of Fuels and Energy
- Intersolarcenter
- Federal Center of Small and Non-traditional Energy
- Darup Associates

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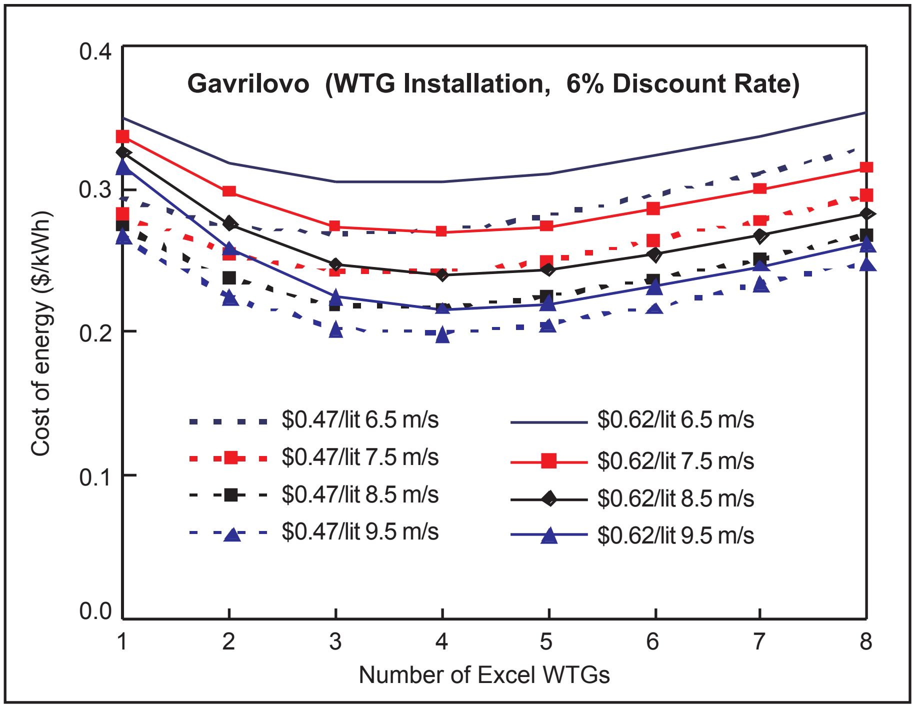

This graph illustrates a study of the least-cost sizing of a wind turbine array for a sample small village, based on preliminary data and analysis, with fuel price and wind speed as parameters. Similar studies were conducted for a number of villages and meteorological stations.

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NREL/FS-510-24199

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Household Wind/PV Hybrid Systems for Inner Mongolia, China

by Dennis Barley 7/98

Background

In 1996, the government of the Inner Mongolia Autonomous Region of China and the U.S. Depart- ment of Energy (DOE) embarked upon a plan to use renewable energy systems in electrifying remote areas of China. The first part of the project involved a policy and case study analysis of existing household and village power systems, and was completed in early 1996. The second part of the plan consists of pilot projects for the Autonomous Region of Inner Mongolia. The Inner Mongolian government, the Chinese Academy of Sciences, the University of Delaware's Center for Energy and Environmental Policy (CEEP), and the National Renewable Energy Laboratory (NREL) have joined forces to design and implement these demonstration projects.

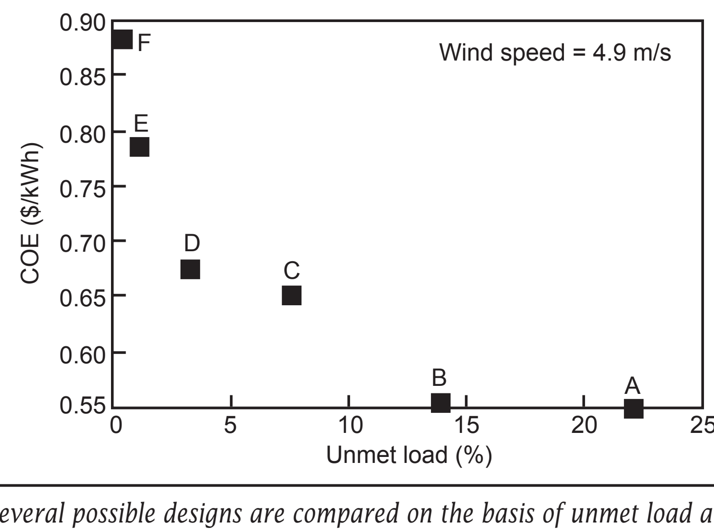
Scope

Phase I of the implementation will involve the distribution of 240 small wind/photovoltaic (PV) systems for household use. The systems will be located in two counties that are rich in wind and solar resources: Suniteyou (Xisu) and Dongwu Zhumuqin. Both counties will be equipped with resource monitoring stations, and several of the household systems will be monitored and analyzed for technical performance.

The project will be cost shared by DOE and the Chinese State Science and Technology Commission (SSTC). The systems, which cost about $2,000 each, will be paid for by the villagers or through a revolving loan fund administered by the Inner Mongolian government. Systems composed of U.S. equipment, Chinese equipment, and combinations of the two will be featured in the pilot project.

Status

Analyses were conducted at CEEP and at NREL to identify the most cost-effective household system designs for each of the two counties.Compo- nents of the analyses included identifying load profiles, assessing the wind and solar resources, collecting price and performance specifications for U.S. and Chinese components, running sophisticated computer models, and evaluating system designs for cost of energy (the system cost per kWh of energy delivered to the load) and percentage of unmet loads. The analyses showed that combinations of wind and PV are the most cost-effective designs for the household systems because the seasonal profiles of wind speed and solar radiation are complementary for the locations. Further analysis is underway to determine cost-effective designs for entire village power systems in Inner Mongolia.



Case	Wind (W)	Solar (W)	Battery (kWh)
A	400	0	1.26
B	400	0	2.52
C	400	50	3.78
D	400	50	6.30
E	400	150	6.30
F	400	200	7.56

Several possible designs are compared on the basis of unmet load and cost of energy.

Planned Activities

In 1998, a pilot wind/photovoltaic hybrid system project will be initiated with the installation of at least 240 remote household systems. In addition, resource data will be collected in several additional counties in Inner Mongolia. The data will be used to assess the potential of wind, PV and hybrid systems for serving remote household and village power needs on a larger scale.

Team/Partners

- NREL/DOE
- The Inner Mongolian government
- Chinese Academy of Sciences
- University of Delaware's CEEP

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NREL/FS-520-24636

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Rural Electrification in South Africa

by Doug Arent 1/98

Approximately 20% of South Africa's rural population is not expected to get utility grid electricity for at least the next 20 years. Many rural South Africans, similar to other rural markets in the developing world, live in sparsely populated, widely dispersed villages with small load requirements. Modular, renewable energy power generation is a cost-effective way to provide clean, affordable, and long lasting low-load electricity to such markets. The South African government recognizes the importance of renewable energy technologies and the capabilities of the photovoltaic (PV) industry in South Africa. The government has approved the use of PV for the electrification of 2000 clinics and 16,800 schools serving this population. Using PV systems to electrify for lighting, television/radio, and light manufacturing in an estimated 2.5 million homes and 100,000 small businesses is accepted as complementary and integral the extensive South African grid-electrification program. These efforts, however, must overcome key market barriers such as the availability of flexible, small scale financing for the rural populace, and establishing an adequate delivery, installation, and maintenance infrastructure to lower the transaction costs associated with dispersed customer bases.

Through the Energy for Development Directorate of the South African Department of Minerals and Energy (DME), approaches will be developed for bringing off-grid sustainable electricity to the rural population. The DME, along with the United States and other international partners, is launching a pilot program that will install at least 2500 photovoltaic systems in rural South Africa. Under support of the U.S. Department of Energy (DOE) and the U.S./South Africa Binational Commission, the National Rural Electric Cooperative Association (NRECA) is bringing their six decades of relevant experience to the pilot. Technical and financial consultation is being provided by the DOE national laboratories.

The Energy for Development Directorate of the DME has a broad portfolio of activities beyond the electrification of rural South Africa. Their other efforts include rural water pumping systems, biomass initiatives, resource assessment, energy conscious low-income housing, education campaigns and hybrid power systems for villages and farms. The latter are being pursued through joint efforts of NREL and the Energy for Develop-ment Research Center at the University of Capetown.

The project partners will conduct system modeling and create a design manual that will complement the Remote Area Power Supply Manual Series previously released by the DME.

The major challenge to bringing small scale, renewable energy electrification to rural South Africa is the creation of sustainable delivery channels for information, hardware, and financing. Four basic delivery models for the pilot project have been defined. Two models, the ESKOM Model and the Community-Based Model, will draw heavily on the infrastructure already created by ESKOM (rural schools) and the Independent Development Trust, IDT, (rural clinics). The two models are expected to provide guidance for the bulk of the first installations. Two others, the Industry-Led Model and Solar Store Model, are largely untried, but have motivated industry to submit several unsolicited proposals for pilot operations. The DOE-supported Mobile Demon-stration Unit will house consumer education and training. The unit was loaded onto a locally manufactured utility trailer that can be towed by a small pickup truck and will serve as part of the community outreach and consumer education efforts of the pilot project.

Efficient distribution channels for the delivery of complementary energy supplies such as PV systems for electricity and liquefied petroleum gas for cooking are being considered for inclusion in pilot efforts in several provinces. A community workshop, held in early July 1997 in Mpumalanga Province, identified many outstanding issues and generated considerable enthusiasm for community participation, and entrepreneurial development. Residents were also eager to learn about the opportunities to reduce their reliance on wood and kerosene.

Initial coordination of training standards was the subject of a September 1997 workshop conducted by the Institute of Sustainable Power. Under DME leadership, with the support of the Development Bank of Southern Africa and the U.S. Information Service, and in cooperation with the South African Department of Education and the Electrical Contractors Board, the initiative hopes to facilitate accreditation of training experts and certification for photovoltaic system professionals.

The initial availability of risk reduction financing through the planned Electrification Fund is key to achieving sustainable rural electrification in South Africa. Also important is the anticipated support for PV electrification from the Electricity Policy Coordinating Committee. The committee believes renewable power options are economically superior alternatives to line extensions for meeting much of the 450,000 annual connections quota. It is estimated that the rural electrification market lifetime will last 20 years, and the total value of installed hardware will be approximately $1 billion.

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NREL/FS-520-24633

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

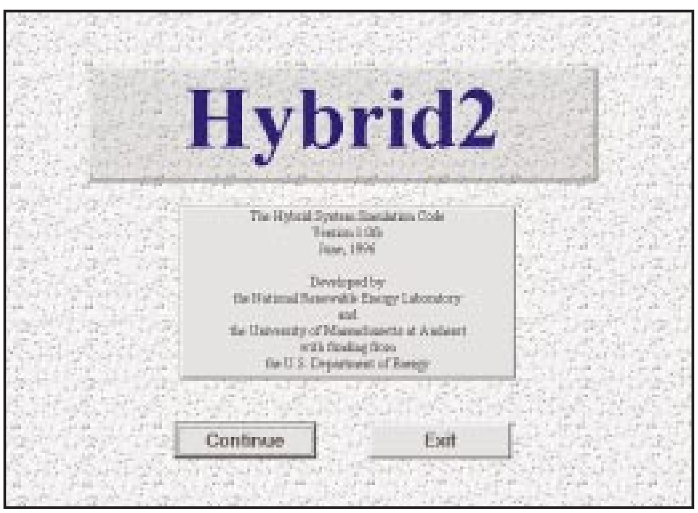
PROJECT BRIEF

Hybrid2, Hybrid Power System Simulation Software

by Ian Baring-Gould 12/97

Background

With the increasing need for electricity generation in the developing world, the market potential for renewable-based hybrid power systems is emerging. In order to address this emerging market, an analysis tool was needed by industry, researchers, and development institutions to accurately model the performance and economics of alternative hybrid designs. This analysis tool would have to have enough versatility to model the many system locations, widely varying hardware configurations, and differing control options for potential hybrid power systems. In response to this need, the *Hybrid2* software was developed. *Hybrid2* is a time-series/ probabilistic model that uses time-series resource and load information, combined with statistical analysis, and manufacturers' data for hybrid system equipment to accurately predict the performance and cost of hybrid power systems. *Hybrid2* allows direct comparison of many different renewable and non-renewable power system designs. This is completed in a user-friendly format where off-the-shelf equipment is incorporated into potential power systems.



Hybrid2 *was released in June of 1996.*

Scope

To define the performance of a variety of wind/ diesel and hybrid power system configurations, the University of Massachusetts and the National Renewable Energy Laboratory (NREL) developed the *Hybrid2* software. The *Hybrid2* code can model many combinations of wind turbines, photovoltaic arrays, diesel generators, power converters, and battery storage, both in AC, DC, or two-bus systems. *Hybrid2* also allows for more than 100 different dispatch configurations with multiple diesel generators, renewable sources, and battery storage. The model has an easy to use graphical interface, an in-depth library to facilitate system design, and a detailed glossary of frequently used terms to assist users who are not familiar with hybrid power system terminology. The code also includes a comprehensive economics package.

Status

The *Hybrid2* code was released in June at the 1996 American Wind Energy Association Wind-Power Conference in Denver, Colorado. The software has undergone numerous updates and is available to the general public for a $100 reproduction charge. The University of Massachusetts is providing support for software users and has set up a homepage where more information can be located. The software is used extensively at NREL and approximately 150 copies have been distributed worldwide.

The *Hybrid2* software will be undergoing continuous upgrades over the next year with planned releases of updated versions in June and Decem-ber of this year. Possible upgrades include the addition of a synchronous condenser, simplified system dispatching, a user-defined control offset and a simple pre-filter for wind and solar resource data.

Team Participants

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- NREL

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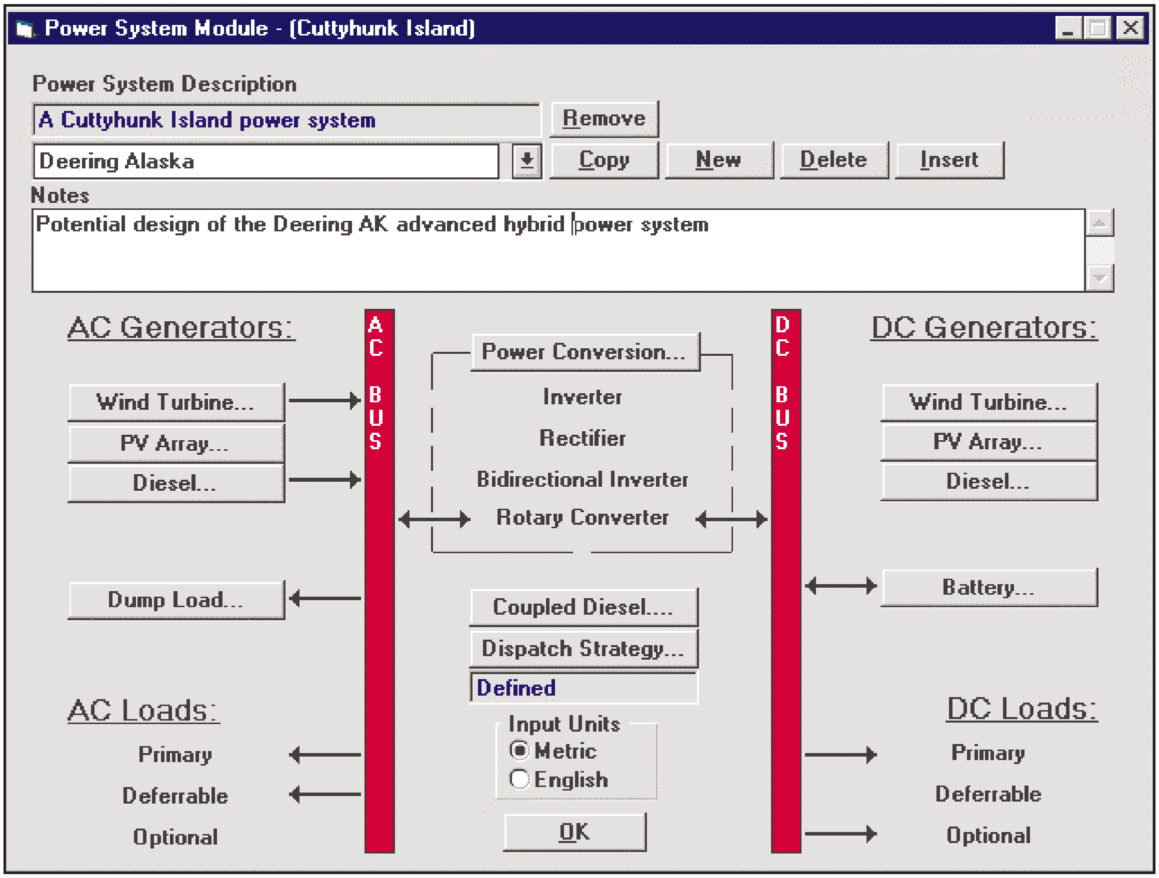

Hybrid2 *software can model many combinations of equipment in AC, DC, or two-bus systems.*

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NREL/FS-510-24197

PROJECT BRIEF

Wind-Electric Icemaking System Development

by Steve Drouilhet 7/98

Background

Small wind turbine suppliers in the United States and several international development agencies have expressed a need for a reliable and cost-effective wind-powered icemaking system. The need is driven by the demand for ice in remote fishing villages. Often, such villages in developing countries do not have access to grid power. With a reliable supply of ice to refrigerate their catch, fishermen in these villages would extend the market for their fish, reduce spoilage, and increase the quality of their delivered product.

Scope

To address the need of village fishermen, the National Renewable Energy Laboratory (NREL) decided to investigate the approach of using a commercial icemaker directly connected to the electrical output of a small variable-speed wind turbine generator. This approach was taken because it promised to be simpler and more cost effective than a system employing batteries and an inverter (to supply conventional AC power). The electric power supplied to the icemaker would vary in voltage and frequency as the wind speed varied. There would be no other energy storage in the system because ice is itself a storage medium. Ice would only be produced when there was sufficient wind power available.

Status

In the first phase of the project, NREL demonstrated variable frequency operation of a standard commercial icemaker connected to a Bergey wind turbine. While the icemaker (a Scotsman) produced ice over a range of electrical frequency and voltage, several operational problems were encountered. Particular difficulty was encountered in starting the compressor motor with the relatively weak (compared with a standard utility grid) wind turbine generator. NREL developed a computer model of the electromechanical system, looking at both the steady state and dynamic operation of the system, to get a thorough understanding of the system characteristics, including the start-up problem. Researchers then conducted bench-scale tests to validate the model and to prove the predicted effectiveness of series capacitors in increasing the starting capability of the compressor motor.

In the second phase of the project, NREL tested a Northstar icemaker, powered by a 10-kW wind turbine alternator, driven by a dynamometer. The Northstar icemaker was chosen because it appeared to have the robustness necessary to provide reliable service in a remote fishing village environment. It also can make ice from seawater (unlike the Scotsman), which eliminates the need for a fresh water supply. The icemaker start-ups were monitored at various combinations of alternator frequencies and capacitor size. Steady-state measurements were taken over the entire range of operating frequencies to determine the power vs. frequency and ice production rate vs. frequency characteristics of the system. The measurements, combined with the known wind turbine performance, were used to determine ice production vs. wind-speed for the system.

Unfortunately, the Northstar icemaker testing revealed its own set of operational problems associated with variable-speed operation. The problems included mechanical resonances, control malfunctions, poor spray jet performance, and attenuated ice production rate at the higher operating frequencies. Taken together, the resolution of these problems would call for a major redesign of the icemaker. The U.S. Department of Energy issued a Small Business Inno-vation Research (SBIR) request that included wind-electric icemaking as a development category. Three awards are anticipated in the category.

Thorough documentation of this project can be found in, "An Investigation of Wind-Electric Icemaking: Analysis and Dynomometer Testing," NREL technical report no. TP-500-24010, and in, "Wind-Electric Icemaking Investigation," NREL conference paper no. CP-500-24662. NREL is currently soliciting interest and proposals from U.S. icemaker manufacturers for continuing this work.

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NREL/FS-520-24631

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

NREL's Hybrid Power Test Bed

by Jim Green 12/97

Background

In a remote Alaskan village, wind turbines and back-up diesel generators can hypothetically provide electricity for lighting, heating, and hot water on a short winter day. This is one of many hybrid power systems researchers can simulate at the National Renewable Energy Laboratory's (NREL's) Hybrid Power Test Bed (HPTB) at the National Wind Technology Center (NWTC).

Hybrid power systems combine multiple power sources such as wind turbines, photovoltaic (PV) arrays, diesel generators, and battery storage systems. They typically are used in remote areas, away from major electric grids.

Scope

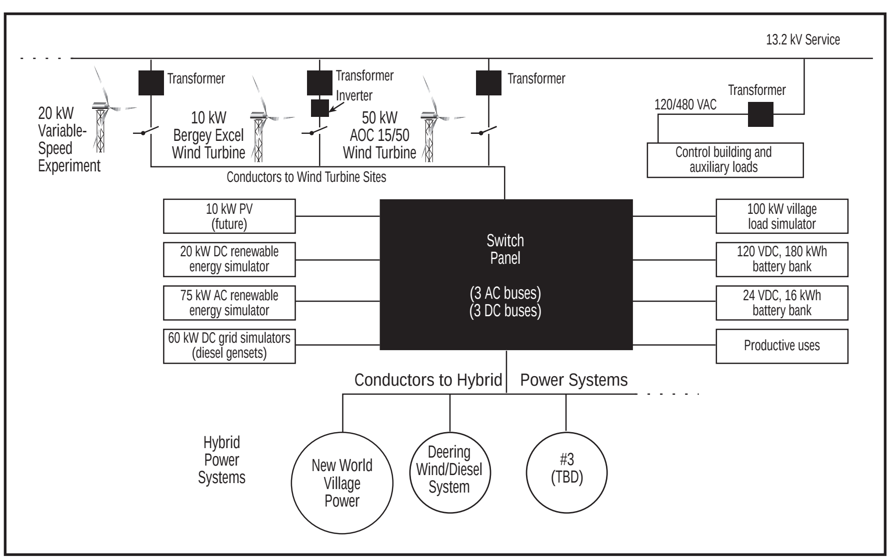
The HPTB is designed to assist the U.S. industry in developing and testing hybrid power generation systems. Using simulated village loads, researchers can evaluate the interaction of hybrid power systems under realistic conditions. Design engineers are able to work through actual problems the system might encounter in the field.

The test bed allows engineers to evaluate system performance, cost effectiveness, and reliability using real or simulated solar and wind energy resources. Simulated energy resources allow designers to repeat experiments as they improve system designs. This feature is important for developing new components, advanced hybrid systems, and dispatch and control systems.

U.S. companies can use the HPTB to train customers from other countries. By providing technical assistance to potential users, the NWTC encourages the growth of international markets for the U.S. wind industry.

Test Bed Capabilities and Features

Engineers can evaluate the moment-by-moment dynamics of hybrid power system operation, gather data on long-term performance,or demonstrate innovative design concepts with the HPTB. High-speed data acquisition equipment monitors power quality, harmonic distortion, and electrical transients. A village load simulator (a load bank with resistive and inductive elements) can create power factors down to 0.5, allowing



Components of NREL's Hybrid Power Test Bed.

test engineers to evaluate system operation under severe conditions that may be encountered in real operations. Engineers can also investigate the power system's dynamic response to sudden load changes and to conditions of phase imbalance or loss of phase.

Test bed engineers can evaluate the long-term performance of a hybrid power system, including its energy delivery (in kilowatt-hours), and diesel fuel consumption. They can monitor wind speed, insolation, and the performance of battery energy storage. They can characterize system performance under a range of operating conditions, evaluate alarms, emergency shutdown procedures, and other critical functions.

The research test bed provides a minimal risk environment for developing, testing, and evaluating new concepts when compared to proving them in the field at remote locations. New power conversion devices, emerging energy storage technologies, prototype control systems, and innovative system architectures are examples of concepts that can be evaluated using the HPTB.

The HPTB has a number of unique features. These features include the ability to test up to three hybrid power systems simultaneously, use either real or simulated renewable energy sources, simulate a local electric grid, test with real or simulated village loads, and test wind turbine systems producing direct or alternating current (DC or AC).

A custom-designed switch panel with 3 AC and 3 DC buses gives the test bed the flexibility to connect or disconnect various system components for tailored testing programs. The switch panel can connect selected components, with combined capacities of up to 100 kW onto common power buses. Engineers can rapidly change testing configurations by opening and closing a few switches.

Simulated renewable energy sources allow engineers to conduct repeatable testing. An induction generator functions as a 75-kW AC source simulator. A DC source simulator is planned for future and will be a solid-state device that provides up to 20 kW of reproducible DC power.

Two 60-kW diesel generator sets are available for use in hybrid systems under test. They may also serve as grid simulators, allowing researchers to test a hybrid power system's ability to synchronize its power output and connect with an existing small grid.

Renewable energy technologies at the facility include three wind turbines, rated from 10 to 50 kW. A photovoltaic array rated between 10 and 20 kW is planned. The NWTC's good solar and wind resources allow a full range of power- system testing under normal operating conditions.

The test bed incorporates a 100-kW village load simulator. The computer-controlled simulator mimics typical electric loads for a small village. The test bed also has the flexibility to incorporate real village loads such as power tools, lighting systems, water pumps, or icemakers into its evaluations.

The HPTB includes a PC-based control and data acquisition system with a graphical interface in LabVIEW8.

Hybrid Power Test Bed Equipment

Component	Rating
AOC 15/50 wind turbine	50 kW
Bergey Excel wind turbine	10 kW
Variable-speed wind turbine	20 kW
PV array (to be added)	N/A
DC renewable energy simulator (to be added)	20 kW
AC renewable energy simulator	75 kW
Diesel gen-set grid simulator	60 kW
Two village load simulators	100 kW
DC battery banks	24 and 120 volts

The HPTB was operational in mid-year 1997, with the testing of a control system for a high penetration wind/hybrid project in Alaska, and completion of a New World Village Power 50-kW power system characterization. We anticipate the HPTB will be a very valuable and heavily used test capability for the next several years.

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NREL/FS-510-24201

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

The Hybrid Optimization Model for Electric Renewables (HOMER)

by Peter Lilienthal 7/98

Background

Hybrid power systems can consist of any combination of wind, photovoltaics, diesel, and batteries. Such flexibility has obvious advantages for customizing a system to a particular site's energy resources, costs, and load requirements. Flexibility also makes the design process more difficult, however. Previous models were either simple spreadsheets or detailed simulations. The simple spreadsheet models do not consider the time-dependent variability in the loads and resources. The detailed simulations, such as *Hybrid2*, give performance projections for specific systems, but are unwieldy to use for comparisons among many different configurations.

Scope

The National Renewable Energy Laboratory (NREL) has developed HOMER, an optimization model that takes into consideration hourly and seasonal variations in loads and resources, simple performance characterizations for each component, equipment costs, reliability requirements, and other site specific information. HOMER ranks the configurations by life-cycle cost and can automatically perform sensitivity analyses on any subset of its inputs. It is intended for prefeasibility analysis when the interest spans a broad range of inputs, either because the input data is uncertain or because the analysis covers a large area with differing conditions. Besides optimized configurations, HOMER provides hourly energy flows through each component, the impact of several simple load management strategies, and economic information such as the cost of energy and net cost of the system.

Results

NREL researchers have used HOMER in several analyses for Indonesia, China, Russia, Argentina, Chile, Brazil, Mexico, South Africa, and for market analyses for domestic renewable suppliers and technology developers. It also has been used for market assessment and screening to initialize detailed site-specific Hybrid2 analyses.

In 1997, HOMER was converted from specialized optimization software to Visual C++. This conversion improved the model's user-friendliness and facilitated wider distribution. There are now two versions of HOMER; a simple version intended for planners unfamiliar with hybrid renewables and an advanced version for experienced engineers.

The specifications of diesel fuel efficiency and maintenance requirements were improved. The dispatch algorithm was improved to reflect antic-ipated operator control. Loads and resources can now be specified either as typical days for each season, with a user-specified level of additional variability, or with a time-series data file for an entire year. It reports both optimal and near-optimal solutions. HOMER has been integrated with a mini-grid optimization model, ViPOR, to help planners compare mini-grids with individual systems for a particular village.

Planned Activities

HOMER will continue to be used for system screening and market assessment. Further enhancements to the dispatch capability are planned. A complete package of documentation is being produced.

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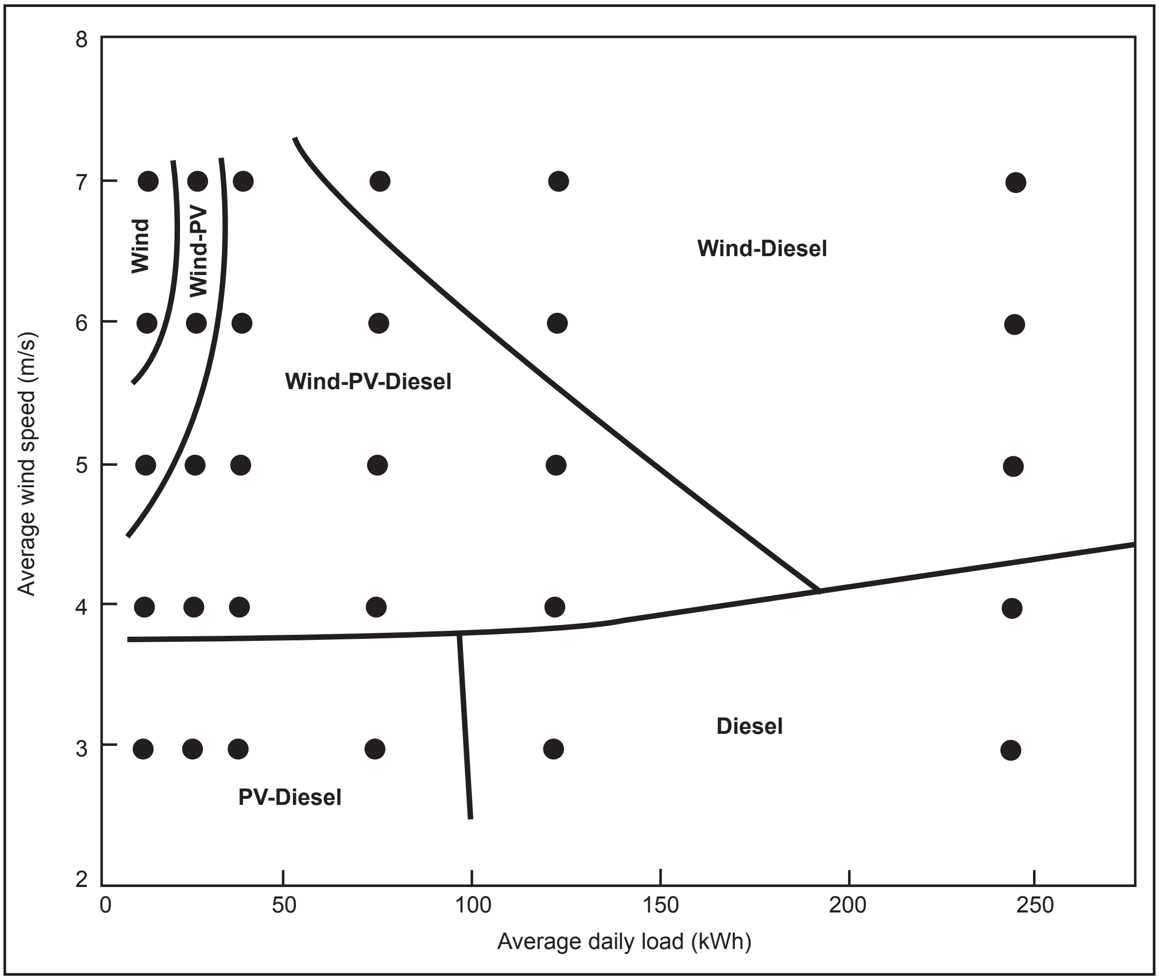
NREL/FS-510-24630



HOMER. *Assessing the "least" cost mix of supply technologies is a difficult analytical problem that depends on the quality of the various resources, the local costs of equipment, labor and fuel, and the site-specific descriptions of the daily and seasonal variations in the loads, as well as the options for simple load management. The Hybrid Optimization Model for Electric Renewables (HOMER) is a screening model that is useful for prefeasibility and sensitivity analysis. This graph is an example of a set of HOMER outputs for specific sets of assumptions. The results can change dramatically with different assumptions.*

Sensitivity analyses were performed on the size of the load and the average annual windspeed. For very low loads in a good wind resource, one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases, a combination of wind and PV is preferred. Although in this example PV-diesel is the optimal choice in poor wind resources for the smallest loads that were modeled (12 kWh/day), a pure PV system would be preferred for smaller loads or higher fuel prices or if more than 5% unserved energy would be acceptable. In the larger sizes, both wind turbines and diesel gen-sets have economies of scale that make PV less competitive. The vertical line representing 125 kWh/day demonstrates a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low windspeeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Desalination for Villages

by David Corbus 7/98

Background

As the world's population grows, so will its demand for potable water. Communities in arid coastal regions or regions with brackish groundwater, especially island communities, are already experiencing shortages of potable water. Many of these communities are small and remote, such as villages on the islands in the Caribbean and Mediterranean, in arid Australia, coastal South America, and the Middle East. Several of these communities can meet their water needs through demand management and conservation. However, for many of them, desalination is the most appropriate solution.

Desalination consumes a large amount of energy. Many remote villages rely on costly, often limited supplies of diesel fuel for their energy needs. Finding methods of using renewable energy to power the process is, therefore, desirable and to encourage communities in their use. Desalination is an ideal application for a hybrid power system. The desalination system can be operated as a deferable load and improve the load management of the hybrid system.

Scope

NREL researchers conducted a survey to examine the various ways in which renewable energy has been used for desalination, including photovoltaic-powered electrodialysis units, small scale solar thermal-powered multiple effect distillation systems, and direct-drive, wind-powered reverse osmosis systems. The survey compared the systems based on capital cost, life-cycle cost, energy consumption, pretreatment requirements, and operational complexity.

NREL also sought to identify the possible ways in which renewable energy could be used for desalination and to decide areas of further research. Because few companies or communities will invest in an unproven application, ideas for key pilot projects to show the feasibility of renewable energy-powered desalination were analyzed.

Results

The survey overview was published in April 1997 and identifies several areas where further research is needed (see Status Table). Many pairings of renewable energy and desalination processes that seem quite viable in concept remain untested. These pairings are shown by empty spaces on the chart. Prototypes and pilot scale testing are needed to decide the viability of such systems and to learn how they compare with other combinations. Both PV- and wind-battery electrodialysis systems have been operated successfully. A mechanical wind pump-reverse osmosis system using pressurized water storage has been tested in Australia, but a similar electrical wind pump system has not, although several researchers have concluded that electrical wind pumps are superior to mechanical pumps in high wind regimes. Recent improvements suggest that vapor compression is potentially the least expensive and lowest energy consuming form of sea water desalination, but a renewable energy-powered system has not been tested.

NREL has tested one of the more promising combinations. An electrodialysis reversal (EDR) system was tested using a wind-electric power source. The EDR processed 1.1 liters per minute (lpm) of brackish water (900 ppm) using an 850-Watt wind turbine from Bergey Windpower Company attached to a 48-Volt, 350 Amp-hour battery bank. The power consumption for the test averaged 114 Watts. The low (1.1 lpm) flow rate was due to a bypass valve leak on the system pump, which was discovered after the test was concluded. The system is part of a Bureau of Reclamation project focusing on desalination units suitable for use on Native American reservations and other remote area locations in the United States. The Bureau has tested this system in Spencer Valley, New Mexico, on the Navajo reservation in a PV/battery design. In addition, the Solar Thermal Division of NREL initiated an investigation into small scale solar thermal-powered multiple effect distillation systems.

Planned Activities

NREL will continue to investigate vapor compression units suitable for use in villages.

Testing of independent hybrid PV/wind/battery systems with and without backup generators is continuing. A cooperative project between Australian researchers and NREL is being discussed with members of CASE/Australia, developers of a commercial prototype of a PV-reverse osmosis system.

Development Status of Renewable Energy-powered Desalination

(Italic text indicates research areas of greatest interest for near-term commercialization. Blank cells represent renewable energy-desalination combinations which have not been tested. n/a means that the particular technology cannot be powered with this form of energy.)

Renewable Energy Source	Desalination Technology				
	Multiple Effect Distillation	**Multistage Flash Distillation**	**Vapor Compression**	**Reverse Osmosis**	**Electrodialysis**
Solar thermal	Pilot plants (Spain, 1988; U.A.E., 1984) *Rugged ME*	Pilot plants (Kuwait, 1984; Mexico, 1978)	n/a	n/a	n/a
Solar thermal electric or mechanical		Pilot plant thermal plus Stirling engine (Texas, 1987)		Pilot plants mechanical direct drive (France, 1978)	
PV-battery inverter	n/a	n/a		Commercial	Pilot plant (Japan, 1988)
PV, no inverter	n/a	n/a		Commercial direct drive (Australia, 1996)	Commercial prototype battery/all-DC (New Mexico, 1995) *PV-direct drive*
Wind-battery	n/a	n/a	Pilot plant (Spain, in progress) *Wind-battery-inverter*	Pilot plants (France, 1990; Spain, in progress) *Wind-battery-inverter*	Pilot plant (Spain, in progress) *Wind-battery*
Wind-diesel			*Wind-diesel-load management*	Pilot plants in progress (Spain, Greece) *Wind-diesel-load management*	
Wind-mechanical	n/a	n/a		Pressurized water storage pilot plant (Australia, 1990)	n/a
Wind-electric direct drive	n/a	n/a		Cut in/cut out control pilot plants (Germany, 1979; France, 1987) *Pressurized water storage*	

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NREL/FS-520-24629

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Wind Resource Mapping

by Dennis Elliott and Marc Schwartz 7/98

Background

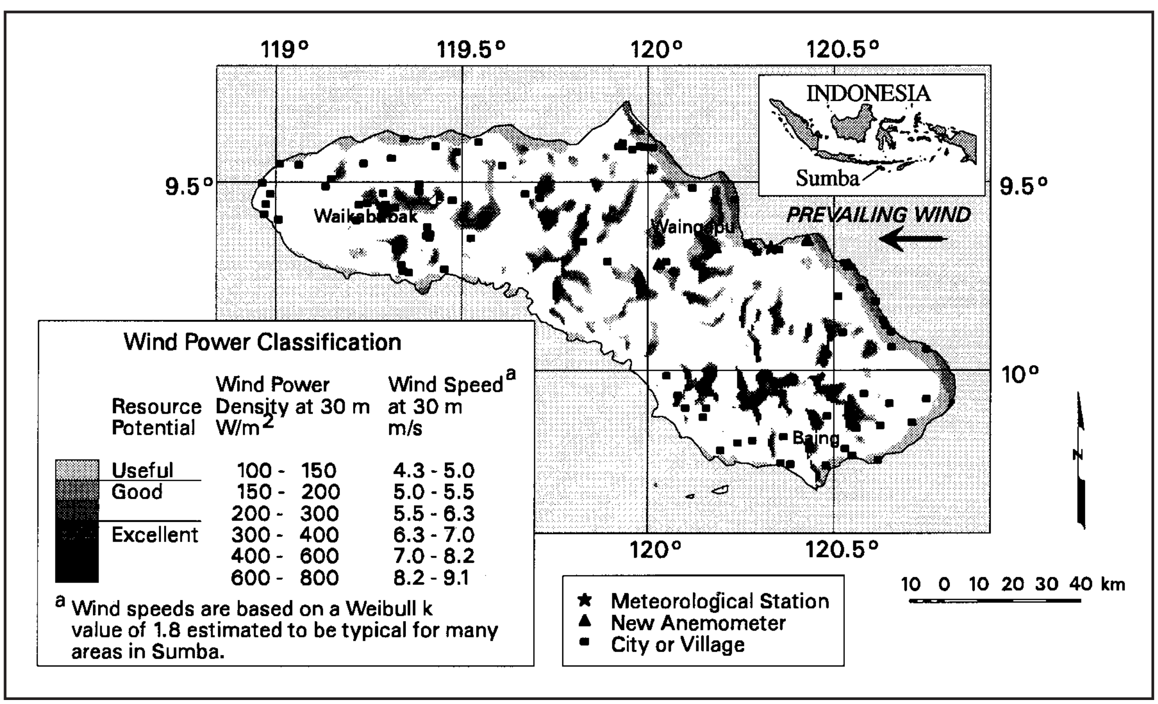
The National Renewable Energy Laboratory (NREL) is to helping to accelerate the deployment of wind energy by producing the most useful and sophisticated wind maps possible. In late 1995, NREL developed an automated wind mapping technique using Geographic Information Systems (GIS) software, improving on previous wind mapping techniques that were limited by laborious and subjective analysis methods.

The distribution of the wind resource for any particular region is often very complex. Previously, maps had to be physically drawn for topographic features such as ridge crests, elevated plateaus, and coastal areas. This process was time consuming, subjective, and often produced inconsistent analyses. NREL's computer mapping technique substantially reduces subjective analysis and greatly improves the accuracy of the maps. The technique enables the analysis of the distribution of the resource to be treated consistently throughout the region of interest. Using advanced computers, the NREL mapping technique reduces the time needed to produce a wind resource map for complex terrain.

Approach

A key component of NREL's wind mapping effort is the development of updated, comprehensive global databases that supply input for the computerized technique. NREL uses a variety of meteorological and geographical data sets in support of wind mapping projects. The principal meteorological data used in NREL's resource assessment projects are surface meteorological data, upper-air (weather balloon) data, and marine wind data from ships and satellites. In some regions, the data are supplemented by surface data from new surface measurement programs. The major type of geographical data used are shaded elevation maps and digital elevation data.

NREL's computer mapping system uses an analytical approach and is designed to portray the distribution of the wind resource over a large area. These maps can be used to identify and target areas for possible project sites and further wind measurement programs.



Results

Wind resource maps generated with the NREL computerized technique have been produced for specific areas of Chile, Mexico, China, and Indonesia. The wind map for the Indonesian island of Sumba (shown here) shows a large island with varied terrain. Sumba has only one meteorological station that has gathered long-term wind data. Nevertheless, using advanced analysis techniques of the regional meteorological data (primarily upper-air and satellite data) and available topographical data, a wind map was generated that delineates the most favorable wind resource areas on the island. Wind measurement activities that will be useful in validating and refining the island's wind resource are underway.

Planned Activities

Additional wind mapping activities for at least eight countries around the world are either underway or planned. The activities include mapping of areas in Chile, Mexico, Dominican Republic, Argentina, China, Indonesia, the Philippines, and Russia. Some of these countries present complex wind flow regimes and topography. Additional modules that take extremely complex terrain and topography into account will be developed and added to the computer mapping system.

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NREL/FS-520-24639

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Village Power Optimization for Renewables (ViPOR)

by Peter Lilienthal 7/98

Background

Throughout the world, many villages lack access to electricity. Many of these villages are so far from the utility grid that the cost of extending utility lines is more expensive than providing the village with its own autonomous electrical generation system. In recent years, wind and photovoltaic (PV) power have become economically viable electricity options for villages with sufficient wind or solar resources. Renewable resources can be used to supply power to many houses through a centralized distribution system, or for isolated systems serving a single house. ViPOR is a computational modeling tool capable of optimizing an autonomous village electrification system using the lowest cost combination of centralized and isolated power generation.

Scope

ViPOR represents the village as a set of demand points, each of which consists of x and y coordinates and an average daily electrical usage. Several economic parameters are required to calculate the costs of the distribution grid and the isolated systems. Centralized generation costs are calculated using the Hybrid Optimi-zation Model for Electric Renewables (HOMER), which has been integrated into ViPOR. The planned location (or several potential locations) of the centralized electrical power plant can also be specified. With such data, ViPOR conceptualizes the lowest cost system that will supply power to each demand point-either with an isolated power source (such as a small wind turbine or a solar home system) or through a centralized distribution grid. The design of the distribution grid involves the selection of the optimum location for the centralized power plant, the placement of multiple transformers, and the creation of a radial network of medium and low voltage lines. The voltage drop constraint is implemented using a maximum low-voltage line length, which limits the length of wire separating a demand point from its supplying transformer. An example of the output of ViPOR is shown below.

Status

ViPOR is a 32-bit Windows application written using Microsoft Visual C++. An alpha test version has been in development since May 1996 and is now operational. Currently, ViPOR is a model for NREL internal use. Analysis using ViPOR is done on a case-by-case basis.

Planned Activities

Several improvements are planned for ViPOR. They include explicitly calculated voltage drops at each demand node, wire costs being dependent on terrain, consideration of several wire and transformer sizes, and a method of accounting for different levels of service between centralized and isolated power systems.

Team Participants

- National Renewable Energy Laboratory
- World Bank
- National Rural Electrification Cooperative Association (NRECA)

NREL Contacts

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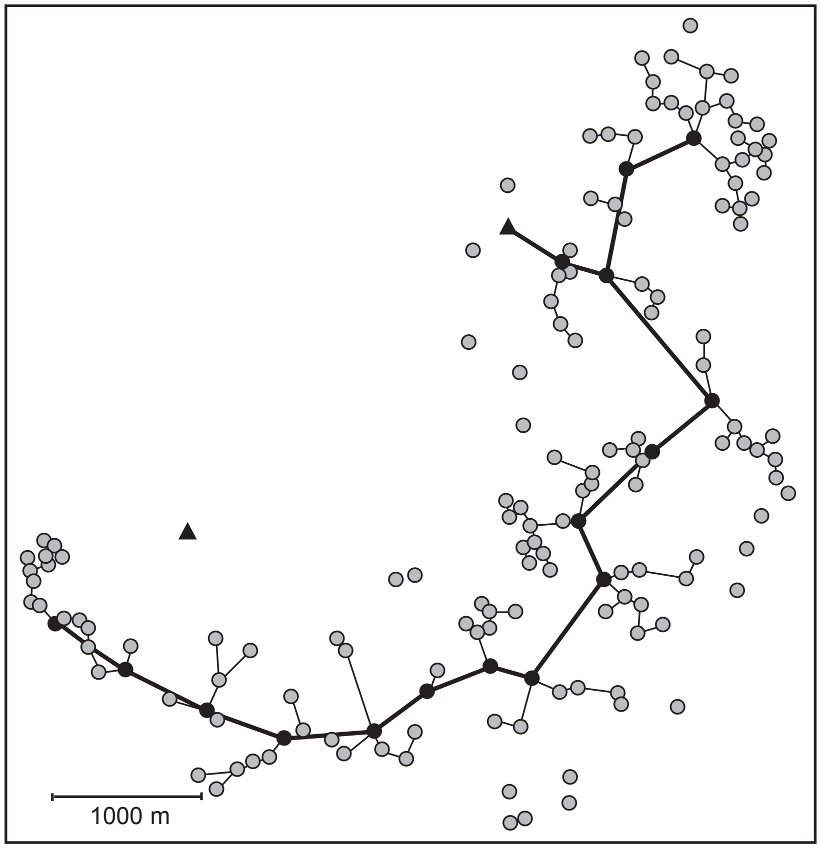
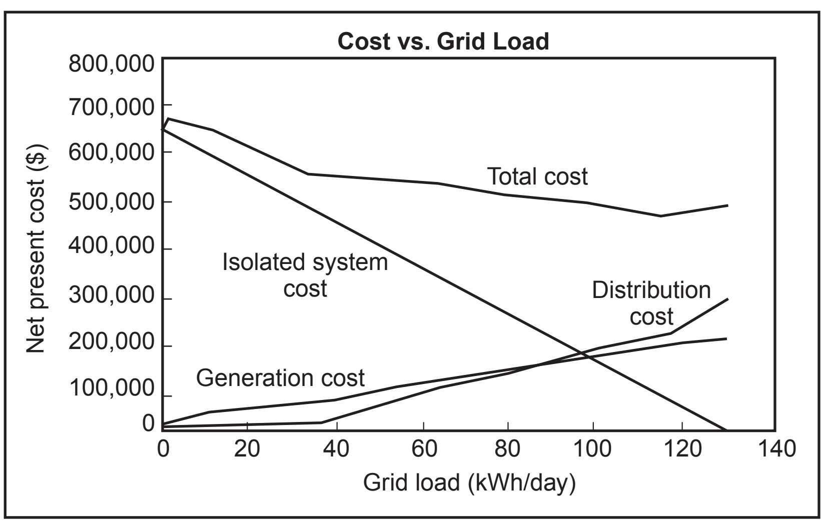
NREL/FS-520-24634



An example of the output of ViPOR. Lightly shaded circles represent houses. Those not included in the distribution grid were determined to be more economically served with isolated systems. Circles indicate transformer locations. Thin lines represent low voltage wires. Thicker lines represent medium voltage wires. Triangles indicate potential source locations; only the one chosen as optimal is included in the distribution grid.



In the cost versus grid load graph, the total net present cost of electrification and its three components are plotted versus grid load.

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Hybrid Village Power Systems in Amazonia, Brazil

by Roger Taylor 12/97

The Amazon region in Brazil is sparsely populated, with 17 million people living in five million km^2. This translates to less than 12% of the country's population living in 58% of its total area. Electri-city generation in the region, where it exists, comes mainly from isolated diesel systems with capacities that range from a few kilowatts in small villages to tens of megawatts in some capital cities. While only 9% of Brazil's electric energy is consumed in Amazonia, consumption in the region has increased at a rate of approximately 18% per year over the last 20 years, greatly outpacing the national rate of 8.2%-growth for the same period. More than 300 minigrid systems are operated by local utilities in the Amazon Basin, and thousands more are privately owned. Still, more than 30% of the population lives without electricity. The table below shows the distribution of system capacity for the 300 utility-operated systems.

Distribution of Utility Diesel Systems, by Size.

System Size (kW)	% of Total # of Systems
0–100	10
100–500	37
500–1000	23
>1000	30
Total	**100**

The cost of remote electricity is high and is largely dependent on system size. In villages with diesel systems smaller than 100 kW, the cost can be greater than $0.50/kWh and the systems operate for only 6 to 12 hours per day. The high electricity costs and limited availability are due primarily to system operation and maintenance problems, low capacity with high demand, and high fuel costs. The small systems are normally very unreliable. High electric costs are not borne by villagers, however, due to fixed electric tariff rates mandated by the government. Electric service, when provided, must be subsidized. The U.S. Department of Energy and the National Renewable Energy Laboratory are working with Brazilian utility providers to bring renewable wind and photovoltaic electricity into Brazil's energy mix.

Two differently configured hybrid electricity systems are being installed at two separate locations in the Amazon Basin. In Campinas, a hybrid system will meet nearly the entire load requirement with photovoltaic (PV)-generated electricity. In Joanes, the hybrid system will operate in a peak-sharing mode, transferring the peak demand of the village to off-peak periods at the diesel generation plant. In this way, it will use the maximum energy available from renewable sources. Renewable generation in Joanes is expected to reach 115 MWh/year, supplying 45% of the total current demand. A concurrent energy conservation program in the village is expected to boost that percentage to more than 60%.

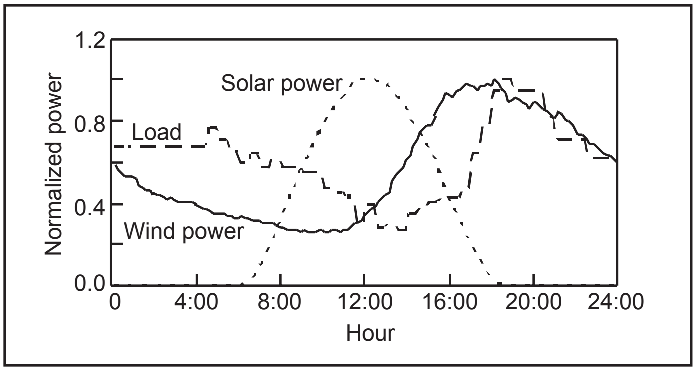
Joanes

The village of Joanes is in the municipality of Salvaterra, on Marajù Island, in the state of Parç. New World Village Power Company of Vermont supplied the system design and the control and power-processor hardware of the 50-kW PV-wind-battery hybrid system installed at Joanes. The system will operate primarily in a grid-interconnected mode. It will deliver renewable energy directly to the grid or charge the battery bank to dispatch its full 50-kW capacity to the grid during times of peak demand.

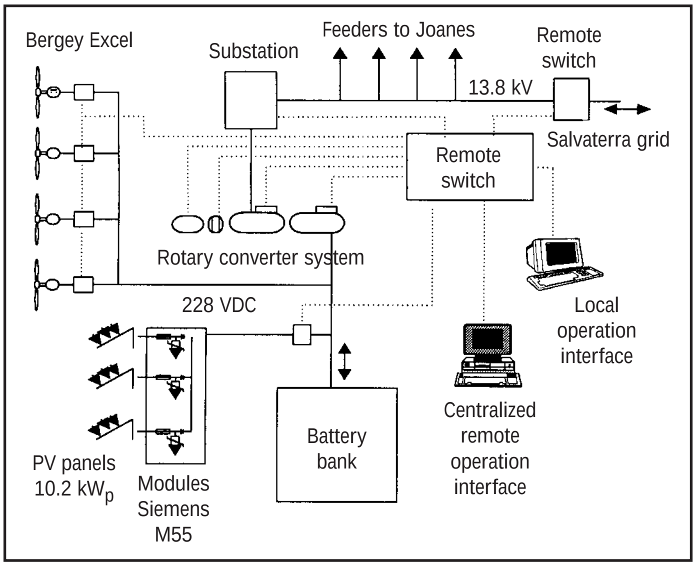
One year of solar radiation (global horizontal, direct normal, and diffuse), ambient temperature, and wind (speed and direction) data is available for the site. During May 1994 to April 1995 the average wind speed was 6.58 m/s, and the daily average global-horizontal radiation was 5.30 kWh/m^2, indicating a good match of resource availability to the demand during a typical day.

The ratio of diffuse to global radiation ranged from 0.26 in July 1994, to 0.63 in February 1995, whereas the clearness index ranged from 0.40 in April 1995 to 0.60 in September 1994. The average temperature was approximately 27°C.

The Joanes system design and configuration are based on a rotary converter (shaft-coupled DC motor and synchronous alternator), for power conversion. It comprises four 10-kW wind machines supplied by Bergey Windpower and 10 kW of PV modules from Siemens Solar Industries. Below, a system schematic shows the connection to the Salvaterra grid.



Daily load and power generation profiles, village of Joanes—annual daily average (1994/1995).



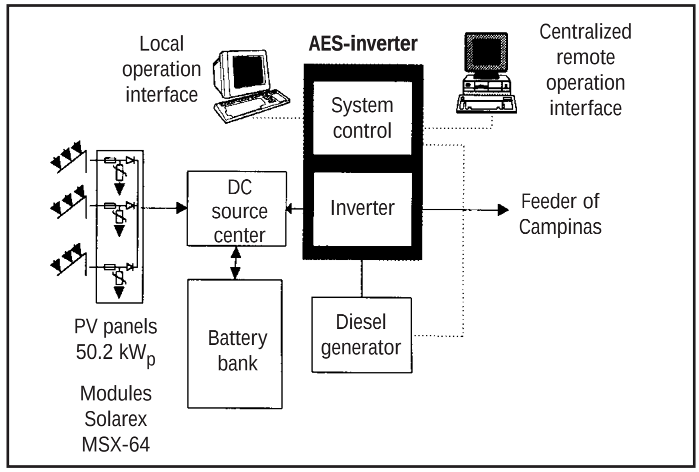
Simplified schematic drawing of Joanes hybrid system.

The Salvaterra power plant is one of 41 utility owned and operated diesel systems presently installed in the state of Parç. The plant has a nominal capacity of 1.2 MVA. Joanes receives electricity from this system, through a 17-km line operated at 13.8 kV. The village has 170 consumers, plus public lights.

Campinas

The village of Campinas is about 100 km upstream from Manaus, in the state of Amazonas, between the Solimões and Rio Negro rivers. The system installed in Campinas is a 50-kW PV-diesel-battery hybrid. Advanced Energy Systems Ltd. (AES), as a subcontractor to Bergey Windpower Corporation, supplied system controls and the power processor for the Campinas plant. Solarex Corpo- ration supplied a 50-kW PV array. Two existing diesel units, currently supplying the village load, are being modified to interface with this hardware.

The Campinas system design and configuration is shown below. The PV panels are fixed. The AES inverter primarily provides control, data acquisition, fault detection, and diagnostics. A local operator interface is connected to the inverter via a serial link.



Simplified schematic of Campinas hybrid system.

These two hybrid systems represent significantly different approaches to the problem of remote power supply using renewable energy. Deployment of both systems is expected to provide the Brazilian utilities with installation and operating experience in hybrid power. Data gathered from these installations will contribute significantly to the body of knowledge about hybrid power systems and influence the design, implementation, and operating strategy of future projects.

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NREL/FS-510-24192

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Renewable Energy Electricity for Social and Economic Development in Rural Ghana

by Roger Taylor 12/97

Background

The Republic of Ghana is between four and twelve degrees north latitude, bordering the North Atlantic Ocean between Côte d'Ivoire to the west and Togo to the east. The climate is warm and comparatively dry along the southeast coast, hot and humid in the southwest, and hot and dry in the north. About 18 million people populate Ghana. Their average per capita income is approximately $400. Ghana has identified 4,221 village communities with a population above 500 inhabitants. As of 1991, only 478 of these communities had been electrified, all of them via grid extension. By December 1995, the number had grown to 904.

Ghana's electric power system is operated by two parastatal utilities: the Volta River Authority (VRA) and the Electricity Corporation of Ghana (ECG). The VRA is responsible for power generation and transmission at 161 kilowatt-amperes (KVA) and 225 KVA. The ECG is responsible for distributing power in the south while the Northern Electricity Department (NED), a subdivision of VRA, handles power distribution in the north. The VRA and the ECG report to the Ghanian Ministry of Mines and Energy.

The government of Ghana is committed to bringing electric service to every community of 500 or more people by the year 2020. The National Electrification Scheme (NES) is planned to proceed in six five-year phases from 1990 to 2020. It has been assumed that grid extension, with community participation under the Self-Help Electrification Program (SHEP), would be used to bring electricity to the more than 3000 villages still in need. This is a challenge and financially difficult for several reasons: the low density of rural populations, low income levels, the significant distances required for medium-voltage lines, and the costs of medium-voltage and low-voltage lines, transformers, and service drops. Most of the equipment is imported, and more than 90% of its cost is in foreign exchange. Also, SHEP requires that communities be within 20 km of a medium-voltage line, a prohibitive condition for many.

Even if the Ghanian NES meets its goals, many remote communities will still lack electricity. However, free-standing photovoltaic (PV) systems can provide valuable electric service to smaller and larger communities that would otherwise be electrified via grid extension. If population growth (3%/year) continues, by the year 2020 the population of Ghana will have doubled, presenting additional challenges for rural electrification schemes.

Project Objectives

The project goals are to facilitate the development of a national capacity, combining both private-sector and public-sector efforts; to use primarily renewable-energy-based technologies, especially PV and PV/diesel-hybrid power systems; and to provide sustainable rural electric power services. These technologies will serve in individual applications and centralized elec-trification of off-grid communities unsuitable for electrification via grid extension.

VRA/NED will own and operate the power systems and provide electric service to target villages on a fee-for-service basis. Rural communities will be expected to keep equipment from being abused or damaged. They will also be expected to invest "sweat equity" in the systems through labor and some capital contribuitons for installation of power poles and PV units. Because the government of Ghana subsidizes electricity prices, the government will cofinance the delivery of electricity services, while requiring a fee for service from the communities. There is some precedent (a PV battery charging project in northwestern Ghana sponsored by the Ministry of Mines and Energy [MOME]) in having rural communities pay for electricity services. The costs are comparable to current household expenses ($5 to $15/month) for candles, kerosene, dry cell batteries, auto batteries, and battery charging. Service costs will be determined in the project design, but the government is committed to cost recovery for electric service as part of economic restructuring and recent utility restructuring legislation.

Technical and economic performance data will be used to assess how pilot-scale renewable energy options might apply to much larger projects. The intent is to remove barriers to the introduction and widespread diffusion of renewable energy technologies for off-grid electricity in rural Ghana.

Project Description

Twelve villages in the Mamprusi East District and the village of Tenzug in Northern Ghana were selected for participation. Microgrids powered by PV/diesel-hybrid systems will be installed in three villages and free-standing PV units used in nine others. A community energy and socio-economic survey was initiated by MOME in collaboration with VRA/NED and the National Renewable Energy Laboratory (NREL) for the target region. The survey will help assess likely energy consumption patterns and community willingness and ability to pay for electricity. In addition, technical standards will be established and local operators and non-government organizations will be trained. The role of the parastatal VRA/NED will be critical in spurring the widespread use of the technologies.

Information on costs, training requirements, operational problems and solutions from previous installations will be used to establish practical technical standards for equipment and installation practices for systems in Ghana. Equipment specifications will be developed by the VRA/NED and MOME in collaboration with NREL and technical experts from the private sector.

Commercial equipment and appliances will be selected for simplicity, robustness, price, local availability and eventual local production. Particular attention will be paid to ease of maintenance in Ghana. Negotiations with suppliers will define the conditions for participating in joint ventures and technology transfer operations.

Energy services will respond to different levels of income and willingness and ability to pay for electricity. Services will include portable solar lanterns, fixed solar home systems, community services such as water pumping, and systems for refrigeration, sewing, carpentry, and grain grinding. Household PV systems will be installed in all twelve of the pilot communities. Lighting options will include high-efficiency compact fluorescent units.

Several villages will be assessed for possible siting of local minigrids powered by PV/diesel- hybrid units. Some will also have distributed PV systems for residential compounds and community functions located too far from the minigrid for hookup. Both technical and economic criteria will be used to determine the best power generation and distribution system designs.

Regional Operations and Maintenance

Providing highly reliable electricity services on a sustainable basis in rural areas requires local operations and maintenance capabilities. An operations and maintenance (O&M) center will be established near the pilot communities. Monitoring the hybrid power systems will permit diagnostics and early warning about potential problems. Quick-response maintenance and repair capabilities will be necessary to respond to technical problems with the hybrid power systems. The center will also support the PV solar home systems.

The O&M center will be established and staffed by trained VRA/NED technicians. A government-owned house will be renovated and equipped to support project implementation and post-project sustainability. The house is located in the town of Nakpanduri, about 30 km northwest of the center of the pilot region in the Mamprusi East District, and is less than 10 km from the nearest pilot community, Bimbagu.

The project action plan is now being prepared for in-country discussion and consensus building. Once the government of Ghana and the United Nations Development Program, with the Global Environment Facility, have approved the plan, implementation can begin.

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NREL/FS-510-24194

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Joint U.S./Brazilian Renewable Energy Rural Electrification Project

by Roger Taylor 12/97

Introduction

In Brazil, an estimated 20 million people do not have access to electric energy. Much of this population lives in the arid northeast part of the country. The electric grid reaches the larger towns and is being systematically extended to rural properties and villages. However, rural extension is costly and the rural electric cus- tomers consume only very modest amounts of electricity, typically 10 to 30 kWh per month. The cost of even short grid extensions is often greater than $1,000, making investments in electricity connections for these populations financially prohibitive.

Small stand-alone photovoltaic (PV) systems can provide the basic low-energy consumption services needed by the rural peoples (lighting, TV, radio) for $500 or less, making the renewable energy option a very promising alternative to grid extension.

A different situation exists in Brazil's northern Amazon Basin. More than 300 villages in this region have diesel electric generators operated by local utility providers. These generators often provide electric service for only six hours each day due to the very high cost of diesel fuel deliveries to these villages—many places are accessible only by boat. Thousands of small privately owned generators also operate in the region.

Renewable energy hybrid (PV, wind, battery, diesel) power systems are of great interest to the state utilities and to Eletrobras (the main federal utility) for enhancing electric services in the Amazon Basin while reducing diesel fuel consumption and the associated cost of fuel deliveries. Today, electricity in 310 villages is being subsidized by the rest of the Brazilian population at approximately $300 million per year. The demonstration of viable hybrid power operation in these remote regions could open a significant near-term market for renewable hybrid power systems.

Scope

The U.S. Department of Energy, through the National Renewable Energy Laboratory (NREL), is undertaking a two-phase joint technology research and demonstration effort with the Centro de Pesquisas de Energia ElÄtrica (CEPEL) in the Federal Republic of Brazil. Objectives of the cooperative U.S./Brazilian program are:

- to establish technical, institutional, and economic confidence in renewable energy systems to meet the needs of the citizens of rural Brazil
- to establish ongoing institutional, individual, and business relationships (U.S./Brazilian partnerships) necessary to carry out sustainable programs that benefit both Brazil and the United States
- to lay the groundwork for large-scale rural electrification with renewable energy systems.

Phase 1 of the cooperative effort put PV electric lighting systems in about 350 homes in the Sertao de Sao Francisco region in the Brazilian state of Pernambuco and PV electric lighting systems in about 400 homes and 14 schools in the outback of the state of Cearç. Under the terms of a contract for subsequent use by the state utilities in Cearç (COELCE) and Pernambuco (CELPE), NREL provided key system components (PV panels, batteries, and charge controllers) to CEPEL. COELCE and CELPE were responsible for obtaining the balance-of-system components not provided by NREL/CEPEL, and for doing the systems integration, installation, maintenance, and evaluation for a 3-year period following installation. Installation of all systems was complete in early 1994.

In Phase 1, a total of 65 kW of PV modules, 1300 (100 Ah) batteries, and 900 charge controllers were installed. The electric utilities in Cearç and Pernambuco provided all other equipment (structures, wiring, switches, DC breakers, housings, conduit, fluorescent lights and ballasts) and installation. Training courses for the instal-lers were provided through a cooperative effort among CEPEL, the equipment vendor (Siemens Solar Industries [SSI]), and PV experts at the Federal University of Pernambuco.

Phase 2 extends the pilot project into six additional Brazilian states (Acre, Alagoas, Amazonas, Bahia, Minas Gerais, and Para). It also extends the demonstration of PV applications to a wider variety of stand-alone end uses and hybrid village power, and introduces the use of wind-electric power generation for selected sites and applications.

The hardware subcontracts awarded under Phase 2 were carried out much like the implementation of Phase 1 and completed in October 1994. The subcontracts awarded under the project expansion have three primary tasks: system design integration assistance, supply of specific U.S.-manufactured components to Brazil, and system installation supervision and operator training. The NREL agreement with CEPEL also was extended to cover supervision of Phase 2 equipment installation and a 3-year operations and maintenance period following installation.

Phase 2 stand-alone systems are being supplied to the Brazilian states of Acre, Alagoas, Bahia, and Minas Gerais. U.S. vendors providing the equipment include SSI, Solarex, Photocomm (using USSC modules), and Bergey Windpower. A total of 51.5 kW of PV modules, 195 charge controllers, 25 inverters, 32 water pumps, 5 wind-electric systems with water pumps, and 2 wind-electric systems with inverters were shipped by the vendors in early 1995.

Besides the stand-alone projects, ***two hybrid power systems*** were installed in the Amazon basin. The first is a 50-kW PV-wind-battery hybrid system in the village of Joanes, on the island of Marajo, near Belem, Parç. The system control and power processor were supplied by New World Village Power, four 10-kW wind machines were supplied by Bergey Windpower, and 10 kW of PV modules were supplied by SSI. A battery bank of approximately 350 kWh capacity was supplied by the local electric utility, CELPA.

The second hybrid system is at the village of Campinas, approximately 100 km upstream from Manaus between the Solimões and Rio Negro rivers at approximately 3.3 degrees south latitude. Accessible only by boat, electricity in Campinas is supplied to about 100 houses through a local electric grid. The grid operates for six hours per day, from 6:00 pm to midnight, off one of two on-site 48-kW diesel generators. Diesel fuel is supplied to the power plant every two months and stored in a local tank.

A 50-kW PV-battery hybrid system was installed in Campinas. As a subtier contractor to Bergey Windpower, Advanced Energy Systems Ltd. Supplied the system control and power processor. The 50 kW of PV modules were supplied by Solarex Corporation. As with Joanes, a battery bank of approximately 350 kWh capacity was supplied by the local electric utility, CEAM.

Conclusion

The Brazilian utilities and federal government continue to show strong interest in developing and deploying solar electric systems as an alternative to grid extensions. Exemplifying the growing interest in renewable energy in Brazil, CEPEL has organized a PV working group among the utilities and other interested stakeholders. The Grupo Trabalho de Fotovoltaica has established a number of working committees to address the broad array of data, standards, and development concerns regarding PV commercialization in Brazil. A program to install solar systems in rural schools and health clinics was recently started by the Brazilian federal government with the assistance of CEPEL.

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NREL/FS-510-24195

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

A High-Penetration, Wind-Diesel Hybrid Power System

by Steve Drouilhet 7/98

Background

Alaska has approximately 250 rural villages with no link to a central power grid. A few of these villages have no central electric generating facility, however, the vast majority are served by diesel-driven generators and local electric distribution systems. Despite Alaska's vast crude oil resource, diesel fuel must be imported by barge because most of the villages are extremely remote and there are few good roads. The great distances and difficult transport conditions result in diesel fuel that costs from $0.80 to $3.00 per gallon delivered. The high fuel cost and high operations and maintenance costs of diesel generating stations add up to electricity generation costs ranging from $0.15 to $1.00/kWh for the villages.

To ease the energy cost burden on rural inhabitants, Alaska's Department of Community and Regional Affairs (DCRA) administers the Power Cost Equalization Program (PCE), which provides a subsidy to rural electric customers as high as $0.41/kWh and totals nearly$20 million annually. Because of declining Alaskan pipeline oil revenues, the fund from which they derived the PCE subsidy payments, is expected to be depleted in approximately six years. To stave off a rural energy crisis, the state of Alaska is urgently seeking to develop alternatives and supplements to diesel for both electricity generation and heating fuel.

Besides the economic problems associated with diesel use, there are significant environmental problems associated with the fuel. Because many ports along the coast and along the interior rivers are accessible only a few months out of the year, large quantities of diesel must be stored on-site in bulk fuel tanks. Many rural village tank farms have deteriorated with age and are leaking, contaminating surrounding soil. Environmental Protection Agency regulations threaten many village tank farms with closure. The DCRA estimates that it would cost $200 million to upgrade existing diesel tank farms to today's standards, not including the cost of environmental remediation. Beyond the looming fuel storage and transport problems, diesel operation introduces substantial noise and air pollution into the village environment. Use of renewable energy for electricity generation will mitigate fuel transport and storage problems and reduce the pollution and noise associated with diesel fuel consumption.

The rural power situation in Alaska is similar to that of many developing countries around the world, where rural electricity, if it exists at all, is provided by small, isolated diesel power plants. Alaska can serve as a domestic proving ground for U.S. industry in using renewable energy solutions to bring power to remote communities worldwide.

Project Objectives

The project staff will design, build, install, and test a high penetration wind-diesel system in Wales, Alaska. Wales is a small village on the northwest coast of Alaska with approximately 160 inhabitants, mostly Inupiat Eskimo. Alaska Village Electric Cooperatives will operate the system as the host utility and the Kotzebue Electric Association will own and maintain the system.

They will integrate the new components of the power generation system (wind turbines, power conditioning, energy storage, and a control system) with the existing diesel system, which has an installed capacity of approximately 360 kW. In addition to electricity generation, the project will show the effective use of community heating loads to absorb excess wind energy and maintain grid stability.

We expect the hybrid system to consume 50–60% less fuel than the current diesel plant, with additional savings coming from the application of excess wind energy to village heating needs. The Wales project will be a prototype to validate the technical feasibility and economic viability of high penetration wind-diesel hybrid electric generation systems for applications in other rural villages, in Alaska and other interational locations.

Project Funding

The Wales wind-diesel project has an overall budget of approximately $1.2 million, with major funding provided by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Alaska Science and Technology Foundation. Additional contributors include the Alaska Department of Community and Regional Affairs Division of Energy, Kotzebue Electric Association (KEA), and the Alaska Village Electric Cooperatives (AVEC).

Planned Activities

Assembly of the system was completed in July 1998 at the Hybrid Power Test Facility at the National Wind Technology Center. System operation was successfully demonstrated in the simpler operating modes, where the wind turbines operate in parallel with the diesel generators, and the diesel generators regulate system frequency and voltage. The more advanced operating modes, which involve the energy storage component and allow the generators to be turned off completely, are scheduled for tests during late 1998. The complete wind-diesel controls package is scheduled for shipment to Wales, Alaska, in spring 1999. Installation, startup, and commissioning will occur during the summer of 1999. Before the package arrives, KEA and AVEC personnel will be working to install the wind turbines, convert the village power plant from single-phase to three-phase, install electric resistance heaters in several village heating systems (for use as secondary loads), and upgrade the existing diesel controls for automatic operation.

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NREL/FS-520-24626

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Wind for Island and Non-governmental Development (WIND) in Indonesia

by Ian Baring-Gould 7/98

Background

Wind-power systems can help indigenous economies achieve social advancement and increased self-sufficiency. The WIND project seeks to mobilize sustained local interest and capability through demonstration and participation. To achieve this objective at least 10 system applications will be carefully selected for locations in the eastern islands of Indonesia. Energy delivery and water pumping systems will be designed, installed and operated with the active participation of the local communities and non-governmental organizations.

One priority of the WIND project is to stimulate interest in wind energy technology as an environmentally sound, commercially viable investment for local and regional economies. The practical application of wind-power technologies should lead to entrepreneurial opportunities and an increased market for related products and services provided through a system of local tariffs. Such economic growth will create the potential for duplicating the project and provide a mechanism for continued system operations and maintenance, vital for long-term project success.

Key Activities

Winrock International has contracted with the National Renewable Energy Laboratory (NREL) to provide technical assistance to the WIND project in the following areas:

- **Wind resource assessment.** Providing guidance in the selection of monitoring sites, the processing and analysis of wind data, and the determination of perspective locations for system installation
- **Technical training in wind energy technology and applications.** Helping with any problems encountered during the installation and operation of wind systems in Indonesia
- **System design review.** Assist in the design and analysis of proposed hybrid and water pumping systems
- **System performance modeling and economic analysis.** Use computer models developed at NREL to perform analysis on systems and prospective system loading
- **System monitoring and evaluation.** Design and install monitoring systems for both hybrid and water pumping systems. This will also allow for continued performance monitoring and evaluation.

Status

Ten data-logging systems have been installed to monitor winds at 22 sites in the eastern islands of Indonesia. The systems are currently collecting data to support the NREL/Winrock wind mapping effort. Nine wind-power systems (Bergey Wind Power Co.) have been installed on the islands of Timor and Sumba to provide energy for community and entrepreneurial enterprises. Five of these systems were installed to provide water pumping for irrigation and household uses. The other systems are hybrid power systems designed to provide electrical power for peanut processing, lighting for community kiosks, a blacksmith shop, freezers for fish storage and popsicle production, and battery charging.

As a second phase of the project, fifty 600-W wind turbines (World Power Incorporated) were purchased for use in Indonesia. The turbines will be configured with other equipment to produce electricity for small hybrid water pumping applications. The systems will be leased to households and small businesses with the profits going to support the purchase of additional systems.

Planned Activities

Partners in the WIND project will continue wind resource assessment and mapping, site identification, and project design activities. They will develop cost-effective system performance monitoring protocols, and install monitoring equipment on a representative set of systems. NREL will assist Winrock International with system startup and commissioning in Nusa Tenggara Timur, Indonesia under the sponsorship of USAID.

Location: Nusa Tenggara Timur (NTT), Indonesia

Project Manager: Winrock International

Sponsor: USAID

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NREL/FS-520-24635

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

The Ramakrishna Mission PV Project—A Cooperation Between India and the United States

by Jack L. Stone and Harin S. Ullal 12/97

Background

The Sustainable Rural Economic Development Ramakrishna Mission PV Initiative was conceived as a small-scale demonstration project that would show the economic viability of photovoltaic (PV) systems in the Sundarbans region of West Bengal. The viability was dependent on the systems being economical without substantial subsidy and eventually without any subsidy at all. The operation and maintenance of the systems were the responsibility of the chosen non-government organization, the Ramakrishna Mission. Mission personnel were to identify beneficiaries of the PV systems, define a financing arrangement that would be acceptable and sustainable to the villagers of the region, and serve as a banker to collect revenues from the end users.

The potential for expanding the project beyond the limited demonstration was also a prime consideration. With U.S. systems used for the installations, our industry would also have the advantage of satisfying any future PV system purchases. The cooperative nature of the project would also be expected to lead to improved relationships between our two countries and further trade expansion. The project was also designed to reflect market forces or Atrue costs.

Without excessive subsidies, and with end-user money required for participation, the systems were expected to have the best of care. Most importantly, the benefits of electricity would be made available to those who had little or no access in the past. Improvements in educational opportunities, health care, productivity, and entrepreneurship would be standards for success of the project. Finally, the project would be self-sustaining. An infrastructure would remain to support additional applications including financing, education, training, repair, and maintenance. Successful deployment of the project would pave the way for acceptance of renewable technologies as a means for providing the benefits energy to the developing world.

Scope

Several villages and various applications were identified for participation in the project. In the village of Gosaba (with 1000 families), the training center will receive ten lights for 4 hours of operation each night, two 30-watt wall sockets, a battery-charging station for ten 100-Ah batteries and twenty solar lanterns, and three stand-alone street lights with 11-watt compact fluorescent (CFL) lamps. The possibility of mounting the charger station on one of the Mission's boats will be investigated. This would allow the service to be transported throughout the island communities. The village of Katakhali, with 100 families, will be provided 100 domestic lighting units with one 11-watt CFL and one 30-watt socket for each home. The youth club will have two 11-watt CFLs and one 30-watt wall socket. In the village of Pakhirala, the weaving center will receive three 11-watt CFLs, a community street light and eight 11-watt CFLs with two 30-watt wall sockets. The electricity for the weaving center will extend production hours by about four per night.

The health clinic in Satyanaryanpur will receive a vaccine refrigerator and eight 11-watt CFLs with two 30-watt electrical sockets. A second battery-charging station for ten 100 amp-hour car batteries will be placed at the Chota Mollakhali youth center. The village of Kumirmari will have 100 home lighting systems installed. The village of Satjelia will be furnished 100 domestic home lighting systems, each with a 9-watt CFL and a 30-watt electrical socket.

A two-week training program will be offered to participants chosen by the Mission for their background in basic electrical applications, including radio and television repair. The Mission has a very good reputation for providing high-quality training. Remote Power International prepared a detailed training manual that will be used by the Mission after trainers funded by the National Renewable Energy Laboratory (NREL) leave. The last week of training will be hands-on installation in the island communities. Applied Power Corporation, the prime contractor for the project, has prepared detailed schematics and installation procedures for all of the proposed systems.

Project Responsibilities

The agreement calls for 50-50 cost sharing with the United States providing the PV modules, charge controllers, a water pump, and training. India provides the batteries, compact fluorescent lamps, lamp fixtures, a vaccine refrigerator, mounting structures, all balance-of-systems components, solar lanterns, and pays all custom duties for imported components. The Ramakrishna Mission is responsible for identifying recipients of the various systems and participants in the NREL training sessions. The Mission will do follow-up training, maintenance and replacement, and serve as the collector of revenues from the end users. NREL will help the Mission to identify potential private sector partners with whom proposals will be submitted to IREDA to expand the project beyond this initiative.

Project Financing

In India, the domestic unit of two lights plus one wall socket along with the necessary PV panel, battery, and accessories cost approximately Rs. 14,000 ($1 = Rs. 35). With Rs. 6,000 available as a government subsidy, the amount to be borne by the user is Rs. 8,000 per unit. The end user will provide a down payment of Rs. 3,500 upon installation. The balance (Rs. 4,500) will be treated as a low-interest loan to be repaid in monthly installments of Rs. 40 per month over 10 years. In this way Rs. 40 x 12 months x 10 years or Rs. 4,800 will be realized-Rs. 4,500 against the loan and Rs. 300 as interest. In addition, Rs. 20 per month will be charged for maintenance charges on each unit and the costs for spares will be at the owner's expense. Thus the users will pay a total of Rs. 60 per month for 10 years. They may also opt to pay Rs. 100 per month (80+20) for five years. Some special category participants, who are not in a position to make the Rs. 3,500 down payment, will need only Rs. 500 down with the balance treated as a loan to be repaid in five to ten years. After the loan is liquidated, ownership will transfer to the users. The amount recovered from the end users' down payments and loan interest will form a Revolving Fund for the project, which in turn will be used to replicate the program to other villages and for other participants in the same village.

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NREL/FS-510-24200

RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Sizing of Stand-Alone Power Systems for Rural Health Facilities

by Tony Jimenez 12/97

Background

It is estimated that two billion people currently live in areas that lack electricity. Many of these areas will not be connected to the electric grid in the foreseeable future due to high grid-extension costs. However, areas beyond the grid can be serviced by a variety of stand-alone systems. These stand-alone systems can consist of combinations of photovoltaic (PV) panels, wind turbines and generators running on diesel, gasoline, or propane. Stand-alone systems range in size from small solar lighting systems that provide 100–200 watt-hours for lighting at night to diesel-powered minigrids with peak capacities of more than a megawatt.

In remote communities, the first facility to be hooked up to electricity is often the local health clinic. Traditionally, the power has been supplied with fossil-fuel generators. More recently, PV panels have been installed in some clinics to provide electricity. Wind turbine generators have received less consideration for providing electricity to clinics. Here we examine the least-cost options for providing stand-alone power to a clinic under a variety of climatic and economic conditions. In this study three load profiles were developed for typical rural clinics of different sizes. A stand-alone power system was designed for each load profile for three different climatic regimes including South Africa, Indonesia, and Brazil. Parametric analysis was performed to study the effects of wind speed, type of wind, fuel price, and capital costs.

Typical Applications

Typically, health clinics require electricity for ***lighting***, communication equipment and refrigeration. Electric lighting is vastly superior to candles and kerosene lamps. Often when a clinic is electrified, lights are included in the initial installation package. Due to the need to conserve power, most off-grid clinics use compact fluorescent lights that typically draw from 5 to 20 watts each. Even clinics that use daylighting need electric lights for emergency night care.

Emergencies also require reliable ***communication equipment***. Electricity provides radio and satellite communications that enable the clinic staff to consult with specialists as needed and to arrange for the speedy evacuation of seriously ill or injured patients.

Health clinics also rely heavily on ***refrigeration*** to maintain the viability of medicines and vaccines. In the last 15 years great progress has been made in the development of vaccine refrigerators. These small, highly efficient, usually DC, refrigerators can be powered by a modest-sized solar array. Typical models draw 80–120 watts and will run for around 10 hours per day. Some super efficient models use even less energy. Even though they are expensive, these refrigerators are becoming increasingly popular and are considered so important that the World Health Organization has set standards for them. Like lighting, a vaccine refrigerator is often included in the installation package when a clinic is initially hooked up to electricity.

Other applications for electric power in clinics include small water pumps, ceiling fans, small sterilizing stoves, vaporizers, computers, centrifuges, and TVs and VCRs. The latter are used not only for entertainment, but also to show instructional and public health videos. Larger facilities such as district hospitals also may have additional laboratory equipment.

Typical Clinic Services

- Inoculations
- Treatments for: Respiratory infections
  - Venereal diseases
  - Diarrheal diseases
  - Skin disease
  - Eye disease
  - Malaria
  - Parasitical diseases

- Trauma: Burns
  Simple fractures
  Wounds
  Snake bites
- Pre-natal/post-natal care and child birth
- Dental
- Referral to hospitals
- Public health education
- Family planning

Typical Electrical Appliance Data

Item	Power (Watts)	Duty Cycle (hours/day)	Energy Use (kWh/day)
Lights	5–20	Varies	Varies
2-way radio	75	1	0.075
Refrigerator	60–120		0.3–0.7
Stove	200–500	1	0.2–0.5
Vaporizer 35-70	1		0.035–0.070
Ceiling fan	5–20	Varies	Varies

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NREL/FS-510-24196

Photovoltaic Electricity in Egypt

by Roger Taylor and Fuad Abulfotuh 12/97

Background

Presently, centers for electrical power distribution along the Nile include a 500-kV transmission line from Aswan to Cairo, a 220-kV transmission line in Cairo and Lower Egypt, and 132-kV transmission lines in Upper Egypt. These distribution systems and lower voltage (66-kV) transmission lines generally do not reach remote, isolated villages in regions such as the Sinai.

The social and economic impacts that result from the lack of electrical power in rural areas have sparked an intensive effort to bring electricity to Egypt's rural areas. The World Energy Council 2 reports that new, single-family homes in much of Egypt's rural territories, that are more than half a kilometer from existing electric lines, are more cost-effectively served by solar energy than by extending the electric grid. Even diesel is more expensive than solar energy in these instances. A diesel-generator of equivalent capacity has a life-cycle cost almost twice that of a photovoltaic (PV) system. Thus, there exists an opportunity for Egypt and neighboring countries to provide cost-effective PV electrical generating capacity to those living beyond a reasonably priced electrical grid.

Scope

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL), the New and Renewable Energy Authority (NREA) of Egypt, and other local and international organizations took the first step in an effort to initiate renewable energy programs in Egypt. The programs include several projects to enhance and strengthen Egyptian understanding and capabilities in rural and remote electrification.

To help the decision-making process and to enhance the awareness level of renewable energy applications in remote and rural areas, two conferences were organized jointly by NREL and NREA in Cairo, Egypt. The First International Conference on Solar Electricity, Photovoltaics and Wind, was held in October of 1994 and the second was held in April 1996. The conferences provided a real-time forum for interactions between PV and wind technology manufacturers/suppliers and technology users, interested researchers and government/industry decision makers, making possible discussions about near-term deployment of renewable energy systems. The two conferences also offered an opportunity to identify the most feasible and cost-effective applications and methods of setting up the technologies in developing countries, particularly the Middle East region. Delegates from more than 30 countries actively participated at the conferences through official meetings with the Minister of Electricity and Energy, Head of NREA, meetings with USAID-Cairo, and other dignitaries, academics, and industrial contacts. Eight project proposals, combined with the joint effort and including financial and human resources, were submitted to various financing organizations for possible funding.

A PV water pumping system was installed on a small farm (15 acres). The system is powered by a 3-kW stand-alone PV system and used for irrigation on the farm 70 miles northwest of Cairo. It was financed through a private sector financing company. The effort was coordinated by NREL through a local NGO. The long-term objective of the project is to prove the economic viability of PV without a subsidy.

A collaborative project for placing PV electricity systems in the Sinai region of Egypt has been proposed by NREL and the Egyptian Rural Electrification Authority (REA). They are working in cooperation with the Renewable Energy and Environment Society, and the NREA. The proposal addresses the critical rural electrification needs in Egypt, specifically in the remote villages of Sinai and along the northern coast of Egypt. Individual residences will receive solar home power systems. In addition to the solar home systems, each chosen village will be evaluated for the possibility of a village community water pumping system.

Using PV for rural electrification is a departure from the utility's normal line extension activities. This pilot project will demonstrate the technical and economic feasibility of providing basic electric service to customers well beyond the area covered by economical extension of power lines. The project is not only a technical demonstration project, but more importantly, it is a model for establishing a financing scheme where farmers repay the cost of the PV systems over an extended period of time (8–10 years). Information acquired from the project will help to answer the following questions:

- How stand-alone PV service compares (technically and economically) to conventional utility line extensions for rural electrification in Egypt
- How do the economics of PV compare to power provided by on-site diesel generation for new and existing loads
- What is the optimum mix of domestic (Egyptian) and imported (U.S.) components
- What is required for the REA to be interested in providing this type of service, and how will providing the PV service affect utility operations
- Will Egyptian Electric Authority (EEA) and REA accept financing of the capital cost of PV service as an option to conventional line extensions
- Can EEA and REA be effective institutional mechanisms for implementing solar-based rural electrification?

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NREL/FS-510-24193

National Renewable Energy Laboratory

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NREL/CP-440-22608 • UC Category: 1210 • DE97000233

Renewables for Sustainable Village Power

Larry Flowers

Presented at International Conference of Village Electrification through Renewable Energy
New Delhi, India
March 3–5, 1997

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

Work performed under task number WE715010

March 1997

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International Conference of Village Electrification through Renewable Energy, New Delhi, 3–5 March 1997

RENEWABLES FOR SUSTAINABLE VILLAGE POWER

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INTRODUCTION

It is estimated that two billion people live without electricity and its services. In addition, there is a sizeable number of rural villages that have limited electrical service, with either part-day operation by diesel gen-sets or partial electrification (local school or community center and several nearby houses). For many villages connected to the grid, power is often sporadically available and of poor quality. The U.S. National Renewable Energy Laboratory (NREL) in Golden, Colorado, has initiated a program to address these potential electricity opportunities in rural villages through the application of renewable energy (RE) technologies. The objective of this program is to develop and implement applications that demonstrate the technical performance, economic competitiveness, operational viability, and environmental benefits of renewable rural electric solutions, compared to the conventional options of line extension and isolated diesel mini-grids. These four attributes foster sustainability; therefore, the program is entitled Renewables for Sustainable Village Power (RSVP). The RSVP program is a multi-disciplinary, multi-technology, multi-application program composed of six activities, including village applications development, computer model development, systems analysis, pilot project development, technical assistance, and Internet-based village power project data base. While the current program emphasizes wind, photovoltaics (PV), and their hybrids with diesel gen-sets, micro-hydro and micro-biomass technologies may be integrated in the future. NREL's RSVP team is currently involved in rural electricity projects in thirteen countries, with U.S., foreign, and internationally based agencies and institutions. The integration of the technology developments, institutional experiences, and the financial solutions for the implementation of renewables in the main line rural electrification processes in both the developing world and remote regions of the developed world is our goal.

APPLICATIONS DEVELOPMENT

While NREL is primarily a technology development laboratory, with an emphasis on science and engineering to underpin cost-shared, industry-based component and manufacturing process development, the RSVP program focuses on village applications. The main objective of the applications development activities is to investigate RE-based systems that will reduce the life-cycle cost and/or improve the performance of commercial RE systems, thereby expanding the market for renewables. Many of these applications have the potential to facilitate economic development within the village, a major goal of many international development organizations and host-country national and provincial governments.

Electrification of rural villages has the potential to power substantial economic development activities if the power is available during the daytime and the appropriate training and marketing infrastructure is available. However, in most smaller villages served by diesel gen-sets it is cost-prohibitive to provide daytime power and this economic development potential is not realized. Renewable energy systems are better suited to deliver 24-hour power in small villages where income generation and economic development are policy goals.

Currently the applications team is examining ice-making, water desalination, water purification, battery-charging stations, and village hybrid power generation. The ice-making project is attempting to "direct-drive" (i.e., no inverter) a commercial ice-making machine with a permanent-magnet-alternator-type (pma) wind turbine. A number of initial technical hurdles have been addressed (e.g., start-up surge requirement) while several others need to be resolved before this concept is ready for a pilot project. The work thus far has consisted of computer modeling, systems analysis, laboratory dynamometer testing, and limited field testing. This concept has significant appeal for remote, coastal fishing cooperatives. In the meantime, the more conservative and expensive approach of a pma wind turbine connected to a battery-inverter subsystem which, in turn, is connected to the icemaker will be field-tested.

In many remote, rural areas, families use lead-acid batteries for powering lights, radios, and televisions. The families transport these batteries to the nearest electrified town for charging on a weekly basis; carrying batteries is a considerable effort and inconvenience. Because many of these rural areas have good renewable resources in close proximity to the homes, a renewable-based battery charging station (BCS) appears to be a good solution for the villagers; it also offers the opportunity of developing a local micro-enterprise based on an environmentally friendly technology. Battery charging stations also provide an alternative approach to PV-powered solar home lighting systems (PV-SHS). Both PV and wind-hybrid BCS are being developed; while there are a handful of PV-based systems in the field, the wind-hybrid systems will be installed in pilot programs in 1997. The technical challenge of the wind-hybrid approach is to adapt existing power conversion devices to pma wind turbines for groups of batteries in such a way as to minimize the life-cycle cost of the system, including the batteries. Both individual battery control and "batch charging" (batteries charged in parallel on a single busbar) are being investigated. The leading concept will be field-tested in 1997.

Water is the lifeblood of many rural communities, yet water quantity and quality is often low. While PV and wind water-pumping technologies are commercially available for potable, livestock, and irrigation uses, adapting renewable sources to desalination and disinfection is just emerging. The RSVP team has investigated various desalination systems appropriate to village-scale needs and is in the process of experimentally characterizing a commercial vapor-compression distillation system for both brackish and sea water. Other institutions are evaluating alternative rural desalination systems; comparison of the performance and economics of these various approaches will be made. Additionally, a review of the alternative water disinfection processes adaptable to renewables, including direct solar, is under way.

Because many villages have either diesels dedicated to a particular use or a diesel mini-grid, they face both economic (fuel cost) and maintenance problems associated with remote diesel operations. Yet in many of these villages, the solar and/or wind resources are good enough to compete economically with the life-cycle cost (LCC) of diesel operation. NREL has a significant program addressing the hybridization of diesel gen-sets with renewables. The recently developed Hybrid Power Test Bed is used to characterize the performance of emerging hybrid architectures, components, subsystems, and control strategies for a simulated village power load profile. The initial hybrid system test combined a 50-kW induction wind turbine with a 175-kWh battery bank and a 50-kW diesel gen-set. Currently scheduled tests include a 50-kW electronic inverter developed under NREL's PVMAT program and the control panel for the Alaska "high-penetration" wind-diesel retrofit project. Smaller hybrid systems, in the 1.5–10-kW range, are scheduled for testing later in 1997.

COMPUTER MODELS

A significant barrier to the adoption of the appropriate renewable technologies for rural villages has been the absence of analytic tools that accurately compare the alternative options, both conventional and renewable. To address this barrier, the RSVP team has developed a set of models that address 1) optimization of hybrid systems (HOMER), 2) the detailed technical and economic performance of hybrids (Hybrid2), and 3) the economics of alternative village electricity options.

While there are several models in use for evaluating the performance of hybrid systems, they suffer from either limited architectures, control strategies, availability, or user-friendliness. NREL, in collaboration with the University of Massachusetts, has developed the Windows-based Hybrid2 model that is versatile in its components/architectures/control strategy options and is publicly available. An extensive library of commercial components is included, as is the capability to input user-defined components and control strategies. Typical hourly wind and solar resource data are available to scale if site data are not available. Village load profile, system architecture and control strategy, unit costs, and financial parameters are inputs. The key outputs are component and system performance, diesel-fuel use, and economic parameters. This model is used regularly by analysts who want to compare the economics of hybrid system options to conventional diesel gen-sets.

Because of the limited experience with hybrid systems, analysts who want to investigate the technical and financial performance of hybrids have a difficult time getting started in selecting an architecture and control strategy that is appropriate for the given village load profile and the available solar and wind resources. To address this issue, the RSVP team developed a Hybrid Optimization Model for Electric Renewables (HOMER) using specialized optimization software. The analyst inputs solar and wind resource data, village load profile, desired service quality, unit costs, and financial parameters; the objective function is least life-cycle cost. The program searches for and selects the architecture and control strategy that provides the lowest LCC. This architecture becomes the input to the Hybrid2 model. It is particularly useful for sensitivity analyses on variables of resource, loads, diesel-fuel costs, and financial parameters.

Conventional rural-electrification methods include extending the utility grid or implementing an isolated diesel mini-grid. For those communities without these solutions, batteries, kerosene, and candles are used extensively, even in the remotest villages. Recently, the use of PV-SHS has been adopted by a number of countries as a viable alternative to non-grid lighting sources. The World Bank's Asia Technical Department (ASTAE) developed a spreadsheet model to compare PV-SHS to conventional electricity options for

Indonesia. The RSVP team has collaborated with ASTAE to expand the comparison to include wind and PV-based hybrids and an optimum mini-grid. This tool can now compare optimum RE-based hybrids to PV-SHS and conventional options, thereby providing an economic comparison of AC and DC options, both conventional and RE-based.

SYSTEMS ANALYSES

Because renewable solutions for villages are relatively new, the anlytical capacity to evaluate options is limited. The RSVP team is collaborating with industry, government agencies, NGOs, and international organizations in analyzing village options using the aforementioned computer models. The analyses fall into three categories: prefeasibility, design, and post-installation system performance. The prefeasibility analyses generally are sensitivity analyses about the key parameters that the collaborators specify. During the last year, the RSVP team performed such analyses for small, remote wind-hybrids for villages in southern Chile, wind-diesel retrofits of isolated communities in southern Argentina, a 50-kW wind-PV-diesel mini-grid in northern Brazil, wind-PV-diesel retrofits in remote fishing villages in Mexico, a wind-diesel retrofit of an eco-tourism resort in Yucatan, diesel retrofits of mini- and micro-grids in eastern Indonesia, PV-wind hybrid household and village systems in Inner Mongolia, wind-PV school systems in Argentina, wind-diesel retrofit of remote locations in the Murmansk region of Russia and fishing villages in northwest Alaska. (The specific results of these analyses are published in other conference proceedings).

Because the RSVP team recognizes that industry uses its own set of design tools and methods, we generally do not conduct detailed design. However, we have worked with industry to assist them in the use of Hybrid2 so that they can adapt it for specific design studies. The use of systems analysis tools to evaluate the performance of operating systems has proven very valuable. While most village system installations are commissioned, they do not include performance monitoring data acquisition systems. The RSVP program and other technical organizations are encouraging some level of monitoring, since monitored data is the best, if not the only, way to determine component and system performance over time. Comparing actual performance to predicted performance can greatly help the system designer and component manufacturer improve their products. Because monitoring is both expensive and time consuming, a set of protocols has been developed for different levels of analysis. Reporting the results to the village-systems design community is critical to the continued improvement and competitiveness of RE-based systems.

PILOT PROJECTS

The role of pilot projects in the development of a sustainable RE-based rural electrification program is critical. Pilot projects require details; details require attention and commitment that lead to in-country knowledge; in-country knowledge is the beginning of sustainability. The pilot-project process addresses three critical areas: technical performance, economic competitiveness, and institutional viability. Because renewables are generally an unfamiliar solution to those who are responsible for the planning, implementation, and operation of rural electrification solutions, it is essential that the hardware be installed in-region. The process of site selection, load estimation, resource assessment, prefeasibility analyses, familiarization with commercial RE equipment and suppliers, system specifications, procurement development, installation and commissioning oversight, and analysis of performance data are extremely valuable to the in-country participants. In many cases, the initial pilot project is heavily invested by the RSVP team, but subsequent pilots in other regions are led by the now-experienced in-country team.

Wind-electric and PV generators, and their balance of systems, are very different from conventional generation equipment in many aspects, and therefore somewhat intimidating to the regional rural electricity provider. To make the transition to comfort, the systems will need to perform as well as or better than the conventional solutions. Robustness, reliability, quality of service, and serviceability are the technical parameters that the local provider will be interested in evaluating. The performance data, including system, resource and load data, need to be collected, collaboratively analyzed, and reported to the project sponsors.

Most rural electrification programs have a methodology for comparing conventional options and providers' approaches and costs. It is important to integrate the renewable solutions into the existing methodology. The pilot projects form the basis for comparing the economics of RE-based systems to conventional solutions. However, the absolute costs of the pilot project are not the appropriate values for the comparative analysis; after all, the conventional options are mature with significant in-country investment and market. Therefore, it is important to make the comparisons with a joint-venture (conceptual) scenario, where some in-country manufacturing and assembly are combined with limited direct imports; add to this the parameter of reasonable volume and the comparison is appropriate for planning for the RE options. The bridging strategy of developing this in-country capacity can then be dealt with from a policy perspective.

While the technical veracity needs to be demonstrated, and the economic comparison needs to be made in the country context, the most significant value of the pilot projects is the development of the institutional viability. There have been countless RE-based, donor-aided rural projects that made technical and (long-term) economic sense, but never were replicated, and in many cases became non-operational because care was not taken in the institutional aspects of the project. RE systems, like all energy systems, require administration, operational, and maintenance attention/discipline. The administration includes the establishment of a tariff (or fee for service) structure that reflects the ability and willingness to pay, as well as energy use; the collection of revenues; the discipline of payment; the management (including training) of the operators and maintenance contractors; and the provision for operational and capital expenses. The type of institution that will serve the rural electricity needs will depend on the local situation and the regional and national regulatory and legal structure.

The RSVP team is involved with a wide variety of institutions in its pilot projects, including national and regional utilities (both public and private), electricity and fishing cooperatives, federal and regional government agencies, international and local NGOs, and private companies/entrepreneurs. In some cases, the operational aspects of the pilot system are divided among several institutions, with the administration by a different organization from that performing the daily operational support and the periodic maintenance. The RSVP team is involved in training of these institutions at the various stages of the project.

Currently, the NREL team is involved in thirteen countries in the design, implementation, and/or evaluation of rural village pilots; the countries include Argentina, Brazil, Chile, China, Dominican Republic, Ghana, Guatemala, India, Indonesia, Mexico, Russia, South Africa, and the United States (Alaska). The technical, economic, and institutional lessons learned in these pilots will help lead RE adoption in other regions of these countries and establish a base for other country programs.

TECHNICAL ASSISTANCE

Because RE solutions for villages are not widely implemented, there is a substantial gap between the state-of-the-art knowledge of renewable technologies and applications and the in-country knowledge and experience. The RSVP team provides technical assistance to government agencies, private companies, and international institutions in the form of resource assessment, prefeasibility systems analysis, specification development, pilot project design and development, training, and performance monitoring and evaluation.

The estimation of the solar and wind resources is critical for the assessment of the competitiveness of these RE systems to conventional options. Historically, the quality of wind resource data, and to a lesser extent solar data, has been inadequate to make reasonable estimates of the performance of the RE systems. There is a substantial effort under way at NREL to assist countries in assessing their wind and solar resources. Based on recent information on the substandard quality of wind data in the developing world, a number of countries have begun programs to develop wind resource data in suspected windy regions. To assist in these efforts, NREL has undertaken a wind-mapping program that uses a variety of meteorological data bases, custom software, and state-of-the-art Geographic Information System (GIS) techniques to develop regional and, eventually, national wind resource maps. These maps help greatly in identifying regions of suitable resource for wind-based village systems, as well as regions where wind systems will probably not be viable. These maps have become the screening reference for identifying pilot project locations. These maps are useful for locating regions for additional anemometry to quantify the wind resource and project value. NREL wind mapping is under way in Argentina, Chile, China, Indonesia, Mexico, and the Philippines, with negotiations underway for similar efforts in the Dominican Republic, Thailand, and India.

The RSVP team's training efforts include participation in country workshops on wind, PV, village hybrids, and resource assessment. A valuable training experience is encompassed in the visiting professional program. Country engineers and analysts typically join the RSVP team in Colorado for a period of one to eighteen months to participate in experimental and analytical research projects. During their stay they are exposed to the latest technical developments in village systems, interact with the RSVP team members, and carry out projects appropriate to their countries. Visiting professionals have worked on battery charging stations, ice-making, hybrid systems model development, productive use load estimation, village mini-grids, wind mapping, and diesel retrofits. The visiting professional returns to his/her country with the knowledge of the current state of technology and analytical tools, and a personal connection to the RSVP team.

The RSVP program sponsors an annual village power conference in Washington, D.C., in order to update the international agencies on current RE-based village activities. Additionally, it is a forum for the discussion of alternative approaches, lessons-learned, and challenges to RE-base rural electrification among industry, NGOs, government agencies, international development agencies, and research organizations. Topics for discussion have included financing, country projects, computer models, institutional approaches, technical issues, operational sustainability, agency initiatives, and comparative economics.

PROJECT DATA BASE

The most common request by in-country officials and engineers is for information on successful projects in other countries. With the advent of the Internet, the ability to communicate quality, up-to-date information on a world-wide basis is rapidly emerging. The RSVP team has responded by making a data base on RE-based village power projects available through the Internet. The data base includes project descriptions, including location, application, system description, economics, financing, participants, and lessons-learned. There is a search engine that can locate specific aspects of interest to the inquirer. We currently have 155 projects in the data base and expect to have 250 by the end of 1997.

We also have taken advantage of the Internet to develop a village power discussion group of more than 100 professionals in the field of renewables and rural electrification from around the world. While anyone of the group can address the list-serve with a particular question, we also convene moderated discussions on village power topics.

SUMMARY

NREL has developed the RSVP team to address the enormous opportunity of bringing electricity to rural villages with economic and environmentally sustainable renewables solutions. While the program is only several years old, it is well positioned to help develop, communicate, and implement RE-based rural applications. A critical aspect of this effort is the partnerships with industry, in-country organizations, international development institutions, government agencies, national labs, and universities. The electrification of the rural world is an overwhelming challenge, but with international cooperation and ingenuity we intend to "make a go of it."

July 1998 ● NREL/CP-520-25032

Lessons Learned from the NREL Village Power Program

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Presented at the 2nd World Conference and Exhibition on
Photovoltaic Solar Energy Conversion; 6-10 July 1998; Vienna, Austria

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U.S. Department of Energy
Managed by the Midwest Research Institute
For the U.S. Department of Energy
Under Contract No. DE-AC36-83CH10093

LESSONS LEARNED FROM THE NREL VILLAGE POWER PROGRAM

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ABSTRACT: Renewable energy solutions for village power applications can be economical, functional, and sustainable. Pilot projects are an appropriate step in the development of a commercially viable market for rural renewable energy solutions. Moreover, there are a significant number of rural electrification projects under way that employ various technologies, delivery mechanisms, and financing arrangements. These projects, if properly evaluated, communicated, and their lessons incorporated in future projects and programs, can lead the way to a future that includes a robust opportunity for cost-effective, renewable-based village power systems. This paper summarizes some of NREL's recent experiences and lessons learned.
Keywords: Sustainable – 1: Developing Countries – 2: Villages – 3

1. BACKGROUND

Following the Earth Summit in June 1992, held in Rio de Janeiro, Brazil, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) became seriously engaged in assisting with the introduction and integration of renewable technologies in developing countries. In 1993, a workshop was convened at NREL with 33 representatives from the private sector, government agencies, development organizations, nongovernment organizations, and research institutions to discuss the issues of applying renewable energy in a sustainable manner to international rural development. A summary recommen-dation was that NREL could assist in renewable energy-based rural electrification (RERE) by developing and supporting six related activities: resource assessment, comparative analysis and modeling, performance monitoring and analysis, pilot project development, Internet-based project data communications, and training. Thus was born the NREL Village Power Program consisting of activities that cut across several renewable technologies and have grown to include a wide range of technical, economic, and social disciplines.

Currently, NREL is active in 20 countries, and is supporting pilot projects in 12 of those countries. Technologies presently include photovoltics, wind, biomass, and hybrids; increasing emphasis on small geothermal and small hydro are on the horizon. The remote rural applications include home, communications, water pumping, school and health clinic, battery charging, ecotourism, and village minigrid hybrid power systems.

While considerable effort has been devoted to developing new computer models for economic analysis, training and working with in-country partners, and gathering and documenting not only NREL experiences, but also experiences of others, it is the facilitation of pilot projects that counts most. Pilot projects are more than mere technical demonstrations—they are central to renewable energy-based village power development. By and large, it has been shown that renewable technologies work. The most important aspects of pilot projects are their inherent ability to engage in-country partners in hands-on experience that can lead to not only technical, but economic and institutional sustainability as well.

It is important to note that many of the pilot projects from which NREL's experience has been gained were funded, and in many cases developed, by other organizations and agencies. NREL has provided a variety of services including technical, economic, regulatory, and project management assistance to a wide range of projects.

The purpose of this paper is to describe the lessons NREL staff have gleaned from their participation in the various pilot projects. We hope that these lessons will help the RERE community to implement increasingly more-sustainable projects that lead to widespread replication.

2. APPROACH

The approach used to document the lessons was to poll eight key NREL Village Power team members who have been involved in the development, implementation, and evaluation of renewable-based pilot projects. Consolidating this information, an attempt has been made to look for common themes, while maintaining the variety of experiences. The following four categories were chosen as a way to capture our experiences: institutional aspects, pilot project characteristics, implementation processes, and technology development needs.

3. LESSONS LEARNED

3.1 Institutional Aspects

Reliable, well-designed, and integrated technology is important, but it is the institutional aspects of a project that make or break long term sustainability.

Partnering. Establishing an effective working relationship with a capable, credible in-country champion is critical to project success. In-country partners understand the local legal, political and social context. However, recognize that partner capabilities and interests may change over time. State-owned electric utilities that are sold to private sector, for profit institutions can undergo a dramatic swing in interest and support.

Maintenance. Nothing is maintenance-free, therefore, a maintenance support infrastructure needs to be established and nurtured. This issue must be addressed from the very conception of a project. It need not be complex, but it does need to be functional and appropriate for the size, complexity, and sophistication of the systems deployed. A training program with documentation that is matched to the local capabilities, regular refreshers, personnel turnover, a spare parts' inventory and supply information, and funds for preventive and problem maintenance must all be addressed.

Tariff design (grid systems). Developing world rural tariffs for grid-connected systems are often heavily subsidized and send the wrong price signals. While rural subsidies may be appropriate in some cases, the tariff design needs to reflect both the actual cost and quality of service. Multilevel or stepped tariff designs are particularly important in cases where 24 hour, ac service with renewable hybrids is subsidized due to the large swings in short-run marginal cost. The technical (metering) and institutional (meter reading and billing) costs of grid connected line extension or minigrids need to be evaluated when considering the tradeoffs between grid power and small stand-alone systems.

Tariff design (stand-alone systems). In small stand-alone systems for homes, schools, health clinics, water pumping, and other applications, strong efforts need to be made to decouple the concepts of electricity sales measured in ¢/kWh from fee-for-service monthly payments. Many rural customers are already paying US$5-15/month for basic energy services that can be better met with stand-alone renewable energy systems (and without subsidies). It is often difficult to convince electric utilities and other local officials to think about an energy-services approach.

Development coordination. Most countries have significant rural development programs including education, health, communications, economic development, agriculture, water, and electricity. The links among these programs and the supporting agencies are potentially substantial, and currently underutilized. Rural electrification, does not, in and of itself, create rural economic development. Linking programs is important for overall success.

Planning tools. Rural electrification planning methodologies and policies generally do not integrate and evaluate renewable energy solutions fairly, if they are recognized at all. While pilot projects seldom need to be formally evaluated, up front, by the planning agencies, pilot projects can provide important input to these agencies to further enhance their adoption of renewables as a viable option. There needs to be a conscious effort to work with planning agencies to modify their evaluation methods to fairly accommodate renewable energy solutions.

Economics. Because rural electrification generally consists of line extension or diesel minigrids based on an annual budget for installations, the concept of life-cycle cost analysis, which fairly compares capital intensive and operating-expense intensive technologies, is uncommon. The concept of life-cycle costing needs to be integrated into the training of planning officials.

Language. Many expectations have not been met because of misunderstanding resulting from language and culture differences rather than nonperformance. It is particularly important in pilot projects to emphasize open and complete communications.

3.2 Pilot Project Characteristics

Pilot projects are more than just technical demonstrations. The most successful pilot projects seek to create an environment that can lead to future replication.

Performance. First and foremost, the project must perform well technically. To this end, extra care and expense should be devoted to the design, construction, commissioning, robustness, and reliability of the pilot system. In pilot projects, robustness and reliability are more important than energy-conversion efficiency. Resist the temptation to field the "latest and greatest" until it has been thoroughly tested under controlled conditions. Repairing equipment in remote locations is difficult and expensive.

Energy efficiency. Energy-efficient end-use applications/appliances are critical to economically sized renewable energy systems. Investments in energy efficiency have much more economic value than adding generation capacity to meet the demand of inefficient appliances. It is important that a complete systems engineering approach be maintained, attempting to deliver the best end-use service for the least overall system cost. Retrofitting expensive hybrid power systems in a village without first addressing end-use appliances is a mistake.

Quality of service. Along with the issue of energy efficiency comes the issue of quality of service. Examples include: electric lighting provides better light than from kerosene wick lamps; 24-hour service is preferred to 4-6 hour service; reliable, available electricity is more valued than an unreliable supply. These differences in quality of service should be reflected in comparing alternative solutions.

Replication mind-set. Pilot projects need to be designed technically and conceptually, with the commercial replication path in mind. Pilot projects that cannot be replicated in the region commercially serve only as technology demonstrations with far less value to the existing electrification program than those designed to feed into a national rural electrification plan. It is important to ask the question: "If the pilot project is successful, what is the likelihood that a commercial solution will follow?" If the answer is "none," rethink the rational for the project.

One-of-a-kind demonstrations. Single projects in remote locations are not sustainable. While it is tempting from a budgetary perspective to do single projects, they quickly become operation and maintenance (O&M) nightmares. Multiple systems in a region are required to develop and sustain the necessary support infrastructure. Single-unit technical demonstrations do have their place. Make sure they are in a place that they can be maintained, or removed, when the demonstration is over.

Loads. Estimating electric loads for newly electrified villages is difficult, often resulting in overdesign, wasted energy, and poor economics. Estimating load growth in villages receiving ac power for the first time is equally difficult. Integrating deferrable and discretionary loads helps system economics, but is difficult in practice. Designing modular systems that can be incrementally grown as village loads increase needs more attention. Incorporating these issues into planning models is equally challenging.

Diesel retrofits. It is often more economical (from a life-cycle cost perspective) to install a new, appropriately sized diesel than to use the existing, oversized, poorly maintained one. However, local authorities and renewable energy equipment suppliers resist scrapping the existing diesel because the new diesel reduces the capital available for the nonconventional equipment.

Performance monitoring. Pilot projects, unlike commercial projects, are explicitly intended, based on their performance, to lead to larger scale replication. To this end, they need to be instrumented to confirm energy and operational performance. They also need to be evaluated for institutional response and effectiveness. The results of these evaluations need to be communicated to both the local and international development communities so that technical and nontechnical lessons can be adapted in the replication process.

Buy-down. Because pilots generally introduce new technical solutions to regional authorities, it is often necessary to cost-share the initial project. However, it is important to require significant cost-sharing by the implementing/operating organization to assure partner commitment and capture management attention.

3.3 Implementation Process

Pilot projects help country programs obtain firsthand experience that may lead to widespread adoption of renewable energy technology in the rural electrification process.

Political will. The most important factor for successful implementation is a supportive, positive attitude by the rural electrification officials. The existence of a champion for renewables for rural services who is in a position of authority keeps up the momentum during the extended process of resource assessment, site selection, project design implementation, evaluation, and replication. There is no substitute to a dedicated, influential, local champion.

Duration. The time from initial interest in renewables to commercial replication takes 4-6 years, in a positive climate. The pilot phase usually takes 2-3 years from site selection through initial evaluation. Pilot projects are part of a long-term process of change. Initial commitments should be coupled with the realization that long-term collaborations are a key to successful programs.

Commercial replication. The transition from the pilot phase to commercial replication can be difficult. The transition is greatly aided by a well-funded pilot phase that includes multiple, regional projects; local capacity building; strong engagement and commitment by a commercial partner; and substantial technical assistance. The transition usually means a change from primarily sponsor-driven activities to business-driven activities. The more the pilot project can be set up to look and act like a business, the easier the transition.

Needs-driven approach. Renewable energy solutions to rural electrification should be resource- and need-driven, rather than based on a specific technology/application. The available renewable resources, the village electrical demand and applications, villager willingness and ability to pay for electrical service, and the economics of alternatives should determine the appropriate solutions. It is important to be objective and neutral in evaluating and presenting options. It is important to let the locals participate, and select, appropriate solutions.

Administration. In order to sustain a newly implemented rural electricity system, an administrative system needs to be developed and sustained. Many rural villages have formed cooperatives for fishing, agriculture, and other economic development activities. The specific electricity administrative solution will be regional or village dependent or both. While a number of models have been successful, care is needed in matching the administrative system to the village social dynamics.

3.4 Technology and Development Needs

While it is essential to deploy only commercial technology in pilot projects, it is fair to say that there are opportunities for technological improvement in components, systems, ancillary equipment, and supporting processes.

Hybrid systems. While wind, PV, and micro-hydro have been commercial technologies for a number of years, their hybridization with fossil fuel generators for rural applications are an emerging technology. Renewable energy-fossil hybrids have their roots in telecommunications applications in remote sites; however, the extremely high-value electricity for telecommunications applications has resulted in expensive, extreme reliability designs that are inappropriate for rural electricity service. While there are tens of thousands of isolated diesel generators deployed throughout the world, village hybrid system sales are infinitesimal at this stage because the design, manufacturing, integration, implementation, and distribution segments of the industry are very sparse and immature. This results in high prices, costly implementation and support, and rapidly evolving designs. Hybrid systems are a potentially significant solution to rural ac electricity needs, but further technology development and industry expansion will be required.

Controls. Electronic controls and converters are the least robust component in the reliability/robustness chain. While there have been significant improvements in the quality and functionality of these components over the last 5-years, they remain the chief cause of system problems. Complicating the issue is the lack of maintenance support capacity for these components in rural areas. Robustness and modular electronics need to be the focus of controls development; in addition, spare parts and development of electronic service capacity need to be part of any pilot project.

Lightning/corrosion. Many developing countries' rural applications are exposed to severe corrosion and electrical storm conditions. While much is known about lightning and corrosion protection of electrical components, in many cases conventional solutions for high-value electrical systems are neither cost-effective nor appropriate for rural systems. Cost-effective application engineering is required for corrosive and electrical storm-sensitive environments.

Meters. Metering and billing are often a problem. Prepayment meters may greatly increase the sustainability of mini-grid systems. While several prepayment meter designs are commercial, they need to be less expensive in order to receive serious international attention.

Resource data. Wind resource data for rural areas are either nonexistent or of marginal quality, yet are critically important for comparing wind-based systems to other options. Wind mapping, using various existing meteorological and geographic databases and customized computer models, has enhanced the ability to evaluate wind as an option. Existing solar databases are sufficient for estimating PV as an option. There is an increasing use of GIS-based census and demographic data in the developing world for grid extension planning. There is an opportunity to combine resource mapping and GIS-based rural planning models for determining the opportunity and the best locations for renewable village electrification.

Integrators/packaged systems. Because the market for rural renewables is just emerging, the role of system integration is underdeveloped. There are a number of component and system suppliers, but the function of system integration (comparing and packaging alternative architectures and solutions, along with due attention to load efficiency and demand-side options) is very limited, especially as an in-country capability. While integrated, packaged systems have certain commercial and functional benefits, they (and their supply) are premature; therefore, the market will need to develop further to attract/enhance the integration function.

4. SUMMARY

Renewable energy solutions for village power applications can be economical, functional, and sustainable. Pilot projects are an appropriate step in the development of a commercially viable market for renewable rural solutions. Moreover, there are a significant number of rural electrification projects under way that employ various technologies, delivery mechanisms, and financing arrangements. These projects, if properly evaluated, communicated, and their lessons incorporated in future projects and programs, can lead the way to a future that includes a robust opportunity for cost-effective, renewables-based village power systems.

ACKNOWLEDGEMENTS

This paper was made possible by generous contributions from key members of NREL's Village Power team. Led by Larry Flowers, team leader, other members include Ian Baring-Gould, David Corbus, Steve Drouilhet, Vahan Gevorgian, Rick Holz, Peter Lilienthal, and the author.

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Photo by: Jerome Weingart

Bud Annan delivers Road Warrior challenge.

Photo by: Jerome Weingart

Village Power '98 reception in the World Bank Atrium.

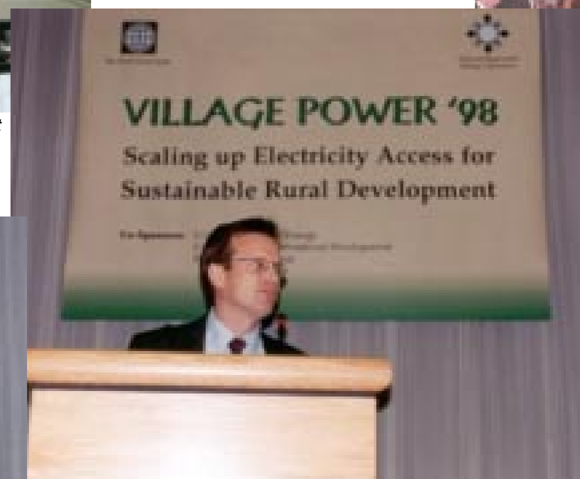


Photo by: Jerome Weingart

Richard Hansen.
Village Power '98 Road Warrior.

Photo by: Jerome Weingart

Larry Flowers presents Richard Hansen with the Village Power Road Warrior Award.

Photo by: Jerome Weingart

Village Power '98 Attendees

Photo by: Julie Cardinal

From Left: Mark Fitzpatrick, Roger Taylor, Judy Siegel, and Aldo Fabris.

Mike Bergey: Village Power '98 Road Warrior Candidate.

Photo by: Julie Cardinal

Photo by: Jerome Weingart

Panel: Organizing for Scaling-up Electricity Access; Models for Sustainable Energy Delivery.

Photo by: Julie Cardinal

RCMP from left: Malcolm Lodge, Tom Lambert, and Steve Graham.

Photo by: Julie Cardinal

Village Power '98 entrance.

Photo by: Julie Cardinal

From Left: Emanuele Scoditti, Daniele Guidi, and Neway Argaw.

Attendees gather renewable energy literature.

Photo by: Julie Cardinal

Photo by: Julie Cardinal

Panel: Promoting Productive Uses and Small Businesses for Rural Development.

Attendees exchanging ideas during a break.

Photo by: Julie Cardinal

Photo by: Jerome Weingart

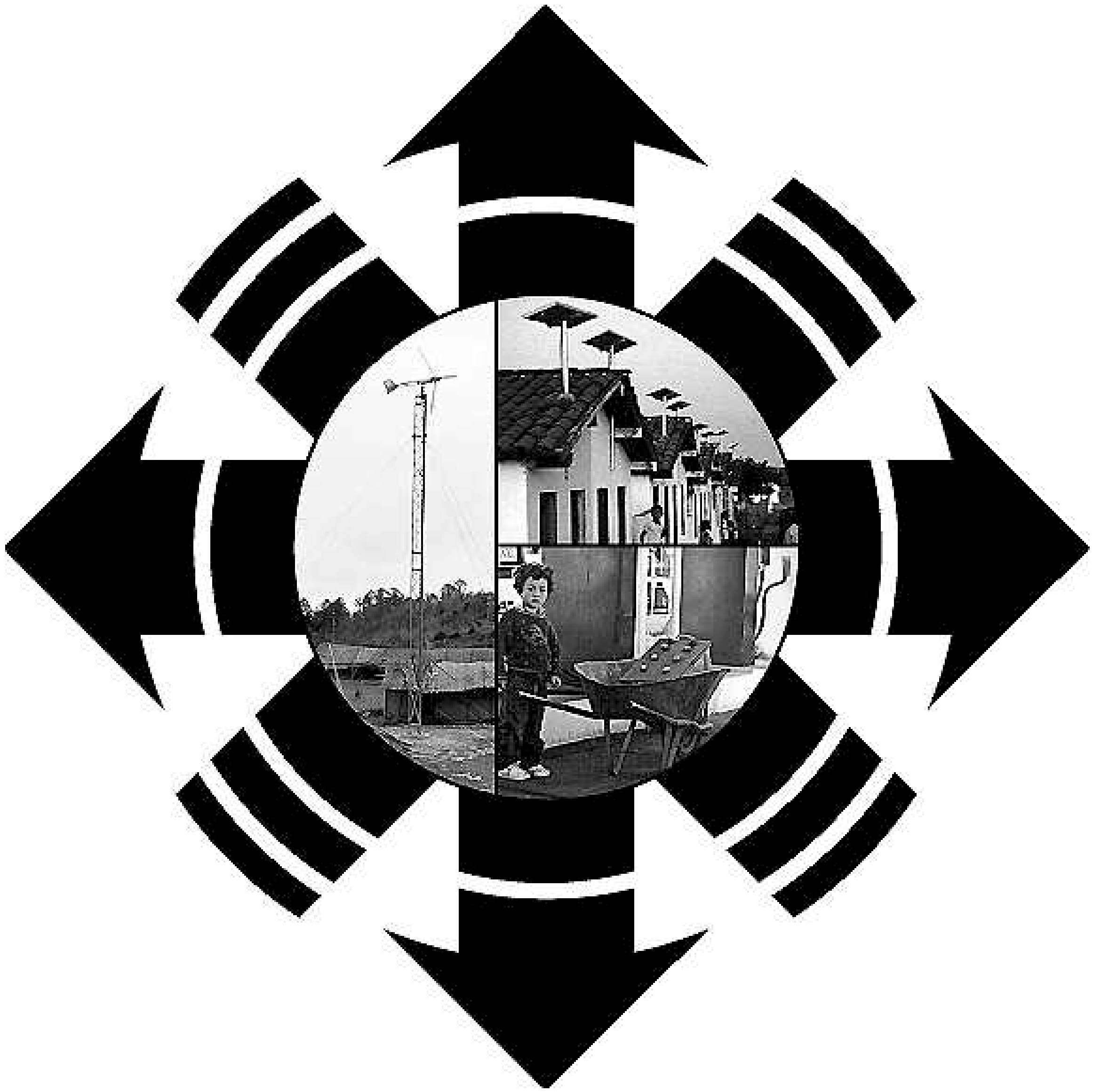
Judy Siegel and Arun Sanghvi enjoy the reception.

Photo by: Julie Cardinal

Panel: Power Supply Options for Decentralized Rural Electrification.

From Left: Doug Arent, Jerome Weingart, Art Lilley, Ian Baring-Gould.

Photo by: Julie Cardinal



Proceedings of

Village Power '98

Scaling Up Electricity Access for Sustainable Rural Development

Volume II

Convened by the National Renewable Energy Laboratory
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World Bank Headquarters, Washington, D.C.
October 6-8, 1998

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CP-500-26264

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A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

Printed March 1999

Village Power '98 Proceedings were produced by the National Renewable Energy Laboratory. For an additional copy of this document in hard copy (Vol. 1 & 2, $50.00) or CD-ROM ($10.00), please send a check to:

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http://www.rsvp.nrel.gov

Appendix B: Monday's Workshops

Sustainable Energy and Gender: A Facilitated Discussion on Linkages

Hybrid Systems: Technologies, Applications, and Issues

Large-Scale Use of Photovoltaic Systems for Off-Grid Applications: Infrastructure Needs and Challenges

Monday, October 5, 1998, Workshops

Sustainable Energy and Gender: A Facilitated Discussion on Linkages

Summary Report
1/31/99
Barbara C. Farhar, Ph.D.
Workshop Organizer
National Renewable Energy Laboratory

An Informal Workshop in Connection with Village Power '98
Sustainable Energy and Gender: A Facilitated Discussion on Linkages

Monday, October 5, 1998
World Bank
Washington, DC

The Workshop was organized to provide a forum for attendees of the Village Power '98 meeting to discuss sustainable energy and gender, a topic that heretofore had not been on the agenda of the Village Power meetings. This Workshop was the first time that gender was a formal topic of the Village Power conferences. Because the Workshop was not listed when Village Power '98 was initially announced, most conference attendees had already made their travel plans when they learned of it, and were unable to attend. Nevertheless, the Workshop's 15 participants created a lively and thoughtful discussion that lasted the entire day. Participants, as well as others who learned of the Workshop but could not attend, requested that another Workshop be held next year.

Participants introduced themselves and stated their expectations for the Workshop. Participant expectations for the Workshop included the following:

- Learn more about what others are doing
- Meet colleagues
- Understand why the Workshop is not more well attended
- Become more exposed to literature that exists
- Explore the potential for renewable energy as a mechanism for gender-sensitive programs
- Disperse and share information
- Focus on rural applications, such as battery stations and communications
- Understand investment initiatives in Africa
- Share information on World Bank project: infrastructure and economics micro hydro in several countries
- Understand how renewable energy can be used more to alleviate poverty, especially in rural areas
- Develop idea that women are key to getting PV implemented widely
- Develop further understanding of gender issues important in development, and the linkages
- Explore how gender and rural development can be further implemented
- Understanding how to involve more organizations in gender and sustainable energy.

Presentations

Joy Clancy, University of Twente, The Netherlands, gave a presentation on ENERGIA. Her overheads are as follows:

1. **How it all started**

   Preparation phase for Beijing (1995)

   It became apparent - despite cross-cutting nature of energy - no international institution had women and sustainable development as a major objective in the context of energy

   Lack of dialogue between gender and energy specialists

   Lack of case studies
   There were good examples from other sectors:

      PROWWESS
      FAO, Forest, Trees and People
      GTZ Household Energy Programme
      UNIFEM

2. **Organizations**

   TOOL Consult
   Energy Environment and Development
   TDG, University of Twente

   Established ENERGIA - a loose network

   <u>Objectives</u>

      Engender energy
      Empower women

   <u>Achieved through</u>

      Information exchange
      Training
      Research
      Advocacy
      Actions

<u>Emphasis</u>

Decentralized actions
Putting people in touch
Dialogue between policy makers and field works

<u>Funding</u>

NEDA (DGIS) - mainly for ENERGIA Newsletter

3. What's Been Achieved So Far

ENERGIA News - 7 issues
Theme issues
Circulation of 1,000

and, on basis of *no funds*:

Training materials
Resources persons at workshops and conferences
Advisory services and work
Advising on project proposal development
Lobbying to include gender in energy
Web Site (WIRE/ISES) www. energia.org

As a consequence . . .

More international energy programmes are taking gender seriously

e.g., UNDP/SEED
NREL

ENERGIA has . . . Inspired/galvanized
Provided support
Provided legitimacy

4. How Does ENERGIA Work?

Membership = anyone who receives *ENERGIA News*

No formal secretariat

Decentralized, "virtual" organization based around production of newsletter

ENERGIA Support Group "Think tank" of 30 professionals
Provide advice and support

5. The Future?

Move from provider of newsletter to facilitator
Putting in touch those who need services with those who can provide services

1. Formalizing ENERGIA into organization with full-time manager

2. Continue with *ENERGIA News*

3. Resource Centre and further development of web site

4. Regionalization
   Extend local membership
   Generate articles
   Local newsletter
   Workshops and training
   Bringing groups together for projects
   Advocacy on women and energy

5. Grants for study, visits, workshops, seminars and meetings
6. Manuals, training materials, videos

7. Development of case studies, especially non-stoves
   Awareness raising

Ellen Kennedy, Winrock International, Washington, DC gave a presentation entitled "Gender and Renewable Energy: An Issue of Language." Her overheads were as follows:

1. Why does gender get left out of renewable energy projects?

   - Lack of capacity
   - Lack of history
   - Culture and language "disconnect"

2. Lack of Capacity

   - Lack of women in energy planning
   - Dearth of women engineers in field
   - Cultural, credit, or linguistic barriers

- Data anecdotal-need more peer review

3. Lack of History

- Renewable energy is still relatively young (some attention in the 1970s)
- Focus on cookstoves
- Past 2-3 years: ENERGIA Network, workshops, seminars, pilot projects
- Would we have had this meeting at Village Power 3 years ago?

4. Culture and Language Disconnect

- Good development professionals identify with the user
- But industry has to operate from the bottom line

Need to translate the importance of gender projects in commercial terms

5. Development Benefits

- Saves time
- Reduces drudgery
- Enables children, especially daughters, to go to school
- Cleaner water, better health
- Cleaner lighting
- Possible income generation uses.

6. But Industry Benefits Are . . .

- Women are key household customers
- Women are excellent credit risks
- Unless purposefully engaged, women may be lost or alienated customers
- Women are good at O&M
- Women are invested in health, education, and other family-related applications.

7. How to Reach Industry?

- Desegregate data for all projects
- Make markets visible
- Team up with other groups working with rural women
- Educate donor community
- Market studies and trials
- Hire women distributors, planners, etc.

8. Doubt Demons

- Backlash for rural women?
- Forcing systems on women?
- What about very cheap, locally made energy solutions that don't involve industry?

Elizabeth Cecelski, Energy, Environment and Development, Witterfürth, Germany presented on Gender, Poverty, and Sustainable Energy.

Overheads for this presentation are included in the regular Village Power '98 Proceedings, and are not duplicated here. At Ms. Cecelski's request, the Workshop reviewed her presentation for the Village Power '98 and offered comments and suggestions.

Barbara Farhar, National Renewable Energy Laboratory, presented information on the gender discussions at the World Renewable Energy Congresses in 1996 and 1998. Highlights of this presentation included the following:

Women in sustainable energy is both a domestic and an international issue. For example, in the United States, more than half of low-income households' budgets are needed for rent and utility; disproportionately high percentages of these households are families of women and children. Abroad, most energy in developing countries is supplied and used by women in households. Environmental effects include deforestation and desertification, and health problems resulting from poor indoor air quality.

Energy projects, even sustainable ones, have been largely driven by technology, rather than by the needs of users.

The potentially significant role of microcredit lending programs to foster sustainable energy and economic development has been largely overlooked; it is just beginning to receive attention.

The need for education in these areas was stressed.

The renewables industries should be involved in better understanding these potential markets.

Gender issues should be included in the energy programs of major development agencies; energy should be included in the gender programs of major development agencies.

Discussion

Because the workshop was small, much of the time was spent on discussion. Important themes on which there was consensus were as follows:

1. In rural areas, access to renewable energy is difficult in general, and even more difficult for women. For example, access to credit and training is even less for women than it is for

men. These barriers need to be overcome by women-specific measures.

2. Participation of local people, including women, is essential for the effective design, implementation, finance, and maintenance of renewable energy projects.

3. International financing agencies should integrate energy into their gender policies.

4. Energy projects should focus on the household-level to benefit poor households in remote rural areas, matching resources with actual household needs.

5. Electricity access can be scaled up by addressing women's energy needs and matching resources to those needs.

6. Financing should be proactively extended to women for the acquisition of renewable energy systems.

The importance of gender in Village Power was formally recognized at the Conference's closing remarks by Roger Taylor, based on Elizabeth Cecelski's presentation and the Workshop.

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Hybrid Systems: Technologies, Applications, and Issues
Welcome and Introduction 10:00 - 10:15– *Larry Flowers, NREL*

Block I: 10:15 - 11:30 Applications
Session Chair: *Larry Flowers, NREL*
Eco-tourism: Case: Costa de Cocas - *David Corbus, NREL*
Isolated Ranch: Case: *Luis Vega, PICHTR*
Small Village: Case: VLA: *Ian Baring-Gould, NREL*
Medium Village: Case: Joanes: *Gary Norton, Northern Power Systems*
Large Village: Case: Kotzebue: *Malcolm Lodge, Island Technology*
Island System: *Niels Andersen, Vestas*

Block II: 12:30 - 1:45 Technologies
Session Chair: *Per Lundsager, Darup Associates*
DC Bus Systems: *Mike Bergey, Bergey Wind Power*
AC Bus Systems/High Penetration: *Steve Drouilhet, NREL*
Battery Diesel Systems: *Steve Phillips, AES*
Retrofitting Diesels: *Ian Baring-Gould, NREL*
Hybrids in Europe: *Kilian Reiche: Fraunhofer Institute*

Block III: 1:45 – 4:30 Discussion Forum
Session Chair: *Gabrielle Seeling-Hochmuth*
Storage: *Steve Drouilhet, NREL*
Control Systems: *Jim Manwell, University of Massachusetts*
Technology Needs: *Mike Bergey, Bergey Wind Power*
Tariffs, Metering, and Economics: *Peter Lilienthal, NREL*
Institutional Aspects: *Ron Orosco, Energia Total*
Reliability & Track Record: *Per Lundsager, Darup Associates*
Credibility: *Bruce Levy, BPG Development*

Block IV 4:30 - 5:30 International Market Perspectives, Panel Discussion
Session Chair: *Larry Flowers, NREL and Per Lundsager, Darup Associates*
Panel members:
Niels Andersen, Vestas
Mike Bergey, Bergey Wind Power
Malcolm Lodge, Island Technology
Steve Phillips, AES
Bob Sherwin, Atlantic Orient Corp.
Art Lilley, Community Power Corp.

5: 30 Closing**:** *Larry Flowers, NREL*

Hybrid Power Workshop Attendee List

National Renewable Energy Laboratory

Costa de Cocos 11 kW Wind-Diesel Hybrid System

David Corbus

National Renewable Energy Laboratory

Hybrid Power Workshop

National Wind Technology Center

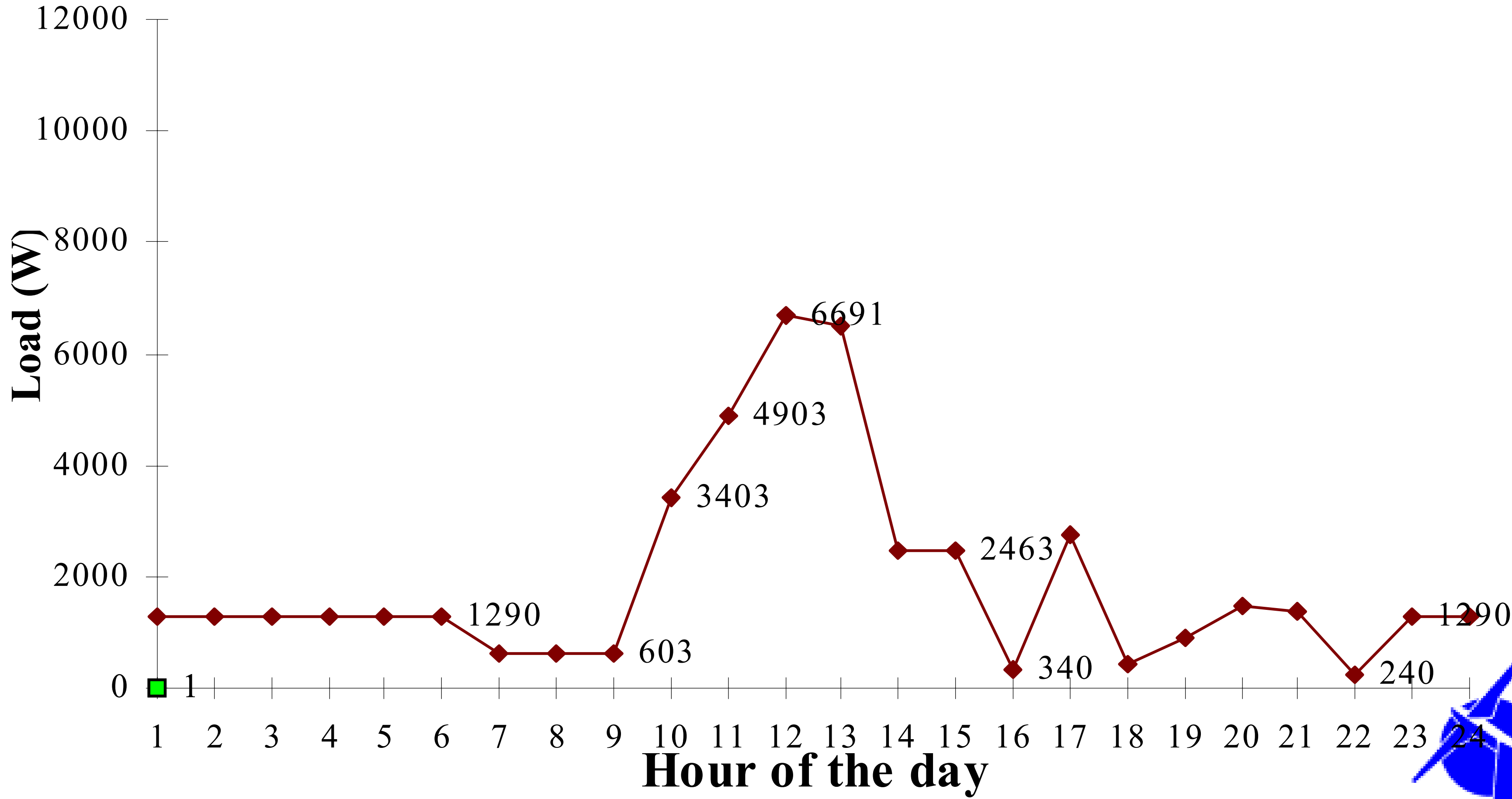
Background of Costa de Cocos Resort

- Small resort in Southern Mexico with existing diesel and small battery charging system
- Need for 24-hour power without running diesel
- Potential for diesel fuel savings by displacing fuel with wind energy
- Owner wanted to use reverse osmosis system for water desalination
- Idea of "green power" and ecotourism appealing; owner familiar with nearby Xcalak hybrid power system
- Cost shared funding available

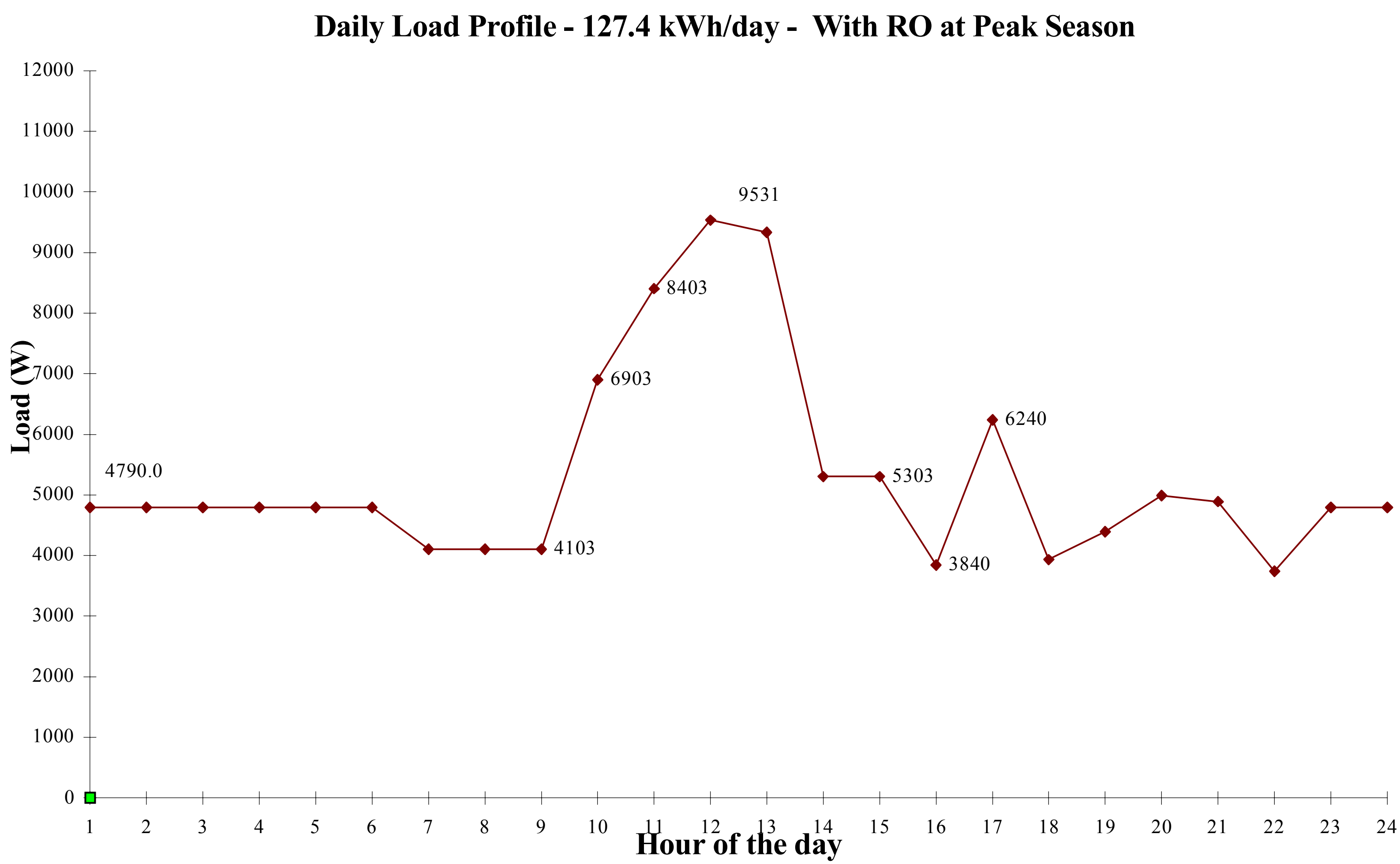
Why Ecotourism hotels for wind-hybrids?

- Ability to pay for system because of cash flow from business
- Owner frustration with existing diesel system
- "Green marketing" concept appeals to owners and customers
- **Smaller ecotourism hybrids are less complicated compared to larger village hybrids….Serve as ideal path for technology commercialization**
  - Mini-grid for resort is small and manageable
  - Resort owners typically have good technical for O&M
  - Energy conservation and load management easier to implement (lighting changed to CFs)
  - Metering, billing and sharing of energy not an issue

Daily Load Profile - 46 kWh/day - No RO Peak Season



National Renewable Energy Laboratory



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Equipment Description

- Bergey EXCEL turbine - 48-volt winding (no transformer); 10 kW output connected to grid, about 7 kW output for this battery charging application (funding only available for 1 turbine)
- New turbine corrosion package addresses problems experienced by nearby Xcalak turbines
  - Stainless steel hardware used throughout including pitch weights; Guy wires use corrosion resistant coating; stator epoxy encapsulated
- Lattice type tilt-up tower
- Two “stacked” 5.5 kW TRACE inverters for both 120 and 240 volt loads (to power RO system) at 11.0 kW total rated capacity
- Three parallel strings of Trojan L-16 batteries (nominal 1050 amp-hours at 48 volts = about 50 kWhs storage)

Diesel Operation

- Wind system *not* designed to run the reverse osmosis system for long time periods; diesel would run the system during high water loads
- System originally designed as switched system where either 3-phase diesel or 2-single phase inverters meeting the load but not both at same time - However, owner bought large RO system that inverter couldn't start
  - Inverter surge capability cannot start oversized RO system so diesel was rewound to two phase and parallel capability between inverter and diesel used

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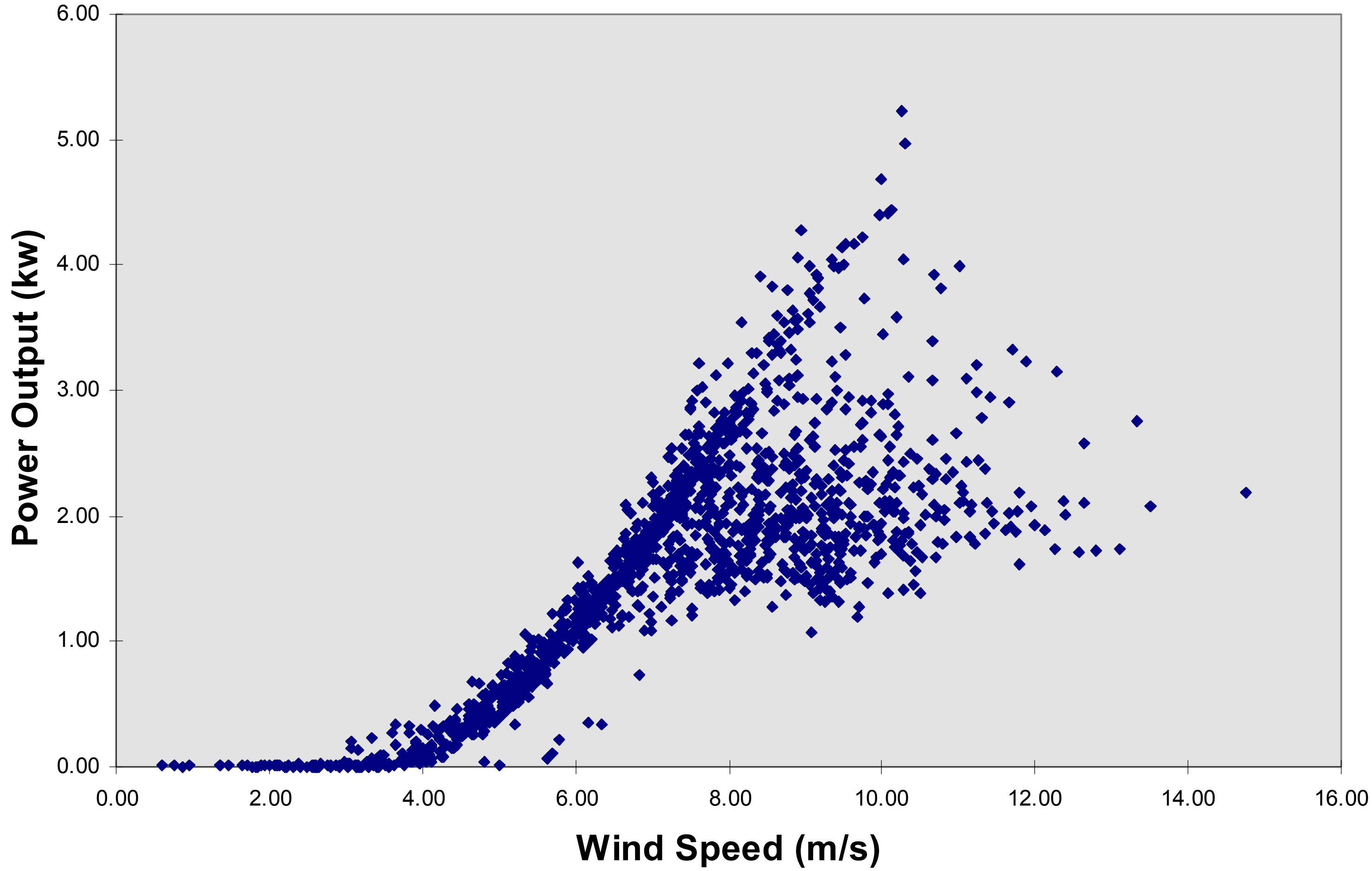
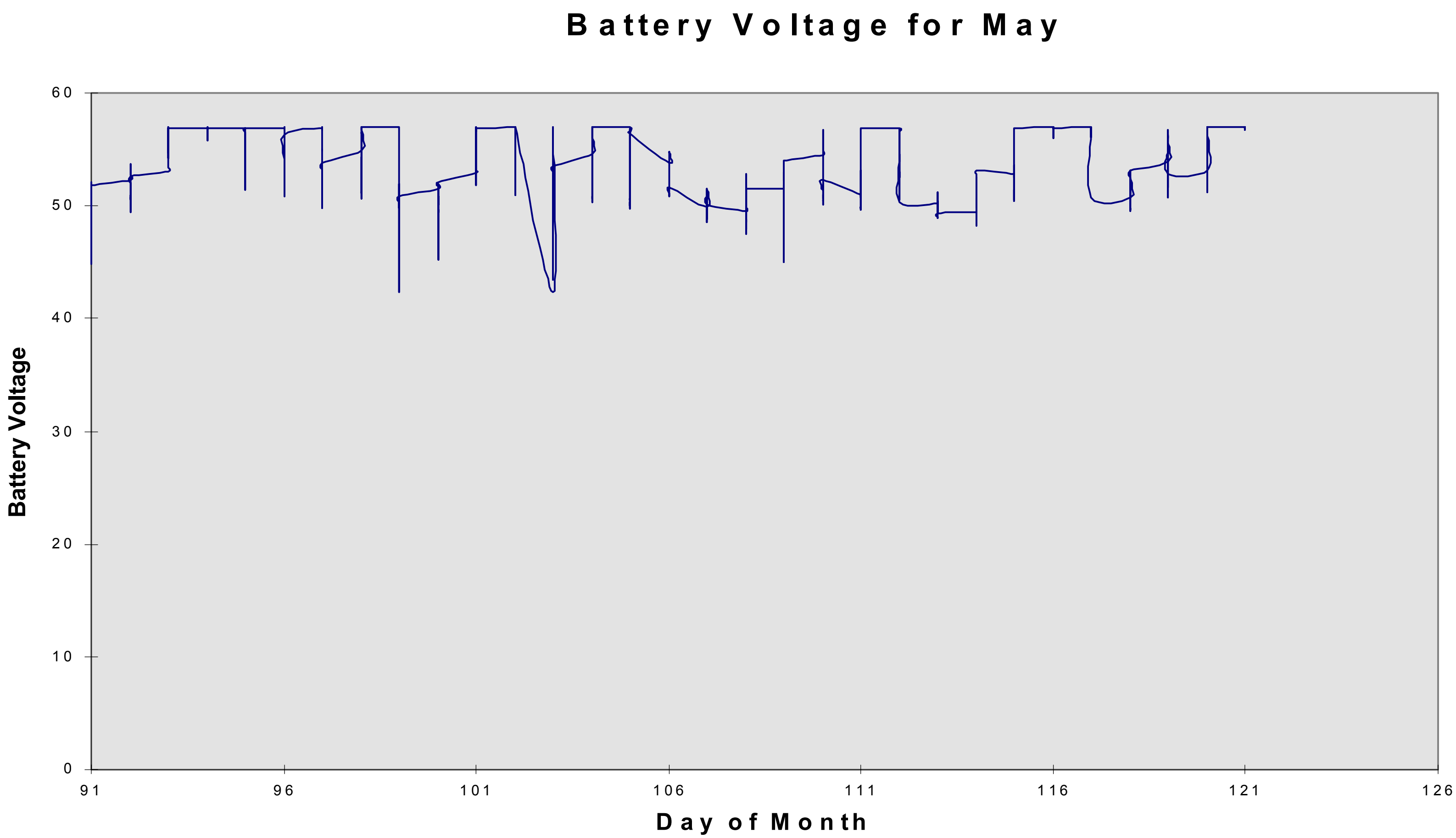
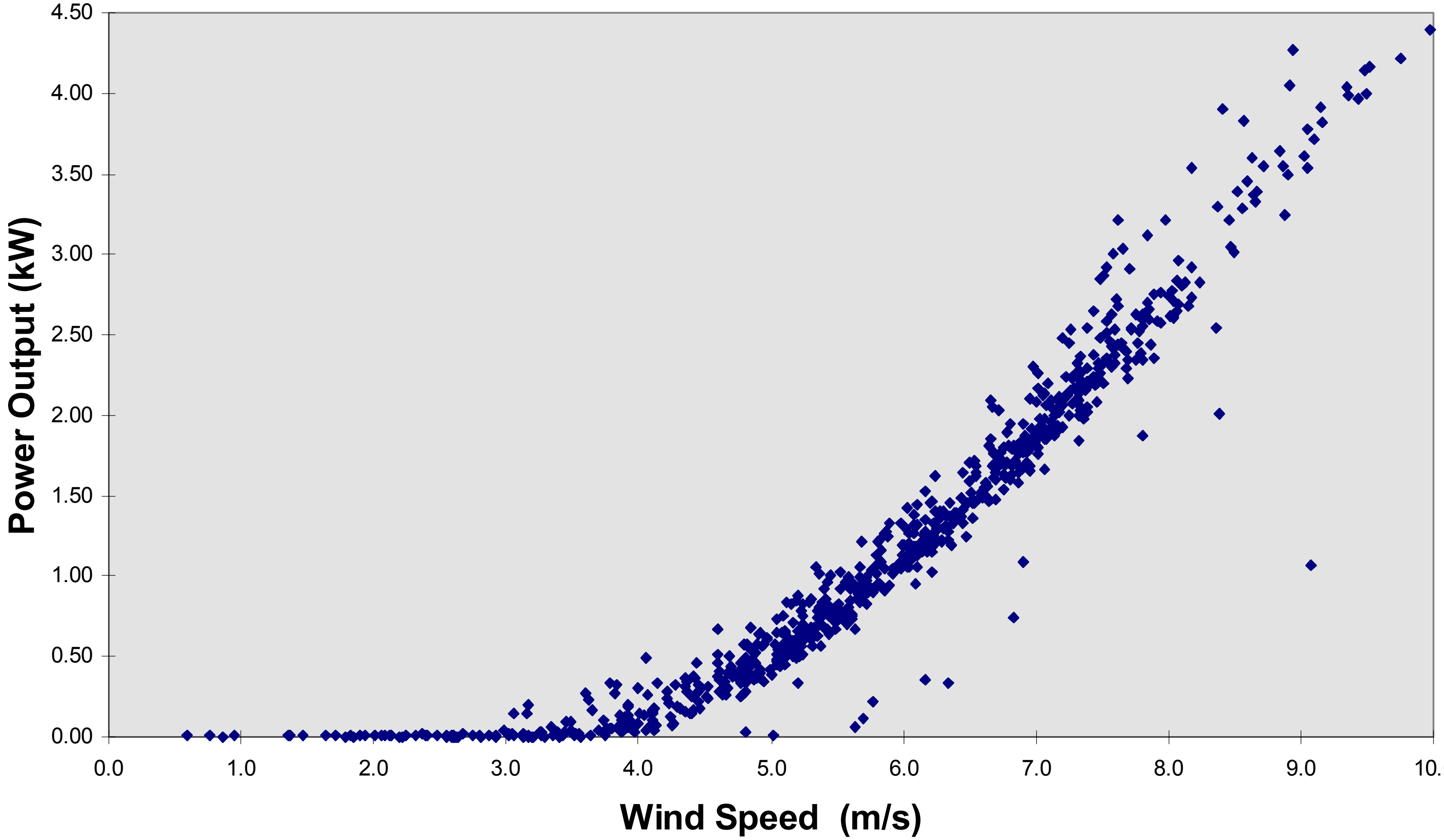
Turbine power versus wind speed - all voltages



National Wind Technology Center


Battery Voltage for May
Battery Voltage
Day of Month
60
50
40
30
20
10
0
91
96
101
106
111
116
121
126

Turbine power vs. wind speed for voltages < 54 volts



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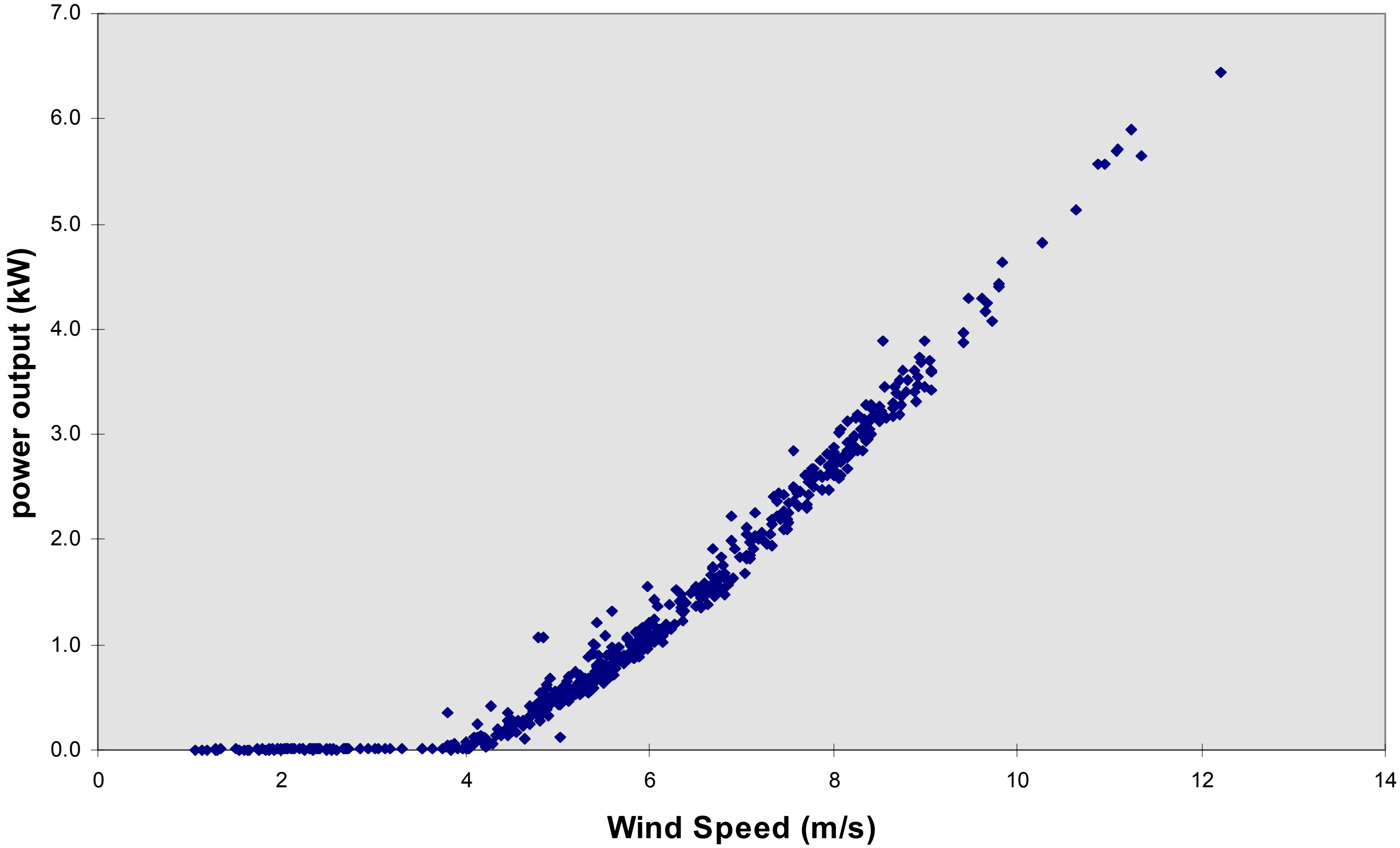
Turbine Output versus Wind Speed (1 second average)



National Wind Technology Center

Summary of Monitoring Results and Lessons Learned

- Noise can be an issue
- Existing diesels can be maintenance nightmare - Usually better to buy new diesel
- Design of 2 phase RO load with three phase existing diesel system important
- Training for RO system important
- Load management important
- Turbine corrosion packages available and should be used for all salt-spray environments - Long term monitoring of wind machines in these environments important
- Low loads have resulted in low wind turbine output and low battery efficiency

HYBRID VILLAGE POWER SYSTEMS:

360 kWh/day Kahua, Hawaii

720 kWh/day Nabouwalu, Fiji

Luis A. VEGA, Ph.D.
Joseph B. CLARKSON

October 1998

Lessons Learned

- **Reliability** is paramount;
- **Reliability** based on: simplicity, capacity, redundancy and history;
- **Affordability** is another extremely important design consideration;
- **Installation** requirements must match in-country capabilities.

MUSTS:

- **involve** the in-country **stakeholders** in all aspects of the project, from resource evaluation to implementation,
- **train** operators,
- use **commercially available equipment**,
- **test** equipment, as part of a system, **before it can be deployed to remote locations**,
- establish appropriate **maintenance** schemes.

Luis A. Vega, Ph.D.
Village Power '98

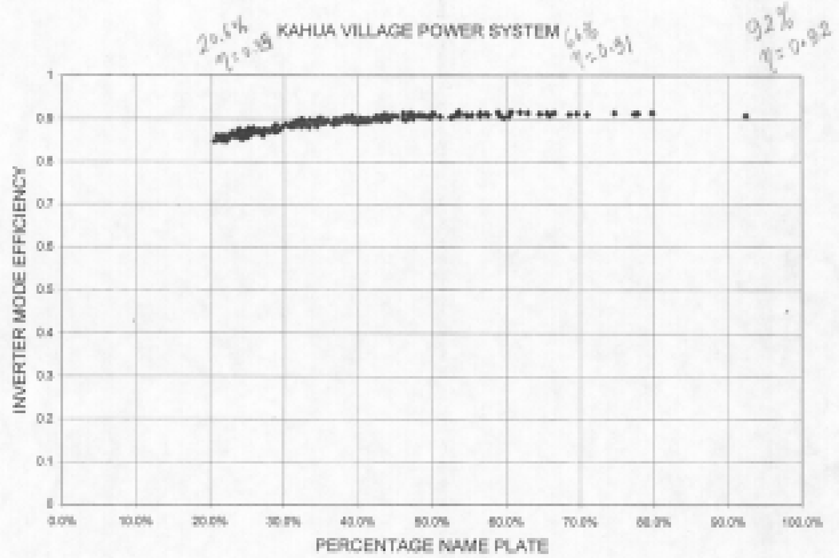
The Nabouwalu, Fiji System

- Eight Bergeys provide plenty of **redundancy** but they were difficult to fit into the site. Three or at most four larger turbines would have been better
- ASE Americas PV modules with high voltage cable connections built into the module, take much **less time** to wire (e.g., 40 kW in Fiji took 25% the time to wire 10 kW in Hawaii);
- One (of 144) module had its glass backing shatter from thermal effects, but it is still operational.

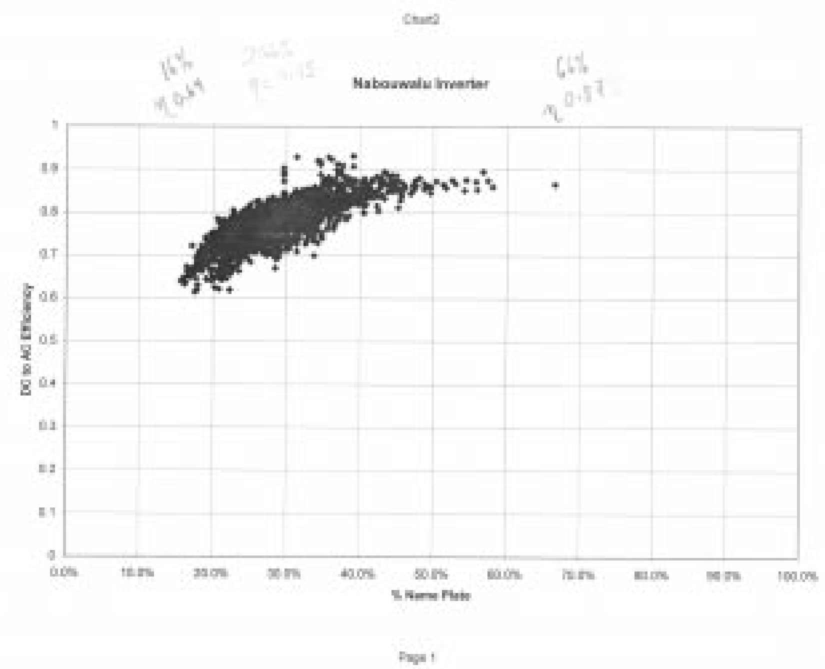
Luis A. Vega, Ph.D. Village Power 98

- The company chosen to provide the Fiji **inverter** had decades of experience in high power **UPS systems** and needed only minor modifications to turn one of its UPS consoles into a hybrid system inverter.
- The inverter is a hybrid rotary system: ABB **motor drive** powering an **induction motor**, which then turns a synchronous **generator**. The **capacity** of the inverter is such that it easily **supplies the load** and can start the entire load.
- The **efficiency is less** than the Hawaii static inverter, but the system has **been reliable** since installation.

Luis A. Vega 257 hourly averages



BIGINVERTER



- To allow **easier installation** and better cooling of the cells The battery in Fiji has cell trays one half the size (six cells vs. twelve cells).
- Either genset can run the village, but neither can start the entire village so if diesel is used to bring the village on line, the load must be **segmented** and placed on the grid in sequence;
- The **major problems** with the system have involved the **gensets**. Only one has actually been placed into service, because of a breaker failure in unit 2. This means that when bad fuel caused problems with the lone operational diesel, the system could not supply load. Public Works is attempting to remedy the **fuel quality problem** and repair unit 2.

Summary

- Incremental increases in **simplicity**, **redundancy**, **capacity** and **operational history** have **increased** the **reliability** of the Fiji hybrid power system over the Hawaii system;

- Both are connected to existing mini-grids that were served by fossil fueled generation. Both grids have seen an **increase** in **power quality**; and, the Fiji grid has seen an increase in **availability**.

Demonstration and Training Facility in Hawaii

- Kahua Ranch Village on the Big Island of Hawaii. The village is the residential and operational center for a cattle and sheep ranch. Baseline (360 kWh/day) facility was **installed June 1996** and **reliable operations** were achieved in **August of 1997**.

- 3 x 8 kW_p Bergey Wind Turbine Generators

- 40 x 245 W_p ASE Americas PV Modules (Crystalline Silicon)

- 428 kWh, 240 VDC Trojan (flooded lead acid) Battery

- 30 kW Solid State (Static) Inverter by AES

- 36 kW Koehler Diesel Generator

Luis A. Vega, Ph.D.

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SYSTEM PERFORMANCE

Design Conditions

- Annual averages of 5.25 sun-peak-hours/day (kWh/m^2-day) and 8.9 m/s;
- The **renewable energy** components were expected to meet **72%** od the demand, with the balance supplied by the genset;
- The COE was expected to be in the range of 0.32 to 0.36 $/kWh (15 years life; 3% to 5% loan; 5-year battery replacement)

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Actual Performance (Since 8/97)

- The **PV array** is supplying **94 %** of the **design** value; and,
- The **WTGs** were only supplying **74 %** of the **design** value; however stator **modifications** should increase production to the design value*;
- The actual COE will be in the design range ($\leq$ 0.36 $/kWh).

*once all stators are replaced.

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KAHUA (HAWAII) REPAIR RECORD

	Date	REPAIRS	I&M
Wind Turbines	4/97	Repaired slip ring brush (unit 3), downtime: 1day	Monthly:
Installed 6/96	8/97	Replaced leading edge tape (all units), 1d	Visual inspection
	9/97	Tail damper shafts failure observed (all units). Apparently since 6/96.	Quarterly:
	9/97	Tail attachment failure (unit 3); downtime: 1 month	Lower & inspect turbines
	10/97	Replaced tail (unit 3); 1d	Yearly:
			Tighten all connections

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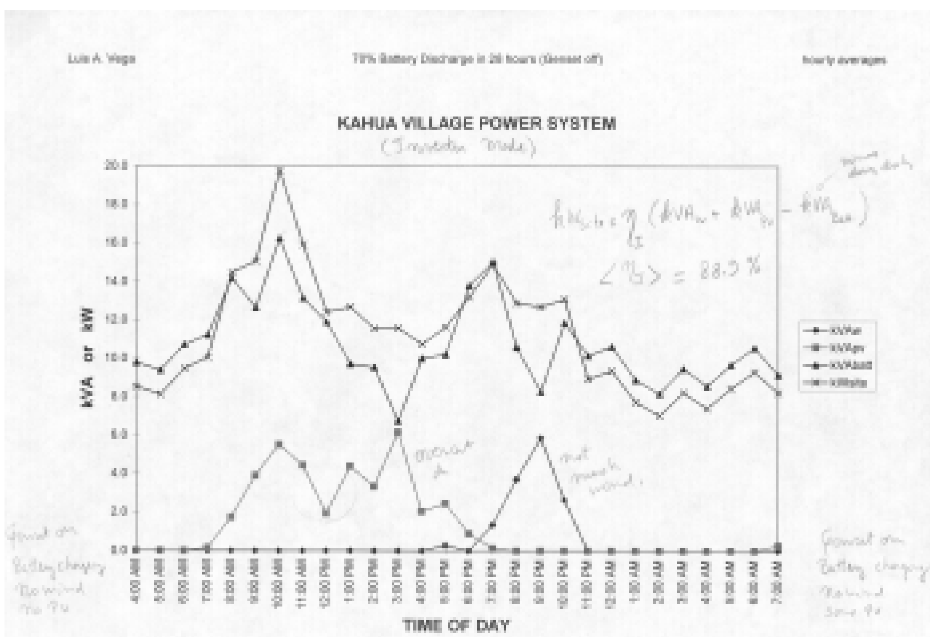
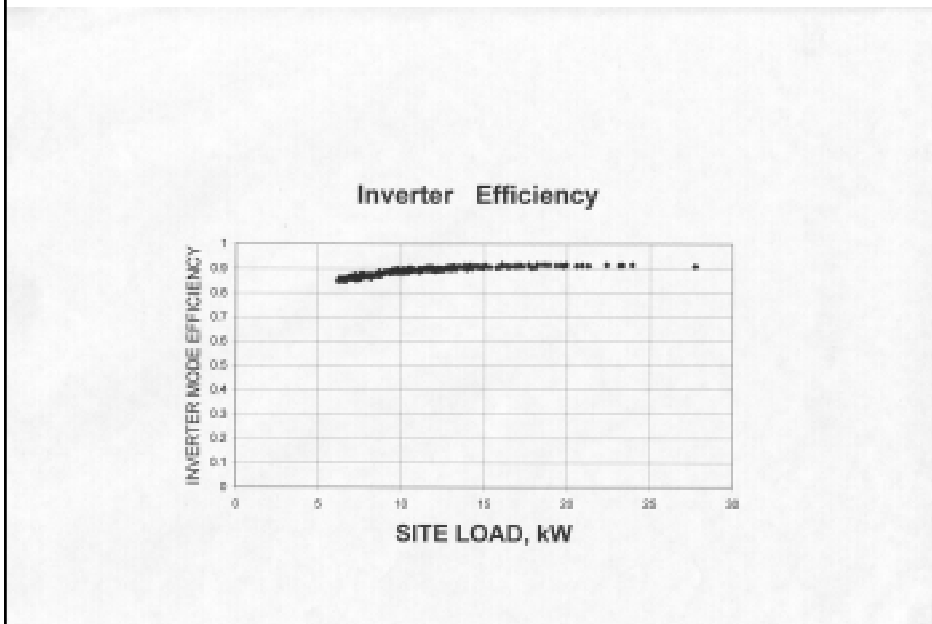
	Date	REPAIRS	I&M
Wind Turbines	3/98	Test of Unit 2 with standard stator vs experimental: Production 1.4 x	See previous page
	5/98	Another tail attachment failure (unit 1); 1 day	
	9/98	New designed tail damper shafts & pins received from Bergey.	
	9/98	Stator for Unit 1replaced with standard design (higher production).	

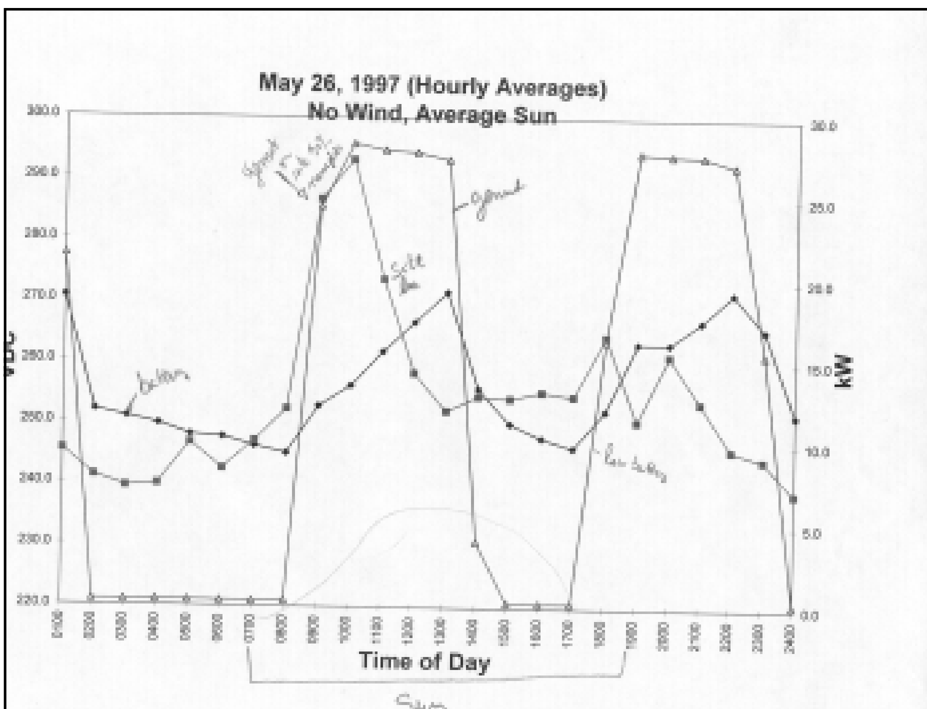
	Date	REPAIRS	I&M
Inverter	4/96 to 3/97	Set point changes	Monthly:
Installed 4/96	9/96	New operating software	Visual inspection
		Replaced failed relay	Yearly:
		Installed diode across contactor	Tighten all connections
	10/96	Replaced burnt capacitors & new firmware	
	12/96	Replaced failed control battery (& 2/97); firmware, etc.	
	8/97	Grounding mods. & ferrite EMI filters to eliminate radiation	

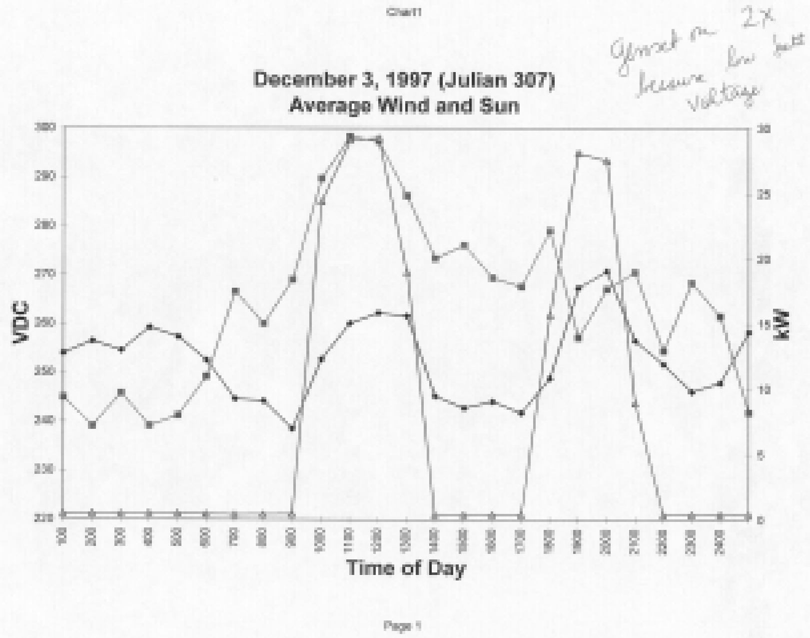
	Date	**REPAIRS**	**I&M**
Inverter	8/98	After 1-year of reliable operation, inverter fails to control genset output. IC socket corrosion suspected. Repair of socket requires de-powering control board…another control program (firmware) lost on re-power of control board	See previous page
	9/98	Control board replaced (includes upgraded firmware); downtime: 6-weeks.	

	Date	REPAIRS	I&M
Battery	6/97	Cleaned terminal corrosion	Biweekly: add 10 gallons of water
Installed 4/96	9/98	Cell 55 (of 120) very low voltage (0.82 V). Unable to charge. Cell jumpered across. Waiting for replacement.	Monthly: Visual Inspection. Yearly: tighten connections.



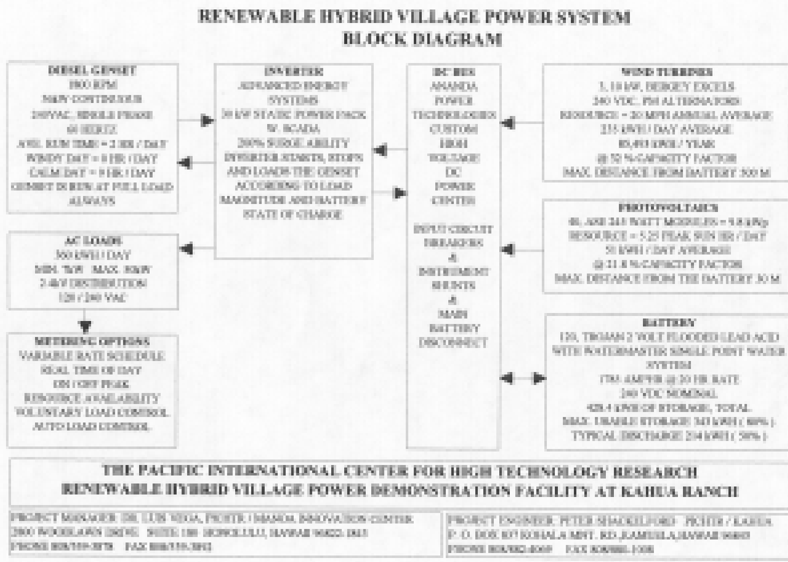

Inverter Efficiency
INVERTER MODE EFFICIENCY
SITE LOAD, kW


May 26, 1997 (Hourly Averages)
No Wind, Average Sun
kW
Time of Day



CONCLUSIONS Kahua (Hawaii)

- Testing has confirmed the importance of considering only **equipment with operational records** for applications in **remote locations**.
- Equipment must be tested as **part of a system** supplying electricity to actual users or to a load bank programmed to represent **realistic load profiles**.
- Preliminary **maintenance schedules** for all components have been developed.
- The **experience gained** was used to design a 720 kWh/day system for the village of Nabouwalu in Fiji.



LOCATION	**Kahua Training and Evaluation Center**			
Village Power System		**Size**	**Cost**	
Diesel	0.4 $/W	**35 kW**	$14 k	
Battery	110 $/kWh	**420 kWh**	$47 k	
Inverter/Controller	1.4 $/W	**30 kW**	$42 k	
PhotoVoltaics	4.5 $/W	**9.8 kW**	$44 k	
Wind Turbine Generators	2.5 $/W	**30 kW**	$75 k	
Installation & Infrastructure			$34 k	
Shipping	Included above		$0 k	20' container OK
TOTAL			$256 k	
CURRENT DOLLAR LEVELIZATION (Constant Annual Cost)				
Site Average Consumption	**360 kWh/day**	Annual Average		
Renewables Average Production	288 kWh/day	Wind	8.9 m/s	32.0%
Installed Cost Renewables (CC)	$242 k	Sun	5.3 sunhours	21.9%
OM, Yearly O&M	$9 k	Includes Replacements		
I, Interest (current-dollar discount rate)	5.00%	ADB/WB<5%	Others: 10%	
ER, Annual escalation (inflation) for entire period	2.00%			
N, System Life	15 years			
CAPITAL PAYMENT RENEWABLES				
CRF, Cap. Recov. Fac. or Invest. Level. Fac f(I,N)	9.63%			
Levelized Invest. Cost: CC*CRF/Yearly Production	**0.22 $/kWh**	"Loan Amortization Payments"		
O&M (Replacement) COSTS RENEWABLES				
CRF: f(I,N)	9.63%			
Present Worth Factor with Inflation: f(I,N,ER)	11.99			
ELF, Expenses Levelizing Factor f(I,N,ER)	1.15			
Levelized Expen. Cost: OM*ELF/Yearly Production	**0.10 $/kWh**	To cover Battery Replacement (10 years)		
Total COE Production With Renew.	**0.33 $/kWh**			

Table 2 Levelized COE at Kahua Training and Evaluation Center

LOCATION	LONG TERM COST GOALS APPLIED TO KAHUA RESOURCE			
Village Power System		**Size**	**Cost**	
Diesel	0.4 $/W	**35 kW**	$14 k	Mature Price
Battery	110 $/kWh	**428 kWh**	$47 k	Mature Price/Double Life
Inverter/Controller	0.7 $/W	**30 kW**	$21 k	Price same as Home Inverter
PhotoVoltaics	3.5 $/W	**9.8 kW**	$34 k	Production Increase Price
Wind Turbine Generators	2.0 $/W	**30 kW**	$60 k	Competition Pricing
Installation & Infrastructure			$34 k	
Shipping	Included above		$0 k	20' container OK
TOTAL			$210 k	
CURRENT DOLLAR LEVELIZATION (Constant Annual Cost)				
Site Average Consumption	**360 kWh/day**	Annual Average		
Renewables Average Production	288 kWh/day	Wind	8.9 m/s	32.0%
Installed Cost Renewables (CC)	$198 k	Sun	5.3 sunhours	21.9%
OM, Yearly O&M	$5 k	Includes Replacements		
I, Interest (current-dollar discount rate)	3.00%	ADB/WB<5%	Others= 10%	
ER, Annual escalation (inflation) for entire period	2.00%			
N, System Life	15 years			
CAPITAL PAYMENT RENEWABLES				
CRF, Cap. Recov. Fac. or Invest. Level. Fac.f(I,N)	8.38%			
Levelized Invest. Cost: CC*CRF/Yearly Production	**0.16 $/kWh**	"Loan Amortization Payments"		
O&M (Replacement) COSTS RENEWABLES				
CRF: f(I,N)	8.38%			
Present Worth Factor with Inflation: f(I,N,ER)	13.89			
ELF, Expenses Levelizing Factor f(I,N,ER)	1.16			
Levelized Expen. Cost: OM*ELF/Yearly Production	**0.05 $/kWh**	To cover Battery Replacement (10 years)		
Total COE Production With Renew.	**0.21 $/kWh**			

Table 3 Levelized COE for Long Term Cost Goals Applied to Kahua Resource

Luis A. Vega, Ph.D.

720 kWh/day Village Power System for Nabouwalu, Fiji

- Government station at Nabouwalu in Vanua Levu
- Wind and solar insolation monitoring station was set up, by FDoE, at a location selected after a field trip and in consultation with the residents
- With six-month environmental and electrical load data records (some correlated with twenty-year long records from a nearby meteorological station), the design was developed by PICHTR working with FDoE and PWD.

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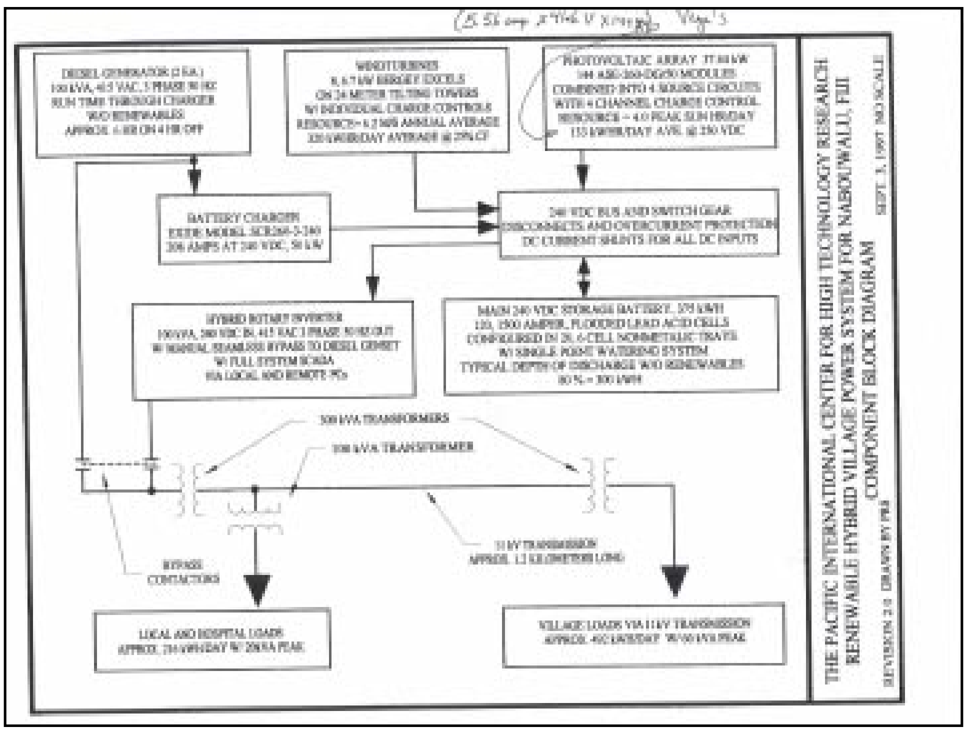
Design Configuration:

- 8 x 9 kW_p Bergey Wind Turbine Generators
- 144 x 260 W_p ASE Americas PV Modules
- 428 kWh, 240 VDC Trojan Battery
- 100 kVA Rotary-Hybrid Inverter by PS&C
- 2 x 100 kVA Diesel Generator and Mini-Grid in Nabouwalu



Energy Sources

Renewable sources are used to energize a DC bus, which supplies the energy to run a hybrid rotary inverter which in turn powers the load, the excess is stored in the battery

Wind Turbine Generators

- The WTGs turn permanent-magnet generators which produce three phase AC power of varying frequency …transmitted to the electrical/control room wherein the power is rectified and the voltage regulated
- With proper IM&R, the life of the wind turbines and towers should exceed 20 years.

PV Array

- DC electrical output of the fixed PV Array is regulated by a controller
- Minimal IM&R is required to attain life cycles of 30 years.

Genset

- The generators produce 50 Hz, three phase, 415 Volt output, to power the load directly and to charge the battery when required (set point 1.9 V/cell)

Energy Storage

- When the renewable resources are insufficient to support the load, the battery discharges to the DC bus.
- Fully charged, the battery can run the village ½ day.
- When the battery is charged (set point 2.4 V/cell), the WTGs and PV controllers limit the charge rate to prevent overcharging (i.e., regulate).
- With Proper IM&R the battery should last 5 to 10 years

DC to AC Conversion

- The hybrid rotary inverter consists of variable frequency motor drive (ABB) which converts the DC bus current to three phase, 50 hz, AC at ≈ 150 Volts RMS… to run an induction motor coupled to a synchronous generator which produces the 415 V, three phase, 50 Hz supply.
- The inverter requires no periodic maintenance other than inspection of the coupling between the motor and generator. The bearings in the motor and generator are sealed and cannot be greased. The expected life of these bearings in continuous service is 20 years.

SCADA

- Control of the inverter is shared between a microprocessor based control board and a GE Programmable Logic Controller (PLC-1).
- Another PLC (PLC-2), controls the operation of the diesel powered battery charger and collects data from various power monitoring and environmental sensors and transducers.
- Communication and collection of data from PLC-2 is through a personal computer running AIMAX software produced by T.A. Engineering.

Small village systems - Villa Las Araucarias

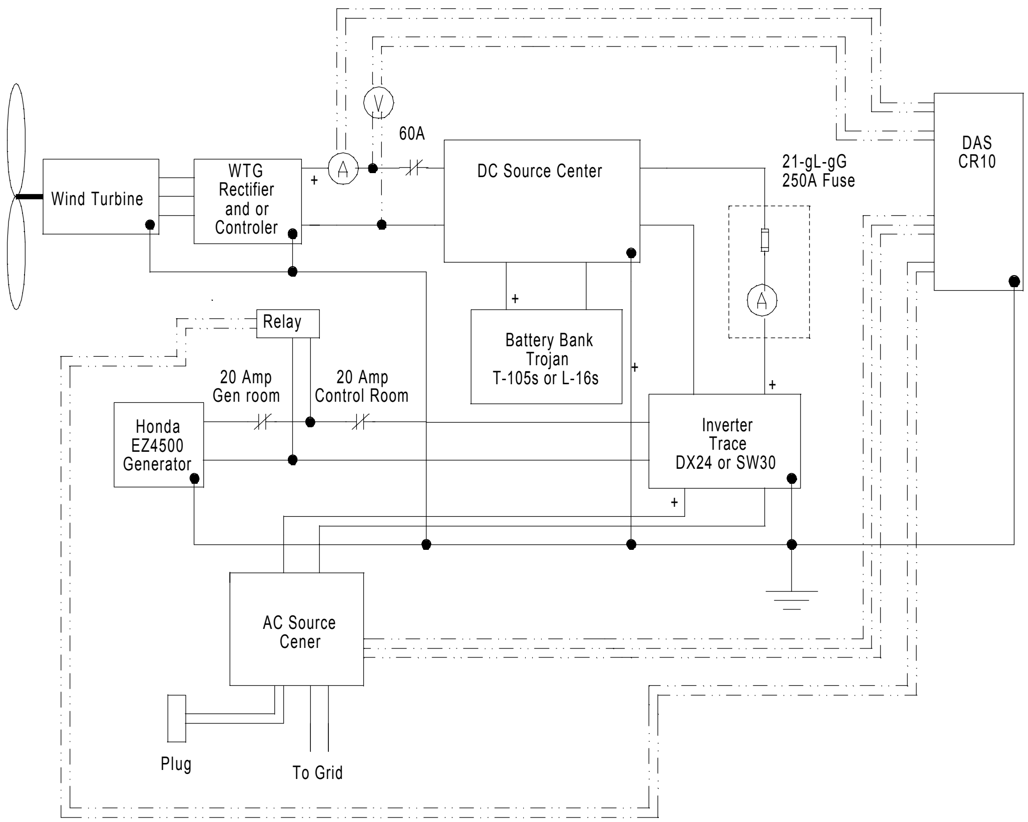
E. Ian Baring-Gould
National Renewable Energy Laboratory
Golden, CO. USA

•Villa Las Araucarias

- Inland community on the coastal range
- Mainly supported by forest industry
- Health post, school and 17 homes
- Community very prosperous and growing
- 9.8 kWh daily load with a 1.2 kW peak estimated.
- Average wind speed of 4.8 m/s

Villa Las Araucarias

Basic System Design



Power System Components

- **Bergey Windpower Excel 10kW wind turbine**
- **33.6 kWh battery bank of Trojan L-16's**
- **Trace Engineering SE3024E inverter**
- **Honda EM4500S 5.4 kW auto-start gasoline generator**
- **48 Volt DC bus with no DC loads**
- **220 V, 50 Hz AC distribution on a 0.91 km grid**

Positive Aspects

- **System has worked well from the technical side**
- **Most problems are of a social nature**
  - Utility
  - local operators
- **Problems can be solved**
- **Utility is pursuing technology in other areas**

Technical Problems - Specific

- **Lightning strike(?) knocked out equipment - Inverter and turbine**
  - Grounding enhancement's
- **Inverter repair problems (delay)**
- **Battery charging irregularities**
- **Repeated system downtime due to local system manipulation**

Technical Problems - General

- **Access to spare parts/repair**
- **Inadequate manuals -**
  - troubleshooting
  - languages
- **Equipment design for sustainability**
- **Poor communications with sites**

Social Problems

- **System service and repair**
  - Utility is reactive not proactive
  - Turnover of key utility personnel
  - Conflicts between utility branches (Engineering verses Operations)
- **Local operators**
  - Systems treated like fiefdoms
  - No apparent understanding of operation

Current Status

- **System operational**
- **Renewed support from Utility**
  - Regular general maintenance
  - Local support of system
  - Understanding of support requirements
- **DAS system operational**
- **Equipment working properly**

Northern Power Systems, Inc.
Waitsfield, Vermont USA

Hybrid Power for Village Applications

Examples of Medium-Sized Systems:

Joanes, Brazil
Lime Village, Alaska
St. Paul Island, Alaska

Presented At Village Power '98
World Bank, Washington, DC

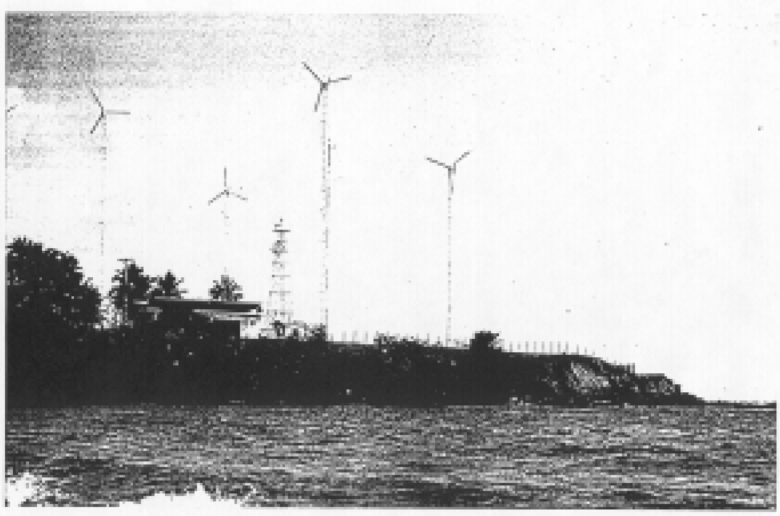
Northern Power Systems

Northern Power Systems

- Manufacturer of renewable & hybrid power systems since 1975
- Telecom & village installations in over 30 countries & on all 7 continents
- Integrated power systems engineered for specific applications or sites
- Northern Power components include:
  - ◊ Hybrid System Controllers
  - ◊ Monitoring Systems
  - ◊ Wind Turbines
  - ◊ Controlled Environment Shelters
  - ◊ Photovoltaic Array Frames & Trackers
  - ◊ Rotary DC/AC Power Converters

Hybrid Village Power System
Joanes, Brazil

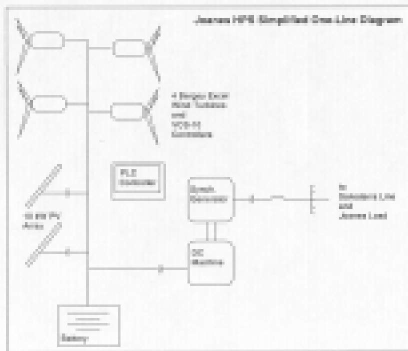
Type of System	50 kW; grid interconnect; wind/PV, battery storage
Application	Support of a weak diesel grid to deliver energy and stabilize power quality during hours of peak demand
Location	Island of Marajo in the Amazon/Toncantins delta
Population	2000
Peak Loads	>75 kW
Funding	NREL; CEPEL (Brazilian renewable energy organization); CELPA (Utility of the state of Para)
Project Status	Commissioned in 1997; being operated by CELPA; satellite link provides access to data

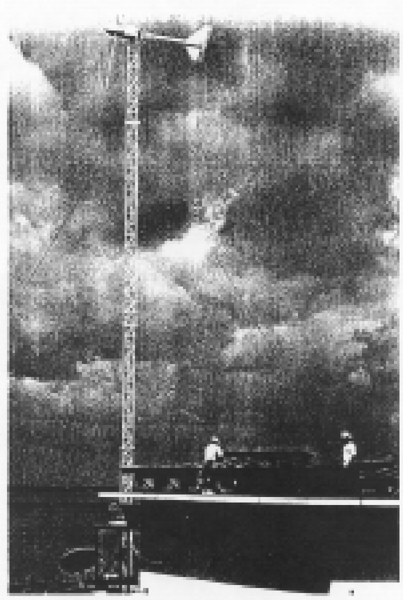


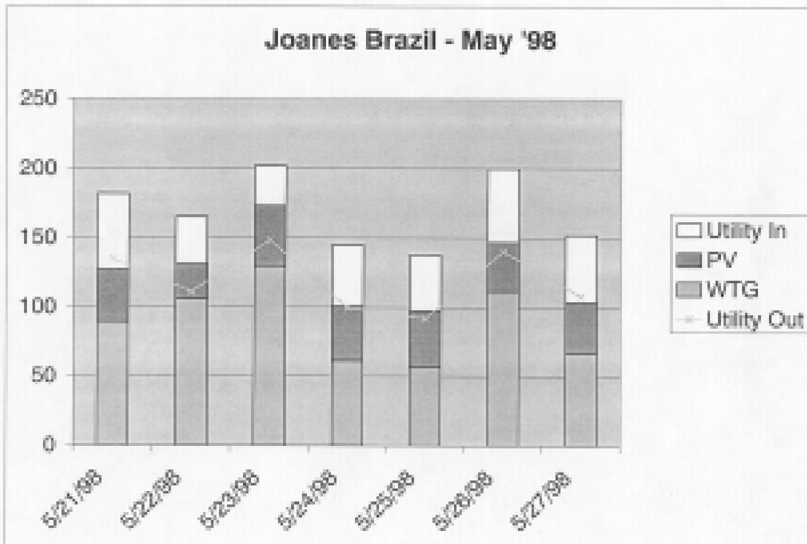
Configuration

NPS Controller/Monitor
Utility Interconnect Switchgear
228 kWh Battery Bank

4 Bergey Excel-R Wind Turbines
10 kW Photovoltaic Array
NPS 50 kW DC/AC Rotary Converter w/o Engine

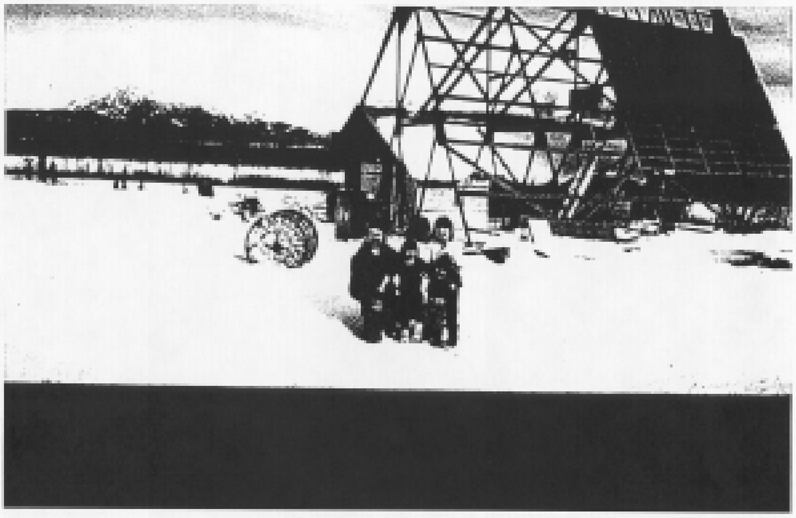






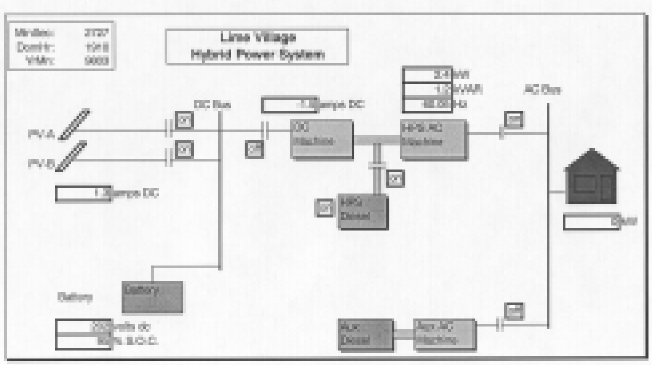
Hybrid Village Power System
Lime Village, Alaska

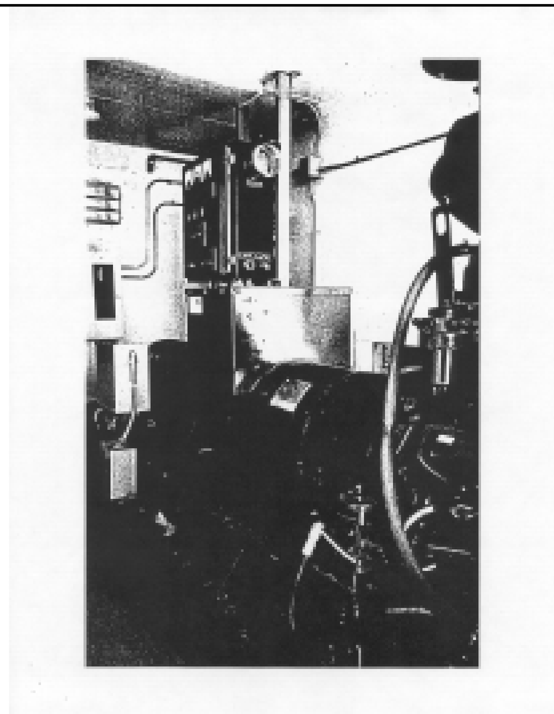
Type of System	50 kW; Stand-alone grid; PV/diesel, battery storage
Application	Village electrification; power previously available only from small individual generators
Location	Roadless interior, approx. 250 air miles from Anchorage
Population	45
Peak Loads	Undetermined
Funding	Alaska Science & Technology Foundation; Lime Village; Univ. of Alaska; State of Alaska
Project Status	Installed in 1998; waiting for generation permit; will be maintained by McGrath Light & Power; phone link provides remote access to operating data



Configuration NPS Controller/Monitor
NPS 50 kW DC/AC Rotary Power Converter w/ Engine
4 kW Photovoltaic Array
100 kWh Battery Bank
Auxiliary 35kW Diesel AC Genset

Lime Village Remote Monitoring Screen:





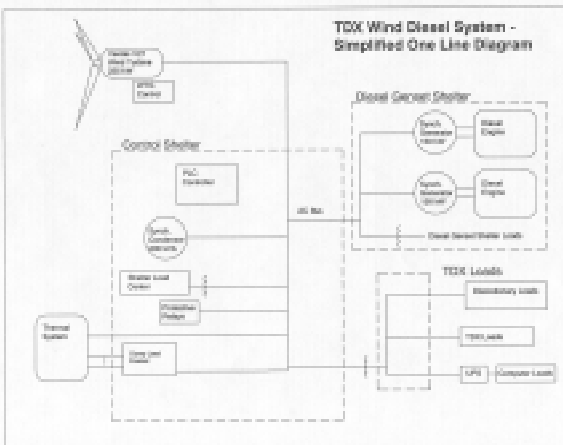
Hybrid Village Power System
St. Paul, Alaska

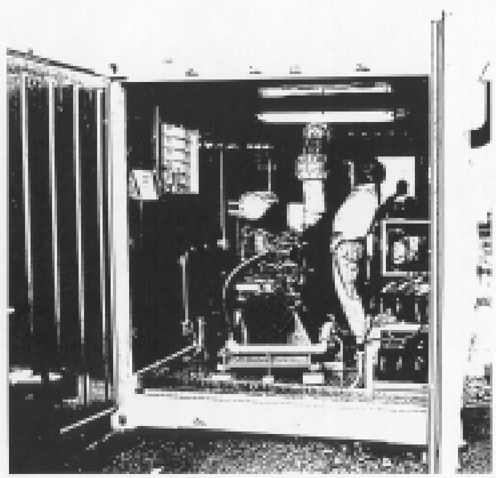
Type of System	300 kW; stand-alone; wind/diesel; heat storage
Application	High penetration wind/diesel system to provide electricity and space heat for village industrial facility
Location	Pribilof Islands in the Bering Sea
Peak Loads	160 kW
Funding	Tanadgusix Corporation (TDX)
Project Status	Equipment shipped from NPS for installation in late 1998; to be maintained by TDX; phone link provides remote access to operating data
Cost of Energy	± $.20/kWh; current diesel grid cost is $.32/ kWh

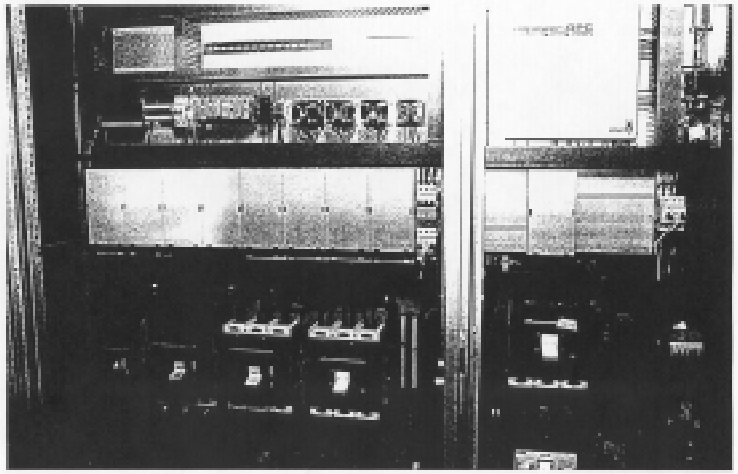
Configuration

NPS System Controller/Monitor
Vestas V-27 225 kW Wind Turbine
2 x Volvo 150 kW Diesel Gensets
HydroQuebec Dump Load Regulator

NPS Integrated Shelter/Container
NPS Heating & Thermal Storage
NPS Synchronous Condenser
Encorp Engine Controls







Kotzebue Electric Association

M. Lodge

- Phase 1 - 3 x AOC 15/50 97/98
- Phase 2 - 7 x AOC 15/50 98
- Phase 3 - 500 + KW

Lessons Learned:

- Site/Access/Construction
- Foundations
- Scheduling/Readiness
- Monitoring/Control
- Quality Control
- Power Quality no problem
- Utility is keen and competent

Hybrid Systems Control

Aspects:

- Monitoring, communication, control

Issues:

- System size
- Single/multi generators
- Paralleling
- Intrinsic control/System control
- Sensors
- Internal/external communication

Requirements:
- Safety
- Protection
- Understandable
- Repairable

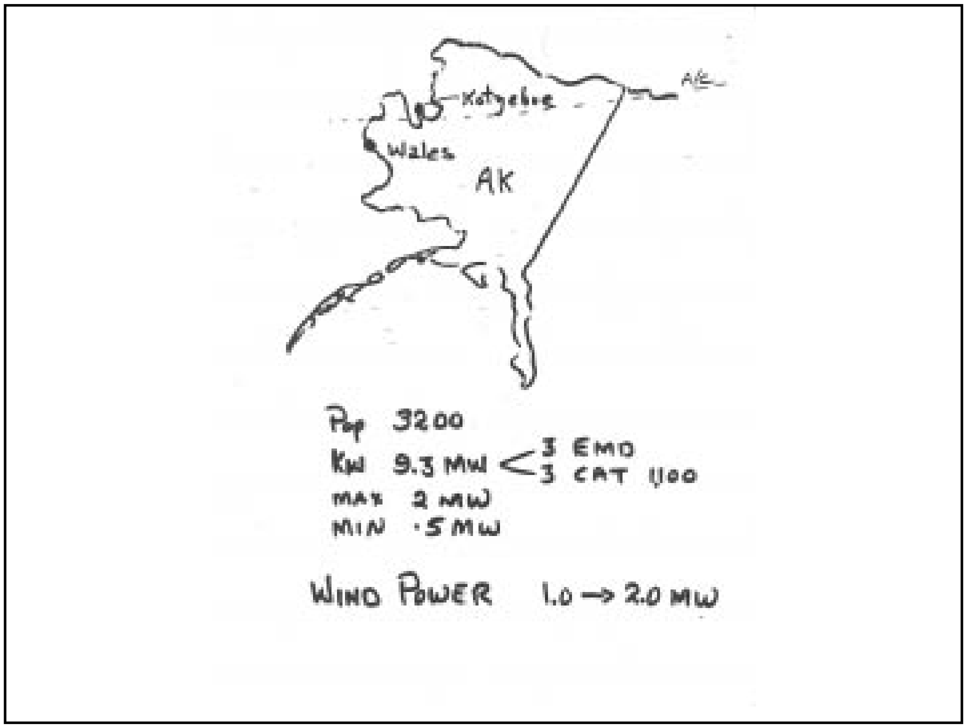
Monitoring
- Control Decision
- Fault Detection/Diagnosis

Power Quality
- Good quality appreciated

Equipment Hardware
- Robust
- User friendly
- PC's / PLC's

Supervisory Control:
- Integration of components
- Multiple functions
- Load management
- "Optimal" control
- Storage/dump loads
- Diesel dispatch
- Dispatchable renewable

Common Language?


Kotzebue
Wales
AK
AK
Pop 3200
Kw 9.3 MW < 3 EMD
3 CAT 1100
MAX 2 MW
MIN .5 MW
WIND POWER 1.0 → 2.0 MW

VESTAS - INTERNATIONAL WIND TECHNOLOGY A/S
Niels Andersen

WIND POWER – ISLAND SYSTEM

Operation of four wind power plants on four islands in the Aegean Sea.

Project Decription:

The each power plant were installed in 1992 as Turn-Key projects by the Consortium Vestas/Rokas on the following islands:

Andros:	7 V27-225KW	(1,575MW)
Samos:	9 V27-225KW	(2,025MW)
Chios :	11 V27-225KW	(2,475MW)
Psara :	9 V27-225KW	(2,025MW)

The wind power plant on each island is connected to the local diesel power station.

A load management system, placed at the diesel power station, is controlling the wind/diesel power output.

Existing Diesel Generation Capacity:

Andros:19,640MW	used:12,100MW
Samos:43,755MW	26,100MW
Chios Psara :46,090MW	26,500MW

DIESEL OIL SAVED BY USING WIND POWER,IN TONS.

	1993	1994	1995	1996	1997
Andros	412,8	424,8	395,1	418,4	425,9
Samos	489,3	538,4	541,5	504,6	415,3
Chios	501,4	614,7	562,8	530,5	503,1
Psara	354,9	418,2	427,7	430,2	443,9

NET PRODUCTION OF DIESEL AND WIND GENERATION

	1993	1994	1995	1996	1997
Andros	33045	35465	38334	37072	33330
	4839	4980	4631	4904	4992
Samos	72869	76415	86912	89663	90676
	5736	6311	6348	5915	4868
Chios Psara	91577	92970	99528	108318	117220
	10037	12108	11611	11262	11101

Above figures = MWh

DC systems

Mike Bergey
Bergey Windpower Company

Hybrid System Workshop
Village Power Conference, 1998

The Industry

- Village power, home systems and telecom
- Small Wind: Undercapitalized, mom and pop industries.
  - Production in industry is growing
  - Industry has some extra money to funnel into development.

Key markets and issues

- Home hybrid systems (PV, Wind etc) - Allows a higher level of service then just home PV
- Very good for very small turbine manufactures
- Standardization of DC bus systems
- Large orders of systems for the same size
- Technology is advancing but reliability is still a problem. More expensive produces trying to reduce the costs while the producers with cheaper equipment are trying to increase reliability.
- Inverters are working well
- Growing evidence of longer battery life when charged by wind systems

National Wind Technology Center

High Penetration AC Bus Wind-Diesel Hybrid Power Systems

Village Power '98
Technical Workshop

Steve Drouilhet

Sr. Engineer

National Renewable Energy Laboratory

Golden, Colorado, USA

Defining the Wind Penetration

$$\text{Energy Penetration} = \frac{\text{Wind turbine AEO}}{\text{Annual primary energy demand}}$$

$$\text{Power Penetration} = \frac{\text{Instantaneous wind power output}}{\text{Primary load}}$$

Low Penetration Systems

< 20% energy penetration
<50% peak power penetration

- Typically only found in retrofit situations
- All renewable energy output goes directly to serving primary load
- Minimal impact on diesel plant operation
- Few additional control components required
- Higher rate of return on investment possible
- Limited impact on fuel savings, diesel run time, and overall C.O.E.

High Penetration Systems

> 50% energy penetration
> 100% peak power penetration

- Larger potential impact on fuel savings, diesel run time, cost of energy.
- Usually requires energy storage to realize full benefit of wind energy component.
- Requires additional components (e.g. dump loads, synchronous condensers, power converters, etc.) to regulate system voltage and frequency.
- Typically lower rate of return on investment, due to higher per kW capital cost of system. Situation is helped by reduction in diesel maintenance cost.
- Increased system sophistication requires greater support infrastructure.

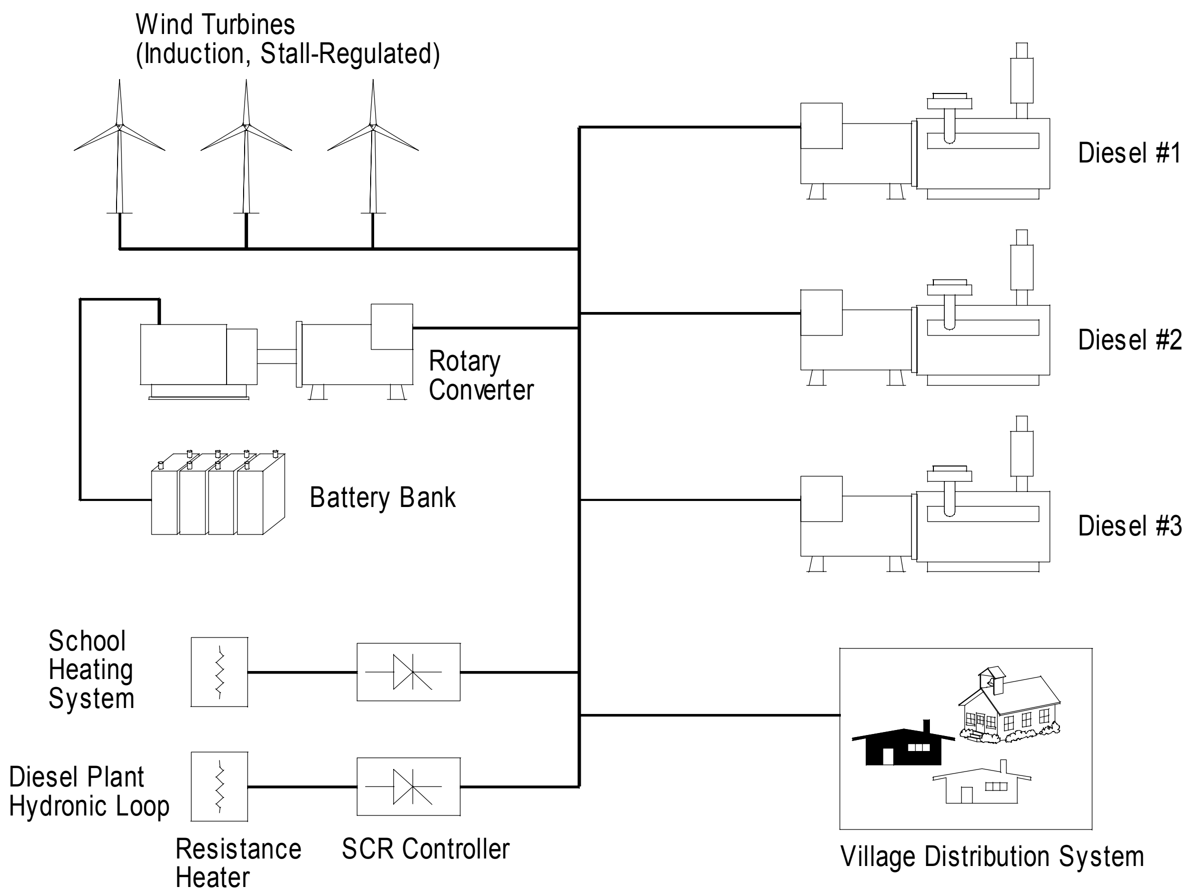
Comparison of AC and DC Bus Wind Hybrid Systems

Issue	AC Bus	DC Bus
Scale	Best suited to systems > 40 kW. Permits use of larger more cost-effective wind turbines	Best suited to small systems. Simpler architecture more easily maintained.
Renewable Energy Path	Wind turbine power can flow directly to the load, without the losses associated with power conversion.	All power must flow through a DC/AC converter (rotary or inverter)
Siting	Existing AC distribution lines can be used to connect wind turbines to power system.	Requires dedicated lines to connect turbines to power system.
Control Complexity	Active control system required to dispatch wind turbines, modulate dump load power, dispatch storage, etc.	Relatively simple system control. However, embedded inverter controls can be complex.
Cost	Often competing with existing diesel power stations. Must be competitive with diesel only.	Often offers 24 hr/day power where none existed. Higher costs are tolerated.

Principles of AC Bus Hybrid Power Systems

- Frequency is controlled by maintaining a balance of real power
  - ⇨ dump loads
  - ⇨ control power to/from energy storage
  - ⇨ diesel load following
    - > ordinary diesel
    - > variable speed diesel
  - ⇨ controllable output variable speed wind turbine
- Voltage is controlled by maintaining a balance of reactive power
  - ⇨ diesel generator voltage regulator
  - ⇨ synchronous condenser
  - ⇨ static VAR compensator

AC Bus Wind-Diesel Architecture for Wales, AK



Conclusions

- High penetration AC bus wind-diesel systems have complex control requirements. Significant engineering development effort is required.
- AC bus architecture appears to be the more cost-effective choice for larger (>100 kW) hybrid power systems
- System integration is the key. The individual components of an AC system can be as reliable as those of a DC system.

Steve Phillips

Advanced Energy Systems
Australia

HYBRID SYSTEMS

- Engines (AC)
- Storage (DC)
- Power Conversion (AC/DC/AC)
- Control (Hardware/Software
- Renewables (AC/DC

POWER SUPPLY SYSTEMS

- Cost
- Reliability
- Quality
- Efficiency

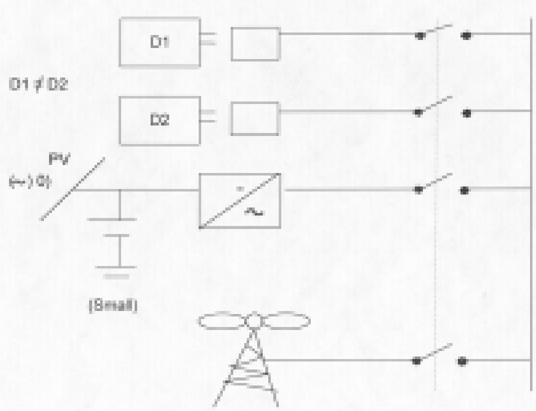
COST

- Process Intensive (least materials possible)
- Software Intensive
- Least Storage
- Least Renewables

RELIABILITY

- Mature Designs
- Field Experience
- Manufacturing Control
  Quality (of power)
- Process Control

PREFERRED DESIGN
(20-1000 kWh/d)



Retrofitting Diesels in International Settings

E. Ian Baring-Gould

National Renewable Energy Laboratory
Golden, Colorado

Retrofitting options

Five types of retrofitting options are seen as most likely:

- **Type A:** Adjust diesel size or install a second diesel engine.
- **Type B:** Add automatic controls to an existing diesel plant.
- **Type C:** Install batteries and a power converter to cover low load periods.
- **Type D:** Install renewables to reduce diesel operation.
- **Type E:** Installation of an advance hybrid power system that will result in shutdown of all diesels.

Retrofit options depend primarily on resource, load size and the load profile

Simulation models greatly assist in the design process

Technical issues

- Resource assessment / Data collection
  - Always a problem
- System Questions
  - stability, voltage, frequency and power system failures
  - Defining requirements of voltage and frequency
  - UPS systems for critical loads
  - Penetration of wind turbine
  - Control system complexity
  - Different methods of system stability control (passive, active)
  - Availability of thermal or controllable loads

Technical issues II

- Continued system support
  - Number of systems to allow support infrastructure
  - Hybrid systems are power systems, they need technical support like any power plant
  - Tariff to allow system sustainability
- Energy efficiency implementations / re-wire
  - Electrical efficiency not critical in many diesel plants & so systems do not have them
  - The cost to produce an addition kWh of energy while the diesel is operating is minimal (Avoided cost of diesel) but with power from renewables/battery it is expansive
  - Installation of energy efficient devices is critical to system cost

Social issues

- Level of service
  - What is currently provided
  - What is mandated or wanted
  - Willingness to pay for increased level of service
- Final decision
  - Usually based on economics and policy considerations (environmental and comfort level secondary)
  - Color of money issues
- Tariff structure to insure operation & control growth
- Training of utility personnel

Steps in Retrofitting

- Resource assessment (Macro/micro)
- Initial social impact assessment: LoS, willingness to pay
- Load measurement: Current, new and large loads
- Options analysis / feasibility study
- Go/no-go decision
- Gathering system information
- Detailed system design
- Specifications of social issues: Tariffs, O&M
- Final decision/project funding
- System installation/commissioning/DAS
- Continued O&M, oversight and expansion

Tres Lagos, Argentina

Existing all diesel power system in remote community.

Community load: 200 inhabitance with 80 power connections

- Hourly average load was 37 kW (17 to 67kW range)
- 200 kWh/user/moth
- Potential thermal loads
- Lots of room for efficiency measures

Wind Data: Collected at the site for about 9 months - Long term data from other area towns

The Tres Lagos diesel plant: 3 diesels w/ local distribution

- Two 80 kW units
- One 100 kW unit

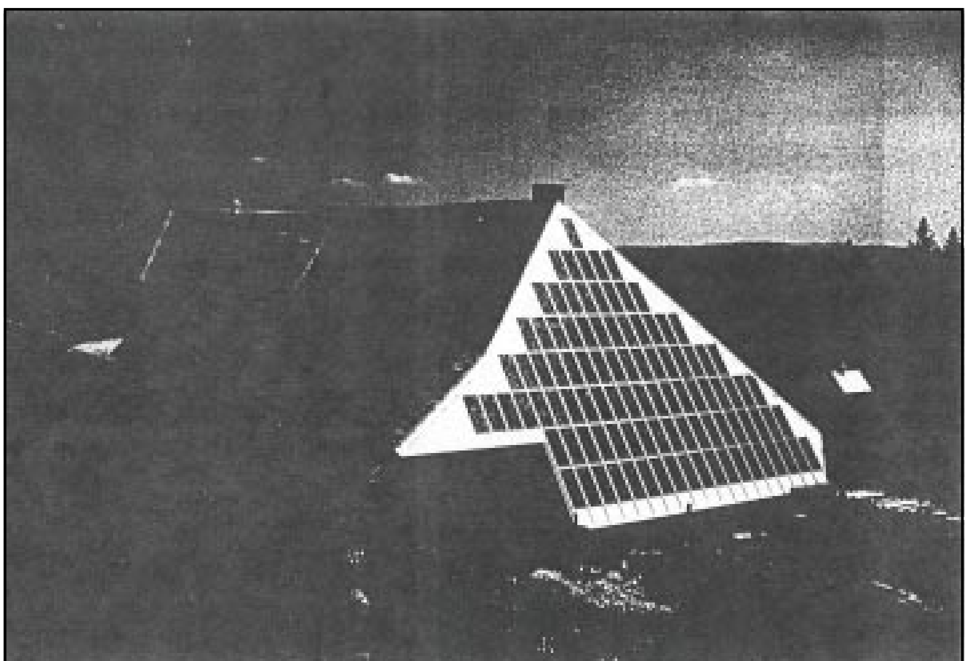
Fuel price: $0.37/liter

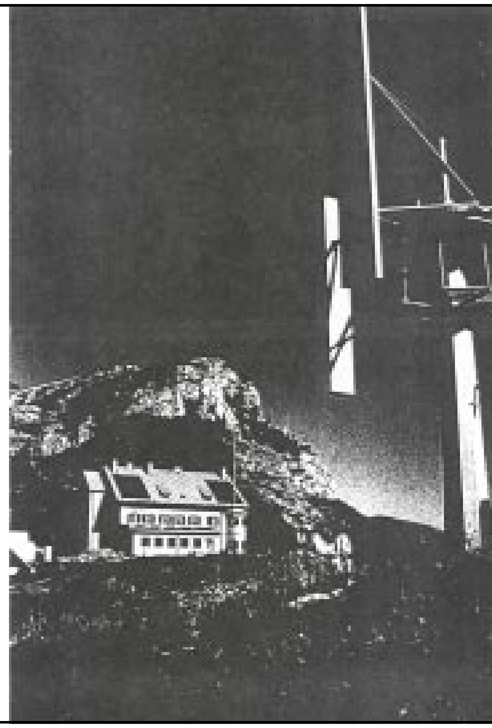
Hybrid Photovoltaic-Diesel-Battery Systems for Remote Energy Supply

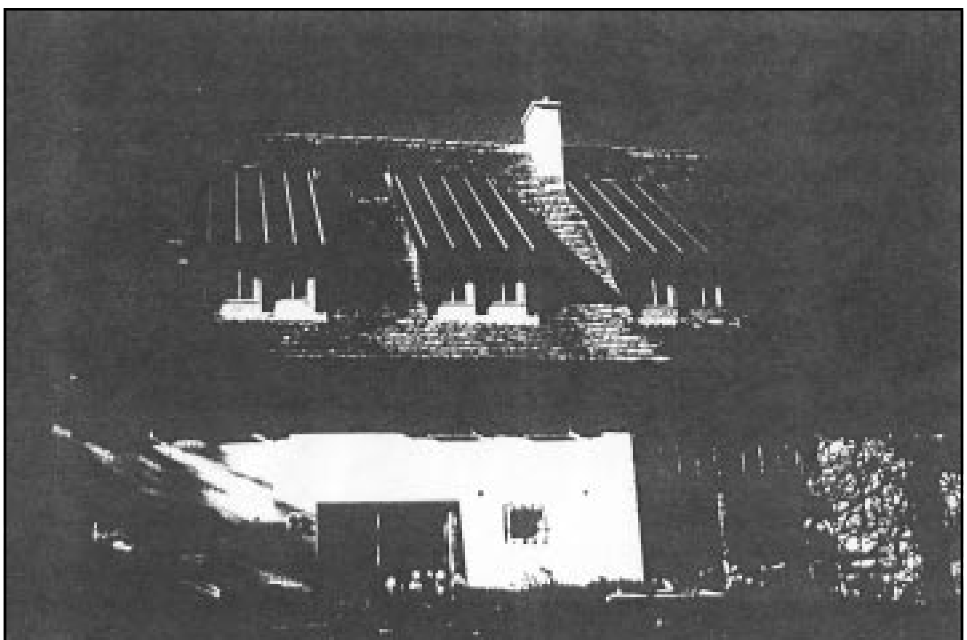
K. Preiser, G. Bopp, K. Reiche

Fraunhofer-Institute for Solar Energy Systems ISE
Oltmannsstrasse 5
D-79100 Freiburg, Germany

Fraunhofer Institut Solare Energiesysteme







Basic technical goals:

- provide a continuous (24 hours) AC-supply
- reach a high supply reliability
  (most systems are for commercial use: farms, tourist facilities)
- reduce the operating times and the fuel consumption of existing diesel generators considerably (thus reducing operating costs and pollution through noise and exhaust gases)

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Hybrid Photovoltaic-Diesel-Battery Systems for Autonomous Energy Supply

Buildings without energy supply from a public electricity grid (in Europe)

Holiday & weekend residences	500 000
Permanently inhabited houses & farms	300 000
Facilities for tourists: mountain lodges, hikers inns, ...	several thousands

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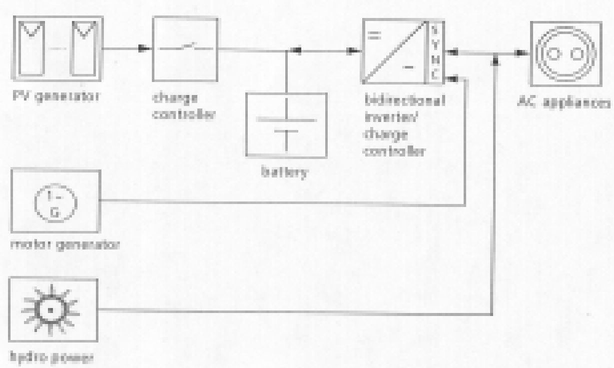

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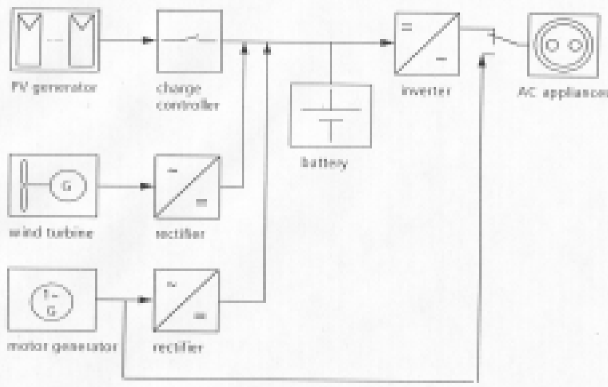

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System layout: Rappenecker Hof

Daily load	9	kWh
Inverter, nominal power	4	kW
Battery, energy stored	32	kWh
PV-generator, nominal power	3,8	kW
Wind turbine, nominal power	1,0	kW
Diesel Generator, nominal power	16	kW

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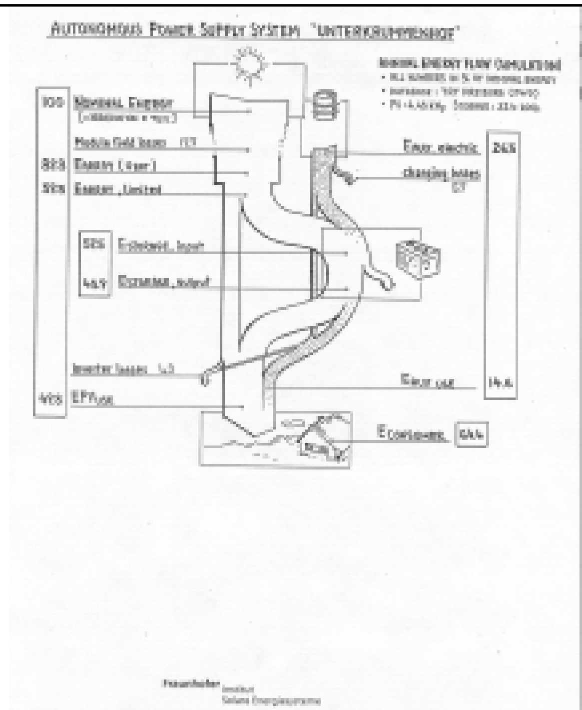
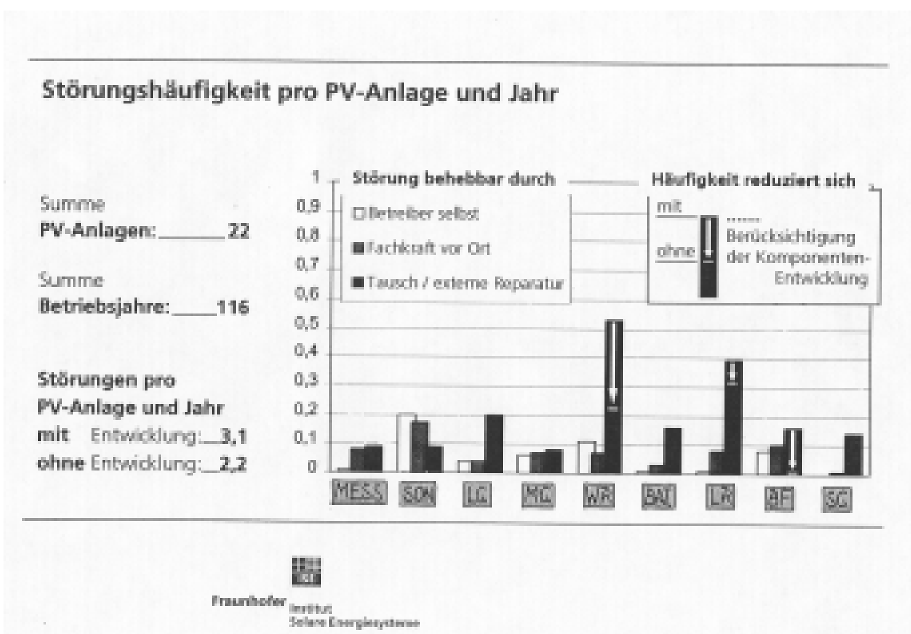


AUTONOMOUS POWER SUPPLY SYSTEM "UNTERKRUMMENHOF"



Störungshäufigkeit pro PV-Anlage und Jahr
Summe
PV-Anlagen: 22
Summe
Betriebsjahre: 116
Störungen pro
PV-Anlage und Jahr
mit Entwicklung: 3,1
ohne Entwicklung: 2,2
Störung behebbar durch
Betreiber selbst
Fachkraft vor Ort
Tausch / externe Reparatur
Häufigkeit reduziert sich
mit
ohne
Berücksichtigung der Komponenten-Entwicklung
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
MESS
SON
LG
MC
WR
BAT
LR
BF
SG
Fraunhofer Institut Solare Energiesysteme

Operating experience / lessons learnt

PV-modules: usually the most reliable part of the system

Batteries: limited lifetime of three to five years
solution: intelligent charge control

Inverters: high part load efficiency is absolutely necessary, few good inverters are on the market

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Operating experience / lessons learnt (continued)

Appliances: energy saving must be an integral part of system planing

Supply reliability: not yet satisfying
solution: professional maintenance schemes

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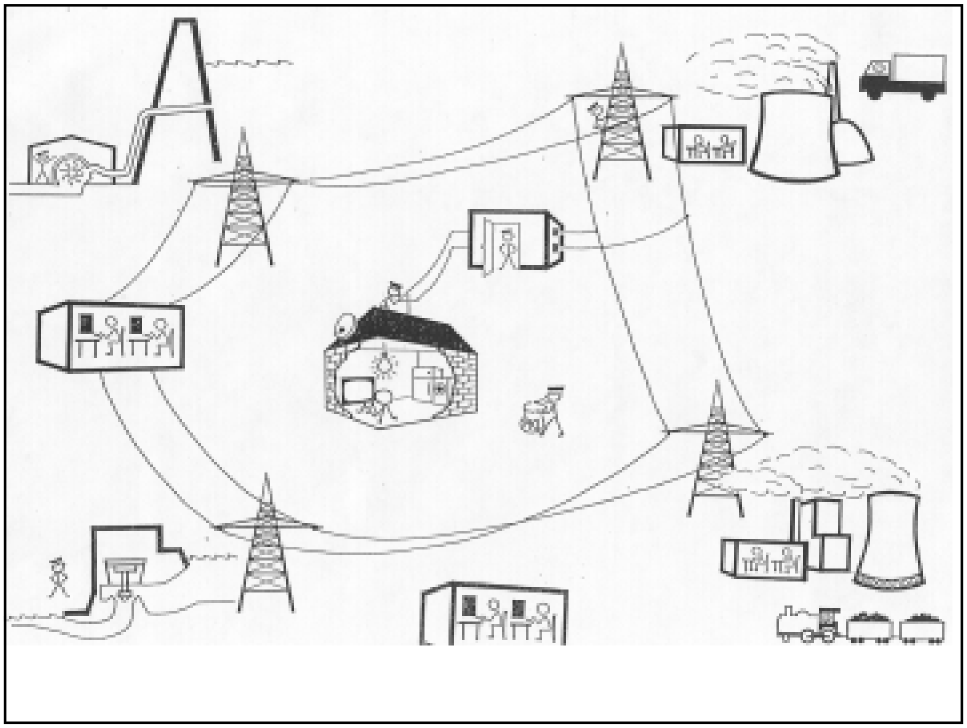
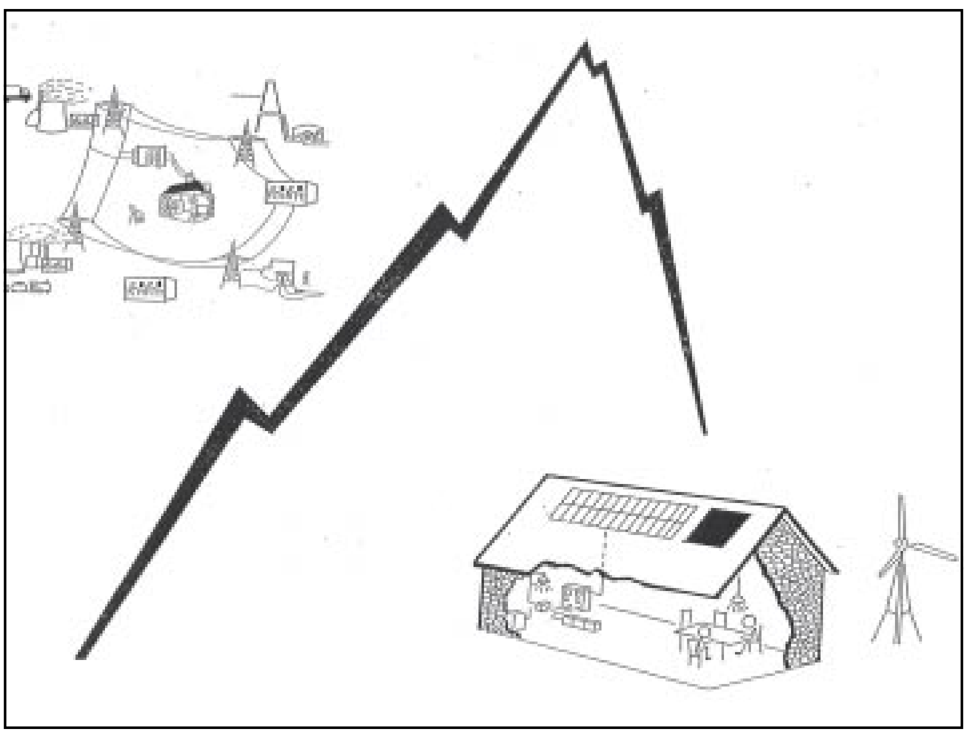




Conclusions

Hybrid Photovoltaic-Diesel-Battery-Systems for remote energy supply are a proven technology.

Potential for improvements

- system reliability
- standardization (modularity) of components and system layout
- battery lifetimes
- energy flow management

Economic evaluation is still under discussion.

Fraunhofer Institut Solare Energiesysteme

National Wind Technology Center

Energy Storage for Hybrid Village Power Systems

Village Power '98
Technical Workshop

Steve Drouilhet

Sr. Engineer

National Renewable Energy Laboratory

Golden, Colorado, USA

Defining the Energy Storage Capacity

- It is convenient to define storage capacity in terms of the time that the nominal energy capacity could cover the load at rated power.
- Example: What is the nominal power duration of a 250VDC, 200 amp-hr battery in a power system rated at 100 kW?

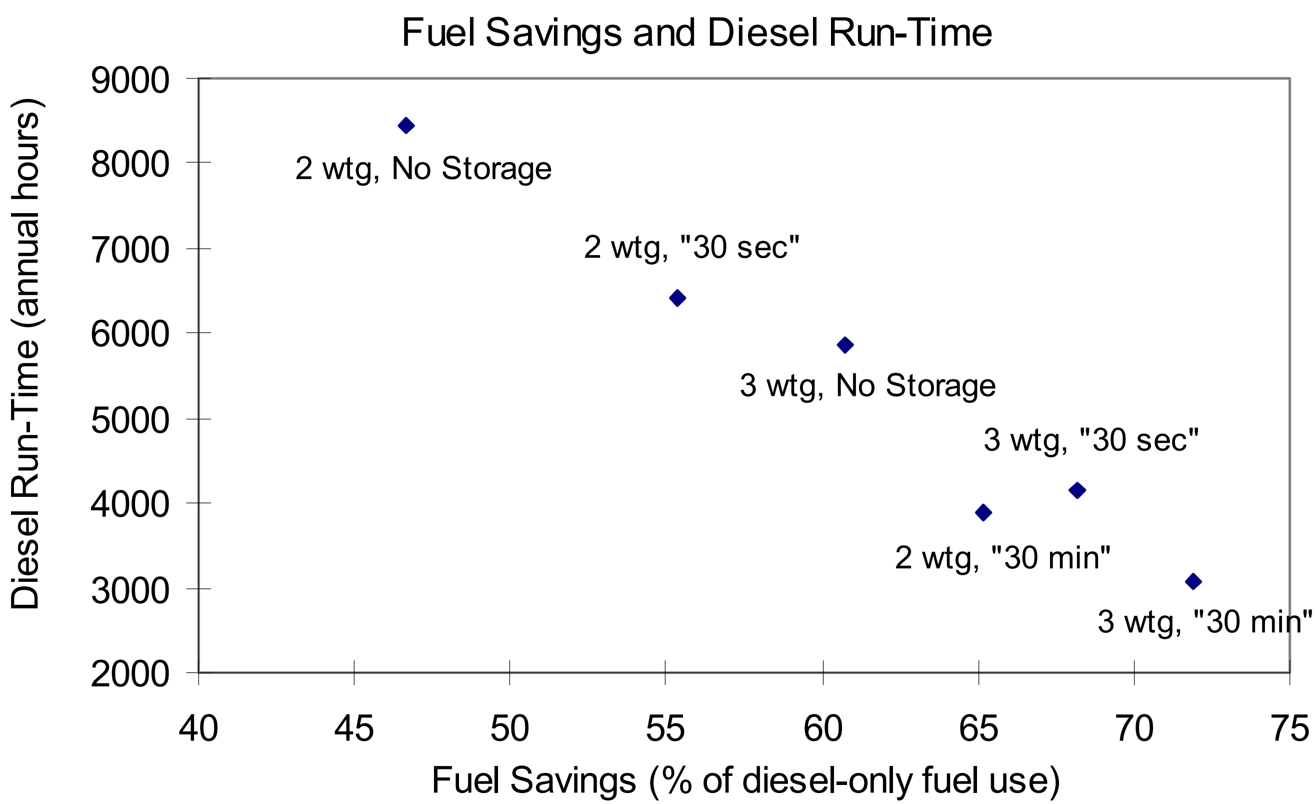
$$Capacity = \frac{(200 \times Amp\text{-}hr)(250 \times Volts)}{100 \times kW} = 30 \times minutes$$

Hybrid Power Systems Use Various Amounts of Energy Storage Depending on the Objective

Storage Capacity	Function of Energy Storage
Very short term (less than 1 minute)	Helps cover the load during the time it takes to start and synchronize the backup generator. • increases system reliability • reduces required reserve capacity
Short term (5-60 minutes)	Helps cover the load during short term load peaks or wind energy deficits, eliminating the need to start the backup generator. • significant reduction in diesel run time and fuel consumption
Medium term (2-12 hour)	Stores excess renewable energy to be used to meet the load later in the day. • Further reduction in diesel run time and fuel consumption • Provides greater utilization of available renewable energy; less renewable energy is wasted
Long term (1-3 days)	Stores excess renewable energy to meet the load during days of higher than average load or lower than average renewable energy availability. • Possibly eliminates need for back up generator

National Wind Technology Center

Impact of Energy Storage on a High Penetration Wind-Diesel Village Power System



Applicability of Various Energy Storage Technologies to Different Storage Requirements

Storage Capacity	Technology	Status
Very short term (less than 1 minute)	NiCad Battery Lead-Acid Battery Flywheel	Commercial Commercial Near commercial
Short term (5-60 minutes)	NiCad Battery Lead-Acid Battery Flywheel	Commercial Commercial Experimental
Medium term (2-12 hour)	Lead-Acid Battery Hydrogen	Commercial Experimental
Long term (1-3 days)	Lead-Acid Battery Pumped Hydro Hydrogen	Commercial Experimental Experimental

Some Energy Storage Technologies Used or Proposed for Hybrid Village Power Systems

- Lead-Acid Battery
- Nickel-Cadmium Battery
- Flywheels (Electromechanical Battery)
- Hydrogen
- Pumped Hydro

Lead-Acid Battery

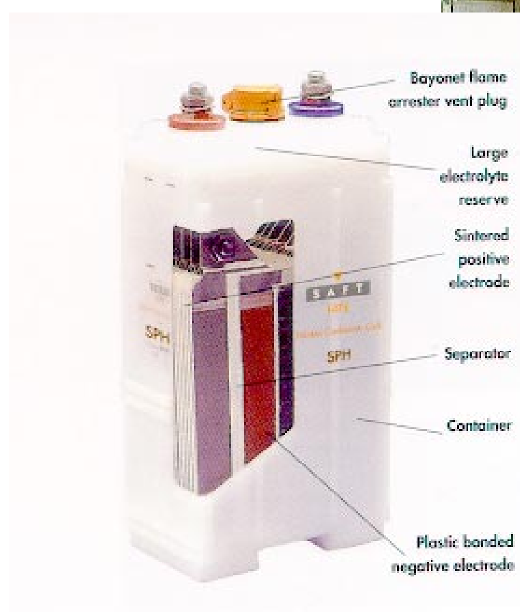
- Well proven
- Reliable if handled properly
- Moderate cost
- High energy density

- Limited lifetime
- Corrosive electrolyte
- Not tolerant of abuse
- Performance suffers drastically at low temperatures.

Ni-Cd Battery

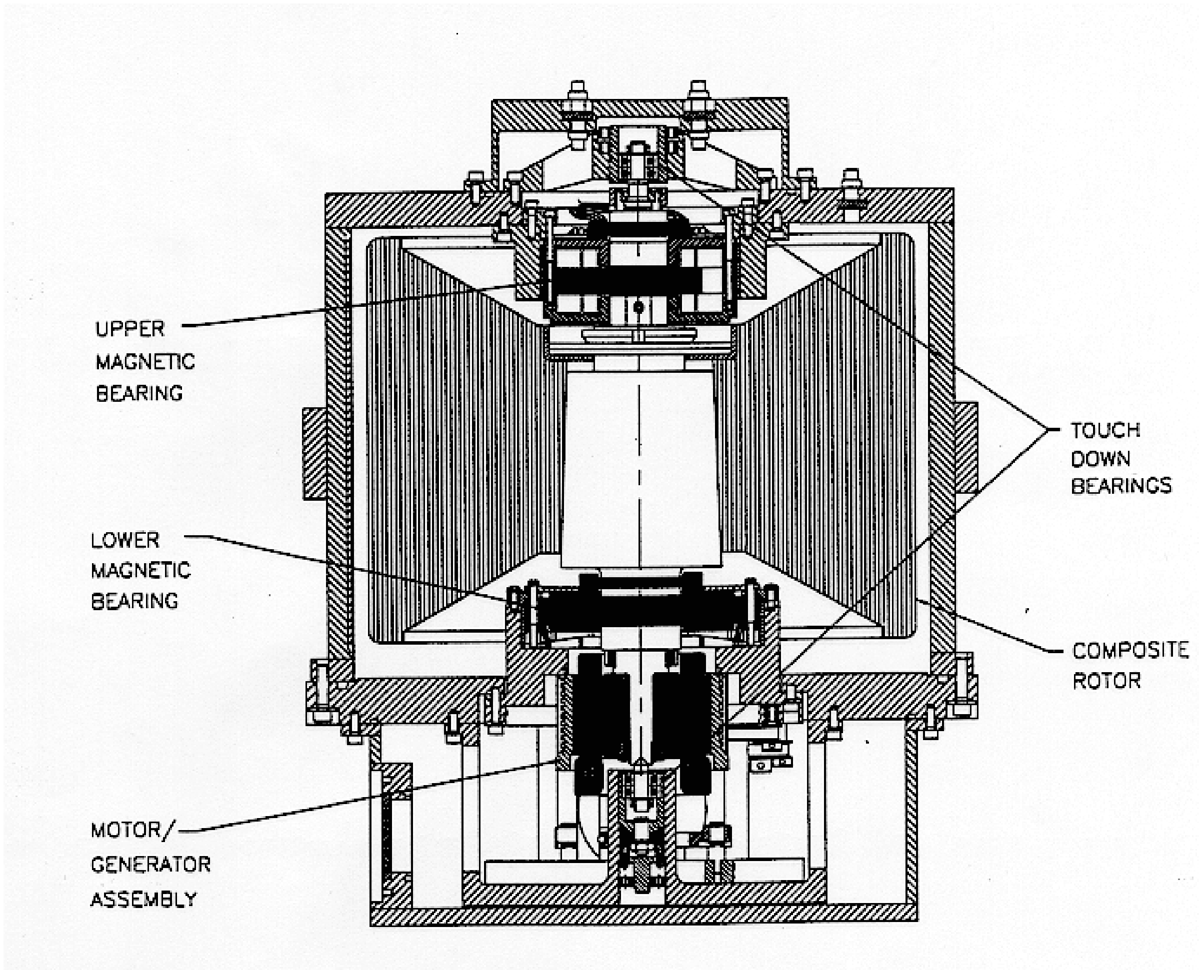
- **Long life**
- **Tolerant of abuse**
- **High energy <u>and</u> power density**
- **Good low temperature performance**
- **Relatively light weight**

- **High cost**
- **Cadmium considered toxic material**

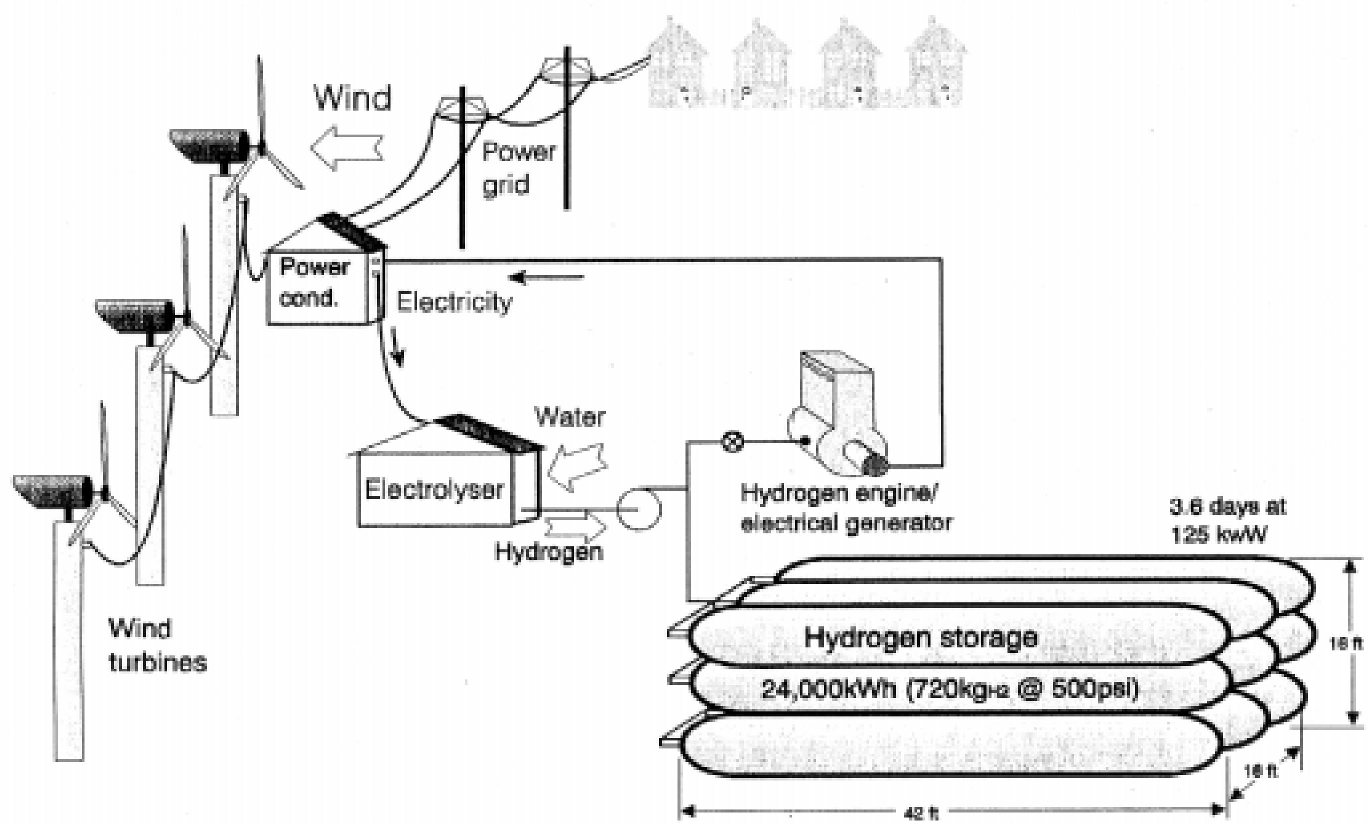


National Wind Technology Center

Flywheels (Electromechanical Battery)

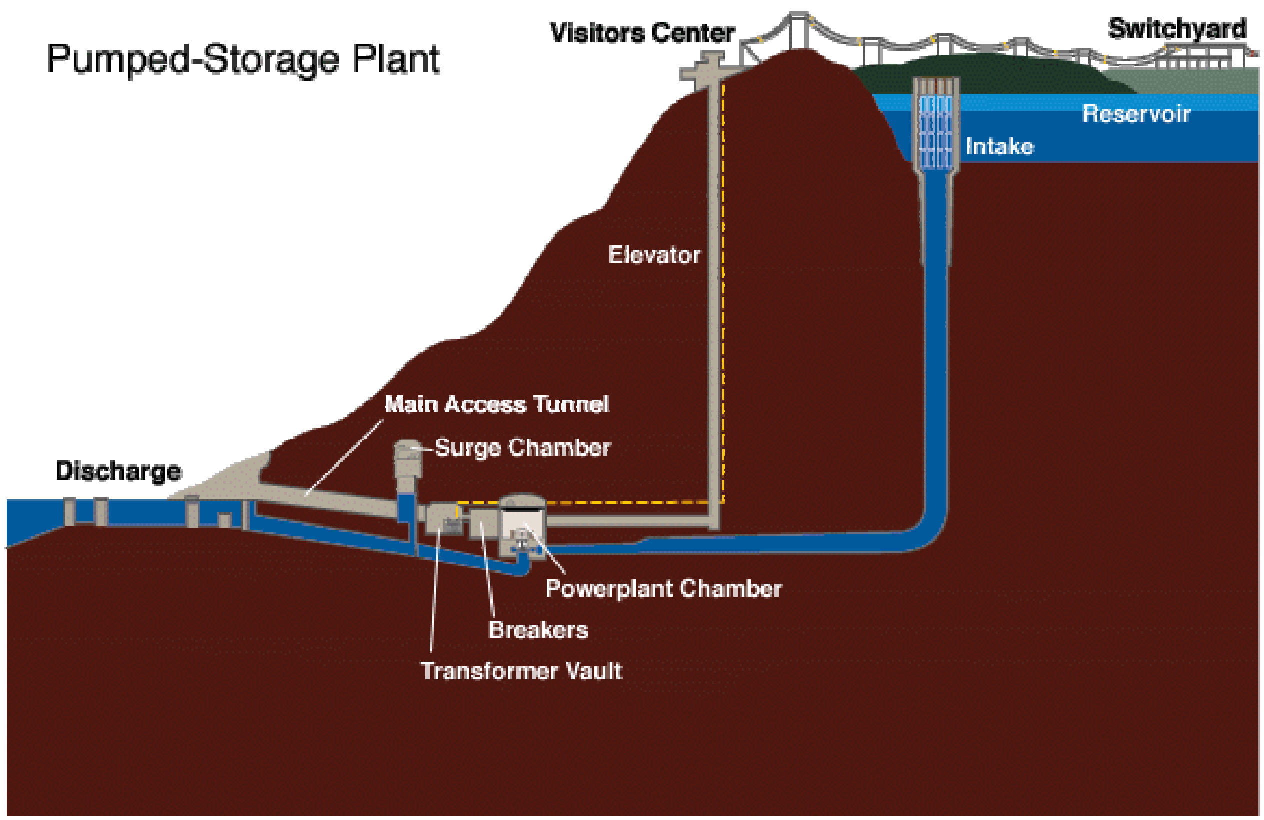


Hydrogen Cycle Energy Storage



Source: Glenn Rambach, Desert Research Institute

Pumped Hydro



Conclusions

- Energy storage is often the key factor in implementing isolated renewable energy hybrid power systems.
- Before choosing the type and size of energy storage, the objective must be considered.
- In most cases, batteries are still the most cost-effective energy storage technology.
- Further R&D on advanced storage technologies will increase the range of options available to designers of village power systems.

Hybrid Systems Control

Jim Manwell
University of Massachusetts

Hybrid System Workshop
Village Power Conference, 1998

Aspects:

- Monitoring
- Communication
- Control

Issues:

- System Size
- Single/Multi generators
- Paralleling
- Intrinsic control/System control
- Sensors
- Internal/External Communication

Requirements:

- Safety
- Protection
- Understandable
- Repairable

Monitoring & Power Quality:

- Control decision
- Fault Detection/Diagnosis
- Good quality appreciated

Equipment Hardware

- Robust
- User friendly
- PC’s / PLC’s

Supervisory Control

- Integration of Components
- Multiple Functions
- Load Management
- “Optimal” Control
- Storage/Dump Loads
- Diesel Dispatch
- Dispatchable Renewables

Common Language?

Do we need a common language so that all of the components in an hybrid power system can talk to each other and the supervisory controller without a great deal of system specific coding and control logic?

Technology Needs

Mike Bergey

Bergey Windpower Company

Hybrid System Workshop
Village Power Conference, 1998

It is not the technology that we need, it's a better market.

Wind Industry Needs

- Wind maps
- Lower cost wind monitoring equipment – Cost and collection
- Lower cost and simpler systems without lots of changes, systems with run hours. Higher level of robustness
- Better remote monitoring and control. Monitor a vast number of these systems
- More wind turbine models with high reliability and low cost
- Advancements in tariff collection systems. Low cost, low power usage.
- Super Reliability

Tariffs, Metering & Economics

Peter Lilienthal, Senior Economist
International Programs
National Renewable Energy Laboratory

Hybrid Power Workshop
Village Power '98
October 5,1998

Subsidies

Renewable suppliers trying to capture the subsidies that go to conventional rural electrification are playing to their opponents' strengths.

Instead of using large subsidies to supply a small number of communities with large quantities of energy at low tariffs, hybrids should use a limited subsidy to supply a large number of communities with small quantities of energy at a high tariff.

Unlike grid extensions and simple diesel systems, hybrid systems can be scaled down in size so that, with appropriate tariffs, full cost recovery is possible.

Tariff Structure

The success of solar home systems is due to their ability to sell power for >$1/kWh without the customer knowing it.

With the right tariff structure load growth can finance the necessary system expansion.

With the right tariff structure, universal service is possible.

Two-part tariffs:

- Place a cap on the financial burden of a subsidy
- Ensure that the bulk of the subsidy goes to the poor
- Allow the more prosperous to use whatever appliance they can afford to use.

Metering

Metering is mandatory for hybrid systems, but optional for part-time diesels.

Pre-pay meters may be the single most important technology to the widespread usage of hybrid systems.

Rural people understand the value of scarce resources and will respond to price signals.

End-uses

Most of the energy in remote mini-grids is used for applications whose value is much less than the cost of power.

The value of the first increment of power is MUCH greater than the cost.

Hybrid power systems that power incandescent lights or conventional refrigerators are management failures.

The slogan “Power to the people” doesn’t apply to 24 hour AC power delivered to dispersed homes.

In rural areas of developing countries where there is excess labor, it is more appropriate to transport batteries, ice, and materials than to build extensive AC distribution systems.

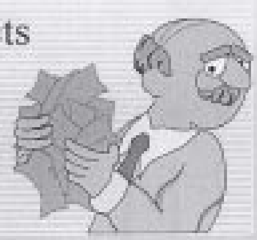
Institutional Issues in Village Power

Ron Orozco, P.E.

Energía Total, Ltd.

Observations of Village Power

- Electricity is not the goal
- Technology is not the problem
- Site selection is more than resource assessment
- Demonstration Vs. pilot projects
- Engineers can not do it all



Energía Total, Ltd.

Lessons from Traditional Rural Electrification Experience

- Competing for funds with health, education and road projects
- High cost must be offset by high economic impact
- Must clearly quantify/justify economic costs and benefits (Munasinghe, 1987; Barnes, 1988)

Energía Total, Ltd.

"Como conseguir o Maior Retorno para cada Real Aplicado em Energia Renovável"

Energía Total, Ltd.

Uso Productivo de la Electricidad

Cualquier uso de la electricidad que mejore la situación financiera del usuario final o que provee un estímulo para el desarrollo económico

Energía Total, Ltd.

There is no Single Institutional Answer!

Some institutional models tried in renewable-based <u>hybrid village power</u>

- None - Xcalak
- State utility - Joanes & Campinas, Brazil
- Private sector- Essene Way Resort, Belize
- Casa Blanca Resort, Mexico
- Other

Energía Total, Ltd.

What can we do to make village power work?

- Let's assure presence of political will at all levels before we get too far.
- Let's coordinate with other development activities
- Let's understand local conditions.
- Let's select our partners (and sites) well
- Let's do true <u>pilot</u> projects!
- Let's show how renewables can really work!

Energía Total, Ltd.

ViP Reliability & Track Record

Per Lundsager
Darup Associates Inc.

1. Main Issues in the ViP market
2. ViP Reliability & Track Record
3. A ViP Strategy

Presented at the NREL Hybrid Power Workshop
Washington DC / Arlington 05 October 1998

Main Issues in the ViP Market

■ The chicken & the egg

■ The market
☐ Resources
☐ Needs
☐ Infrastructure
☐ Policy / Strategy
☐

■ Implementation
☐ Money
☐ Advice
☐ Cooperation
☐

■ A product
☐ Technical performance
☐ Economical performance
☐ Environmental impact
☐ Infrastructure requirements
☐

■ *Where to start?*

ViP Reliability & Track Record

- ■ Village Power systems
  - □ Small systems for individual power supply
  - □ Medium size systems for community grid supply
  - □ Large systems for island grid supply
- ■ Still a chicken & egg situation
  - □ No market => No products
  - □ No Products => No markets
- ■ How to break the deadlock?
  - □ Customers establish credible markets
  - □ Producers establish a positive track record
- ■ What is in a positive track record?
  - □ Systems MUST work technically
  - □ Robust design using proven components
  - □ Ability to fail gracefully
  - □ Ensure proper infrastructure & product support
- ■ What is a ViP Customer?
  - □ End users have needs but no money
  - □ Financiers have money but no need
  - □ Who has the the socio-technical expertise?

A ViP Strategy

- ■ Implement an action plan based on the experience with grid connected wind energy
- ☐ Clear long term energy policy goals linked to economical incentives
- ☐ Economical incentives linked to compliance with increasingly tough technical-economical criteria

- ■ Main issues in the strategy
- ☐ Establish a positive technical track record by giving top priority to simple, robust & reliable systems in realistic & reliable organisational setup
- ☐ Currently update priorities in view of the technical development
- ☐ Establish clear & realistic acceptance criteria for ViP projects
- ☐ Current monitoring of project to evaluate technical & organisational performance

Credibility

Bruce Levy
BPG Development

Hybrid System Workshop
Village Power Conference, 1998

The Utility/Private Industry

- If you are dealing with the utility or the industrial market all they want is:
  - lower operating cost
  - high quality and reliability
  - fast payback
- Life cycle cost is a non-issue, meaningless in the private world
- There is a real need for rural power and utilities see this

Is there credibility?

No and there is no comparative technology to grid electrification.

If you want to make a project:

You can make a hybrid work even if it is 10 times more than the diesel if you have the following

- Great wind (18mph or greater)
- Diesel must be shut off at least 50% of the time
- Commercial use for the dump load
- Automation
- You need to nail down the maintenance issue

Notes from the 1998 Hybrids Workshop
Held as part of the 1998 Village Power Conference
Washington D.C., October 5th, 1998

Please note that these were my personal notes and although I tried to catch what people were saying I did not always succeed. I have left out material that was already discussed in specific presentations but tried to cover all of the questions and answers that followed each presentation. Although I tried to credit specific people with comments I did miss some and I have left a blank beside the specific comment. In some cases I was forced to paraphrase, I apologize if I have miss-stated someone's argument.

In the following segments, I identify people by first name and a last initial. The first time their name is referenced the last name is also be given in full. ***Ian Baring-Gould***

Applications
Eco-tourism - Costa de Cocos Mexico: Dave Corbus – NREL

Isolated ranch systems: Luis Vega –PICHTR
Questions:
- Failure mode of inverters: Took a long time to have confidence. Control software. Bata system that was not ready for remote areas, Salt water
- Turbines: Damper problems. Salt and high wind.
- Day to day operation (charge): Fiji- publics work department w/ training

Small village, VLA Chile: Ian Baring-Gould – NREL

Medium sized villages: Gary Norton – Northern Power Systems
Questions:
- PV systems in AK – Some analysis was done and it came out competitive
- Why not use diesel in St. Paul: Political issues.

Large Communities, Kotzebue AK: Malcome Lodge – Island Technologies
Questions:
- Cost? Utility is not putting in much money. Lots of government. 3 turbines from State of AK, Utility and DOE. 7 additional from DOE.
- What is the penetration? Right now it is low but it will get larger – up to 30% in the next stage (600kW of wind). Plan on going up to very high penetration. Problems with larger diesels will start later.

Greek islands: V27-225kW turbines: Niels Anderson – Vestas
Questions:
- Do they plan on expanding the systems? Yes. Vestas is having a hard time finding the market for specialized turbines and are only installing grid connect
- Corrosion/lightning? Over voltage protection for lightning. Corrosion package increases price of turbine by 10k.

Technology
DC systems: Mike Bergey – BWP
Questions:
- How can you cut costs by 2? Production economies of scale. Production costs spread over more units
- When will the 30kW unit be ready? Year or year and a half.
- What is the basic advantage of DC over AC? Stability of the systems. There are enough of them out there so the industry is more advanced. AC's don't have this now.

- Why do you say inverters are working well? Have 800 units in the field and have not reported many problems.

AC bus systems\high penetration systems: Steve Drouilhet - NREL

AC bus and diesel battery systems: Steve Phillips – AES
Questions:
- Controls add a lot of cost to static inverters, will this come down? Controls are important added value, also get DAS and SCATA. Price will go down as numbers go up.
- You use gel batteries, are you ready to use Lead Acid? Yes, but wet cells are a problem. Gel cells also have better draw and discharge ability. LAS have better life.

Retrofitting Diesels: Ian Baring-Gould - NREL

K. Reiche – Hybrid PV systems for Rural energy – Fraunhofer-Institute
Mainly PV/diesel hybrid systems, but also use wind where applicable.
Questions:
- How do you monitor? Have automatic data logging via phone line
- Describe the way the design team works? Had 200 engineers and hired one sociologist.

Discussion Sessions

Storage: Steve Drouilhet–NREL
Types of storage: Looks at LA and NiCad bats, flywheel, pumped hydro, hydrogen. Also air and hydraulic accumulators.
Stuff is going forwards is Flywheel (Automotive and UPS industry)
General Discussion:
Per Lundsager: Not much direct work on Flywheels – Lester University.
Bob Surwin: Storage of fresh water and Desal in Europe.
Per: No one has really looked at different charge patterns for batteries from an economic point of view.
Kilian Reich: Fraunhofer inst. is doing some work in this.
Mike Bregey: Thinks that rapid cycling of batteries makes it work better
Steve Phillips: Battery throughput is fixed
Dave Corbus: Wind can equalize while PV can't.
Luis Vaga: Looked at 5 different manufactures and could not get a good life data or estimate of life.
Steve P: The battery is just too expensive, initially and in the life cycle.
Kilian R: Fraunhofer inst. has just reported a report on progress in batteries

Monitoring, communications and control: Jim Manwell –Univ. of Massachusetts
General Discussion:
Should there be a common language?
Steve P: ModBUS communication software is used by AES. This can
Lewis V: thinks that AES has got this done.
Dave C.: we are still in the one off days. Are we ready to give packaged control and data collection.
Steve P.: Bugs come because everybody wants their own stuff with their specific functions. Small companies can't do this
Bob S.: People cause problems when they go in and rewrite the software. Bob thinks that this should be kept hands off and would worry about a common language.
Need simple systems, more complex

Technology Needs: Mike Bergey –BWP
General Discussion:

Bruce L: feels the real problem is the cost of the power, not the people stopping the project. – for utility and industrial processes. Privet sector is not the problem because they are $ oriented, governments do not do this.
Steve P. Every part of the industry needs innovation. Sell the same thing for two years and then upgrade. Everybody needs technology improvement.
Luis V: You need to have economy of scale to make the systems work. Gensets are cheep and so is fuel. Need to look at what people can afford. Prepayment meter to supply day by day power.
Per L: Many opinions about what the Europeans need. Make the simple system work the way that we what them to. Use this to create the credibility for the industry. How do we do this in an industry that is not presently cost competitive. The perfect system does not work and we have made a failure.

Tariffs, metering and economics: Peter Lilenthal – NREL
Questions:
Are tariffs market based on national standards? They should be whatever the market can bare.
Luis V: Financing failure is a problem
Peter L: We need financing
Art L: There are lots of communities / people that want power without subsidies
Per L: in the beginning you need to subsidize this stuff, once the subsidies start to increase, you are in trouble. So, we can keep going as long as the subsidies are decreasing.
___ Need a competitive subsidy program that is designed to eliminate itself.
Peter L: As a premature industry you do need subsidies but these things should be targeted and then removed from the subsidy when it is not needed.
Steve P. Use a three stage structure were AES charges a monthly fee that covers all of

Institutional aspects: Ron Orozco – Energia Total
Questions:
Gary Norton: Exactly who do you need to get involved with
Ian Baring-Gould: Where do you stop working with the people and start working with the utility
Ron O: When you have a strong utility (usually small)
Raj Rangi: In northern Canada you do have problems because there is no benefits. Price of power is fixed and so there is no real savings to the people by the addition of the renewables.
Peter L: New technologies incur costs and need money
Ron O: need to keep in mind
___: Need to target specific areas, we are in part of the solution
___: We need to develop market so we can develop the technology

Reliability & track record: Per Lundsager – Darup Associates
Nils Anderson: Real price of power in Europe is going down, Wind is now competitive compared to coal plants. Using the standard conditions, wind is actually lower cost than coal plants for a site of 6.5 m/s. – Grid connect.
Bruce L: Cost is going down because of gas plants. Also wind can't be dispatched so it has lower value. They are only add-on's to the existing power grids. Work great in the developed world but the developing world is a different question.
Nils A: From an environmental side it is better and Europe has the ability to pay for the environmental aspects of renewables
Malcome L: Utilities do not work in the area if environment when they have to.
Per L. Cost of energy from wind has decreased over time with Grid connect, why cant we do the same thing for the village market.
Bruce L: If this is the case, why has the development of the small turbine been abandoned?
Per L. Because people have not seen the market.
Jim M. These type of systems work best if they are larger. Maybe we should be looking at some small number of large systems on week grids
Per L. How do we make the village market follow the grid market
Kilian R: there is a market for green power in the developing world.

Credibility: Bruce Levy – BPG Development

General Discussion

Luis V: Who are the "They"

Bruce L: General folk, any body

___: Needs to be automatically controlled to reduce labor costs.

Bruce L: Hybrids will work in very specific places, just need to look for these systems.

Describes the St Paul system. Total cost of 1milion, to eliminate all power from the grid as well as thermal loading. Funded by a local bank.

Luis V: This is stuff that costs $1000/kW installed, this is to much money and to large a turbine

Bruce L: I can't compete with you, this is a system that would work and you are working in another type of system.

Gary N: Hybrids are not necessarily village, hybrids will be implemented in the industry and other reasons. Village is only a subset (a hard subset) of the whole market.

Discussion: Panel

Larry F: How do we develop the market? We are in this one's and two's donor market, how do we go to the commercial market. Water, Schools, healthposts, Eco-tourism, diesel retrofit. PV is putting systems everywhere, even if it does not make sense so that there is an industry for hybrids.

John A. Two questions. 1) how do you do the economics of the small users – Art 2) Opportunities for large systems in specific places.

Bruce: All it takes is someone with money, nerve and the ability to get financing. There is a market, there is a technology.

Art: How do we get hybrid into village power. Don't build it on Subsidy. Art goes to the consumer who is spending $12/month. We need a lot of those people and some financing for the initial instalation. We need to move on to replication.

Steve P. Technology is secondary, we need a customer. Need to know the Customer. Need to keep up on regulation and other artificial constraints.

Mike B: It is inevitable that the market will come about. Feels that our technology is at the short end of the Subsidy chain. We have good technology and so it is a question of political mandate. Everything is a subsidy issue and we are at the short end of the stick. Pilot projects help.

Kilian R: The CO2 issue is more important in Europe than it is in the US. They are thinking about CO2 emissions and the taxes that will follow. Fraunhofer is getting a lot of calls about this issue. This will increase the market for renewables. It is a political statement and the market will follow.

Steve P. Planning on a long-term subsidy is playing on thin ice. The projects need to be bankable and there are many markets where this will not happen.

Bob S. Domestic market did not materialize and it is on hold. AOC was thinking of this as a testing ground. Domestic market is a vacuum and so we are going to places that we were not ready for. Have had to move to other areas.

Larry F.: Brazil what is keeping this market opportunity down

Ron O. The market is still open. They are willing to take on the investment (350M/year in diesel subsidy) but people need to step up to the plate with a technology that will work.

Gary N: It is there but it needs to be from the power perspective, not a renewable energy system

Dave Sutton: Need to be an IPS, can't be an equipment supplier. Have to do stuff with productive use. Have to make the power real, bring in $$. Need to get by the transaction costs, need to do a region not a village.

Bruce L.: Need funded developers and they will pull the equipment (if it is good equipment)

Larry F.: Why is this not happening in Canada

Malcom L. They are the richest rural communities in the world why not renewable. They get it all for free. No incentive to do anything because there is no value of money, it is just given to them by the government. Any change will take a political act in deciding that they can not waste .5 Billion a year funding healthcare and energy in the northern regions. Now that the government is moving to the regional level, things will change but there is no motivation from the population. Also a bunch of inside infrastructure that is resistant for change.

Luis V.: Diesel prices wont change, batteries won't change. WTG-PV is the only way to make them feasible. We need to reduce cost by 2. Need to have at least 10 systems to make it work from an O&M point of view. Putting in 10 systems can take 5 years and will need subsidy for those 5 years to make the project feasibility.

Larry F.: Richard Hanson has worked the PV side of things and was able to squeak by. Is there a way to make this work for hybrids?

Mike B. Yes, but with subsidy it will work faster. If you take away the infrastructure (background work, lawyers, NGO's) cost (which is subsidized) then you don't get anywhere fast. What Richard has done is a good job with sustainability and ownership.

Peter L. Market development, environment and poverty elevation are all reasonable rational for subsidies. What is the difference between what Bruce and Art are proposing?

Mike B. Trend is the push to private sector development

Bruce L.: We can't go the PV route because every system will different. We are starting down that trial because we are standardizing in some ways but we will never get to it

_____: Why should we do hybrids – why should it be subsidized

Lots of clarification discussion

Kilian R: Want to reduce effects on environments

Patricia Delano, WP technology: Need a developer in country

Luis V.: There are private people out there

Larry F.: This is a valid point. We do not have enough people in the world doing this.

Mike B. The PV people have helped this because they have the industry.

Art L.: CPC was started to do act between the technology industry and the customer. The biggest problem has been finding the risk capital even though there is poof that it works and it is safe money. Things need to be aimed at replication with people a commercial stake in the project. This will bread success.

Kilian R: We are going into a solar century, wind, PV etc. Each success story helps us all and so these should be publicized.

___: Many countries have plans for renewable development. How much of the project is the cost of Money because these countries have access to cheep money. Development companies should look at these contras to development potential.

Larry F.: Recognize Javier Castio who is working for replication in Chile. We are trying to make a partnership between Europe, Australia and the US looking at the operation in hybrids. If you have operating systems with advanced data collection come talk to Larry.

Hybrid Power Workshop

Attendee List

Scott	Aldous	NC State University
Daniel	Ancona	Princeton Economic Research
Niels	Andersen	Vestas
John	Anderson	National Renewable Energy Laboratory
Hugo	Arriaza	National Rural Electrification Cooperative Association
Jorge	Ayarza	American Wind Energy Association
E. Ian	Baring-Gould	National Renewable Energy Laboratory
Mike	Bergey	Bergey Wind Power
Javuer	Castillo	Consultant for CNE, Chile
David	Corbus	National Renewable Energy Laboratory
Chris	Dabi	Climate Institute
Patricha	Delano	World Power
Roberta	DiPasquale	Analytical Services & Materials
Steve	Drouilhet	National Renewable Energy Laboratory
Ray	Erbeznik	Stirling Technology Company
Larry	Flowers	National Renewable Energy Laboratory
Katherine	Hamilton	National Renewable Energy Laboratory
Malek	Kabariti	National Energy Research Center, Jordan
Omer	Kittaneh	Palestinian National Authority, Israel
Bruce	Levy	BPG Development
Peter	Lilienthal	National Renewable Energy Laboratory
Art	Lilley	Community Power Corp.
Malcolm	Lodge	Island Technology, Canada
Cindy	Lowry	Consultant for USAID
Per	Lundsager	Darup Associates, Netherlands
Jim	Manwell	University of Massachusetts
John	Maylor	Shell International
Jacqes	Monovois	Groupe De Recherche et D'Echanges Technologiques
Ahmed	Muhaidat	Royal Scientific Society, Jordan
Charles	Newcomb	Consultant for NREL
Milton P.	Nogueira	Aquasol Engineering Sustainability
Garry	Norton	Northern Power Systems
K	Oduro-Kwarten	ACP Development & Finance
Ron	Orosco	Energia Total
Steve	Phillips	Advanced Energy Systems, Australia
Mark	Ranalli	Niagara Mohawk
Raj	Rangi	Natural Resources Canada
Kilian	Reiche	Fraunhofer institute, Germany
Gabrielle	Seeling-Hochmuth	Consultant
Raphael	Semiat	Israel Institute of Technology, Israel
Bob	Sherwin	Atlantic Orient Corp
Randall	Smidt	Energy Technologies, Inc
Adam	Smith	Echelon International
Garry	Staunton	ETSU
Dave	Sutton	Advanced Energy Systems, Australia
Luis	Vega	Pacific International Center for High Technology Research
Charles	Whitlock	Analytical Services & Materials
Bruce	Wilson	Sunwize

Large-Scale Use of Photovoltaic Systems for Off-Grid Applications: Infrastructure Needs and Challenges

Decentralized Renewable Energy Applications in the Philippines - *Silverio T. Navarro*
Municipal Solar Infrastructure Project - *Barry Greenwood, Bruce Robins, Katrina Ignacio*
Funding and Repayment Management of PV System Dissemination in Sri Lanka II - *Lalith A. Gunaratne*
Lessons Learned in Small-Scale Renewable Energy Dissemination: A Comparison of China and Thailand - *Debra Lew*
PV Technology for Global Village Power - *Robert R. Walters*
Solar Photovoltaic in Rural Electrification: Market Assessment Survey in Bangladesh - *Hasna J. Khan and Asma J. Huque*

Decentralized Renewable Energy Applications in the Philippines

by
Silverio T. Navarro, Jr.
Solar Electric Co., Inc.

Village Power '98
World Bank, Washington, D.C.

Figure 3 SBCS in Sara, Iloilo

The SBCS in Malalison Island

In August 30, 1996 a 300 Wp SBCS was installed in Malalison Island in central Philippines [4] as shown in figure 4. There were only 9 battery users at that time with only one TV set in the whole island. The number of battery users grew to 20 within four months of the SBCS operation.

Figure 4 SBCS in Malalison Island, Antique

Two years later, the site was inspected to repair the faulty ampere-hour meter. Utilization of the station has dropped because two diesel generators are now operating in the island. Of the 110 households, 50 were connected to the genset with a monthly fee of $ 3.75 . There are now 8 TV sets in the community with two video houses. A store runs another generator and operates a refrigerator producing cold water. The improvement of livelihood in this fishing village was mainly due to the increase in their catch as a result of a successful resource management program.

As this was anticipated, people in Malalison chose to use diesel gensets because there are no solar home systems available for them to rent. Fuel is accessible for the genset operator and for fishing boats. The genset operator claims to have a total monthly collection of $ 125.00 with 50 consumers against an operating and maintenance cost of $ 75.00. Operation of the genset becomes viable with more than 20 consumers paying $ 3.75 per month.

The SBCS in Malalison still serve battery users in the island that are not connected to the genset. Their houses are far from the main street and the cost of connection is expensive.

National Power Corporation SBCS Projects

Two pilot solar photovoltaic electrification projects were launched by the National Power Corporation (NPC) in Mindanao last 1997 [5]. The projects consist of 26 SBCS rated at 300 Wp and 5 rated at 150 Wp. The projects has an estimated 570 household beneficiaries. NPC provided PHP 4.5M for the purchase of the charging stations and the DC electrical systems for the households.

The projects serve as a good investment for NPC since this is an earning venture and not a complete dole-out. The local cooperative will manage the project to repay back the investment at a very low interest rate. Revenues generated from the project will be used to purchase additional SBCS equipment for other unelectrified communities.

SBCS for the Underground River

Two hours ride from the center Puerto Princesa , Palawan is an underground river. This underground river in Sabang is a favorite tourist destination. Adventurous visitors take a boat with a professional tour guide for $ 6.25 per person to see the spectacular view of stalactites and stalagmites with a pitch black background. Before, the tour guides use open flame lamps but pose as a health hazard to tourist and the soot accumulates on the ceiling of the caves. Now, they are using battery powered lamps that is more convenient and safer to use. Outside the cave are solar battery chargers mounted on the sand to recharge the batteries used in the cave shown in figure 5.

Applications like this will remain as is because of the nature in the use of PV. In fishing villages where batteries are used for lights when fishing at night, SBCS are acceptable and in no way be converted to solar home systems. Running a diesel genset solely for battery charging were tried in several locations but operation was short lived.

Figure 5 SBCS for the Underground River, Puerto Princesa

Lessons learned

In clustered communities, operation of diesel gensets becomes viable with the higher energy demand of several households and cheaper distribution cost. Comparing the cost of connecting to a genset against using batteries in Malalison, the genset monthly fee is $ 3.75 while the battery charging fee only costs $ 2.00 if done four times per month. What matters most is the cost of battery replacement every two years or less. Another is the inconvenience of battery handling. An automotive starting battery with 70 AH capacity costs $ 80.00. If the typical service life is only two years, the additional monthly expense for using batteries is $ 3.33 for a total of $ 5.33 monthly. This makes gensets more attractive and practical in clustered communities with regular access to fuel.

For communities with scattered households, battery users increase their frequency of recharging with their increasing demand. This makes battery charging more difficult and not practical anymore. Battery users then move up to solar home systems. If the community has no access to loans for SHS, their next option is to use a diesel genset.

Successful application of SBCS are those in areas where batteries are used for mobile applications such as lights for boats. This proved to be more practical and competitive against running a diesel or gasoline genset just for the purpose of charging batteries.

Rural Photovoltaic Electrification

The Rural Photovoltaic Electrification (RPE) is a project jointly undertaken by the National Electrification Administration (NEA) and the German Agency for Technical Cooperation (GTZ) under the Philippine-German Special Energy Program (SEP) [8].

The financial scheme involves the solar generator composed of a solar module, mounting frame, controller and house wiring amounting to $ 480 financed over 10 years at 12% interest. This results to a monthly amortization of $ 6.88 with an additional 10% for operation and maintenance. The household buys the balance of system composed of the battery and loads for a DC system.

The program is implemented through the Electric Cooperatives (EC) who take care of installation, operation, monitoring and fee collection of these decentralized systems. SEP provided 50% of the system cost as an incentive to the EC. Households are not subsidized and the full amount is charged as a commercial project to recover the investment and loan interest. Areas where grid extension is not considered, a rent to own scheme is offered with $10.50 monthly payment for 36 months with16% interest.

Initially, SEP selected 10 ECs with good financial and operational performance. From 1992 until the end of 1995, there were 975 households energized and requests for additional 1918 installations were received.

Status of RPE

There are now of 30 ECs involved in RPE. There are 11 ECs in Luzon area, another 12 in the Visayas and 7 in Mindanao. There were 2,220 systems installed under the RPE program [2] with a total capacity of 144,479 Wp serving 2,484 households as of June 30, 1998. The installation is made up of 2,154 SHS and 66 SBCS. The SBCS installed has a total capacity of 4,994 Wp.

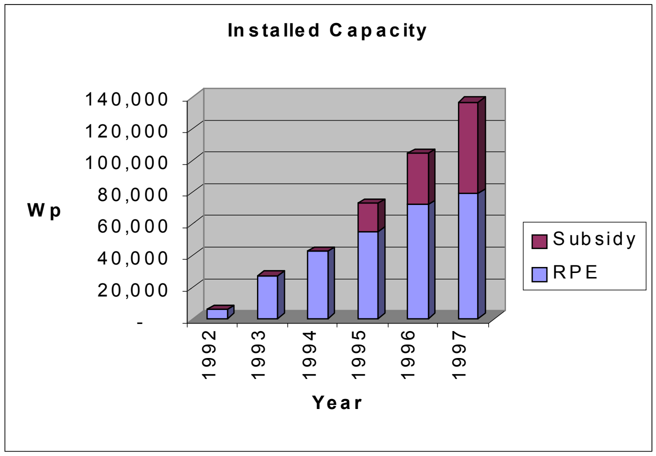


Figure 6 Installed Capacity of RPE project

NEA released $ 182,218.88 to 11 participating Ecs. An amount of $ 28,046.15 was repaid immediately by four cooperatives for full payment of their loan. A total outstanding loan of $ 135,103.19 still have to be collected with an average collection efficiency of 147.9%. Although the payment term is ten years, households opted for the 3 years rent-to-own scheme. This is why collection was high with shorter loan repayment periods.

There are still 4,800 communities to be energized using solar energy from calendar years 2000 to 2010. With a grant of DM 400,000 from the Federal Republic of Germany through GTZ plus NEA's counterpart, a funding requirement of $ 90 Million is still needed.

There were 23,876 communities electrified by 120 electric cooperatives using grid electricity with a total potential of 35,362 communities for 100% electrification [7]. The Philippine Department of Energy estimates that to reach the 80% electrification goal in the Philippines will cost $1,500 Million. The same goal can be attained with SHS for $ 72 Million [3]. With lower material requirement, the RPE method needs extended management with higher input of local labor.

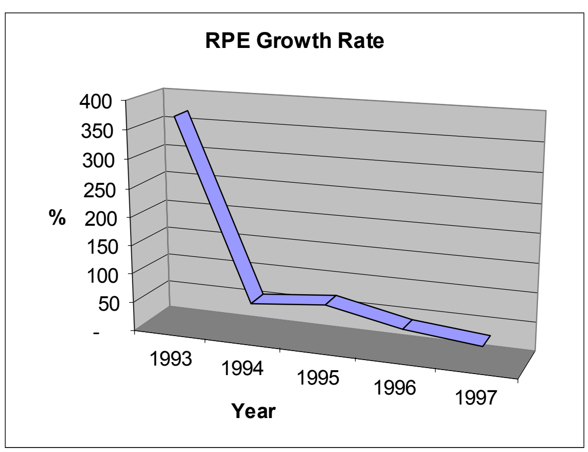


Figure 7 RPE Growth Rate

Subsidy

As it was intended, the RPE was designed to fully commercialize photovoltaic electrification without subsidy. As indicated in figure 6, subsidy was introduced in 1995 and by 1998 grew to 31% of the total project share (figure 7). As the project growth declined after the boom in 1993 shown in figure 8, subsidy has become a significant factor in the continuation of the program.

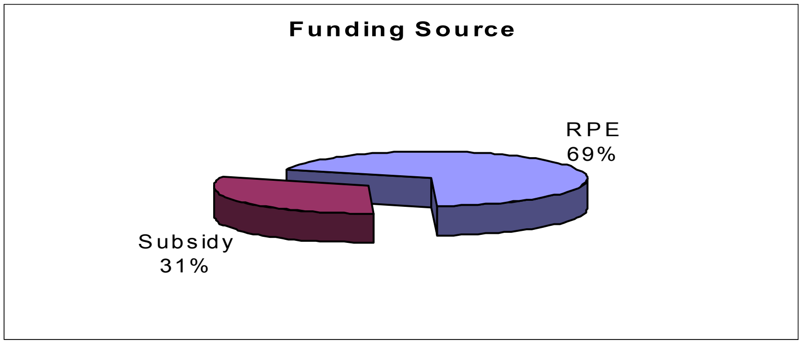


Figure 8 Subsidy share on RPE projects

Subsidies do not necessarily mean dole-outs for rural households but another funding source provided by the local government. Monthly dues are still collected from SHS users to maintain the systems, making the project sustainable. The local governments find the RPE project beneficial to their constituents. This has been integrated in their rural development plan to offer basic services to the communities. With subsidies, ECs are less burdened from loan repayments and interests.

Photovoltaics in Batanes

Batanes is the north most province of the Philippines composed of three groups of islands; Batan, Sabtang and Itbayat. Livelihood is mainly agriculture and fishing. Diesel power plants owned and operated by NPC provide electricity for 3 to 12 hours per day [9]. The current cost of power production in Batanes is $ 0.439/kWh while the selling rate to the EC is $ 0.063/kWh. While cost reduction is being explored by NPC-Strategic Power Utility Group (SPUG) with NREL using wind-diesel hybrid retrofits, Congressman Florencio Abad of Batanes had been implementing PV projects through the Batanes Development Foundation, Inc. (BDFI) with systems supplied and installed by Solar Electric Co., Inc.

From 1995 to 1998, a total capacity of 13,671 Wp of solar PV and 1,100 watts of small wind turbine generator has been installed [10]. These systems include solar power for homes, municipal buildings, hospitals, health centers, district hospitals, freezers, telecommunication and wind-solar hybrid potable water pumping systems. A typical system is shown in figure 9. PV systems were installed as back-up power for grid connected communities and as main power source for off grid installations.

Figure 9 PV installation in Batanes

This is a special case where the population of communities are small, access to fuel is very difficult. Batanes lies on the typhoon belt and ships delivering goods from Manila only comes less than ten times a year. Small planes land in the capital, Basco; twice a week but cancel their flight unpredictably during bad weather. Decentralized systems are practical in this situation because of big distances between load centers with very low consumption. When there is a major technical trouble and spare parts are not readily available, decentralized systems has the advantage of operating independently from other systems.

SPUG's projection of an average annual growth rate of 9.3% reaching a 56.6% growth in 5 years [9] to justify additional generating capacity seemed to be too high. The isolation of the island from the main land keeps its energy demand from growing fast. However, PV systems are modular and can be upgraded according to the growth of energy demand. Because of the proportion of the Countrywide Development Fund (CDF) of Congressman Abad to the small population of Batanes, many had benefited much from the solar electrification project. As the initial investment is subsidized, the users' responsibility and counter part is the operation, maintenance of the systems.

Conclusions and Recommendations

PV installations in the Philippines are shown in a map in figure 10.

Factors affecting the use of renewables for electrification

1. Density of households in the area

   In areas where transmission line requirement is long and the demand is low, the cost of transmission may not be justifiable. The next thing to consider is the density of the village.

The denser the village, the lower the cost and viability of centralized systems such as gensets, centralized PV or hybrid systems

2. Access to fuel

   Operation diesel gensets greatly depended on the availability of fuel in a particular location. Fishing villages usually have access to fuel not only for electric power generation but also for their fishing boats. Access to fuel is more difficult in mountain villages specially during rainy season. This is where renewables becomes more competitive.

3. Payment capacity of households

   The type of energy systems in villages also depends on the income level of the community. Poor villages tend to use kerosene and dry cell batteries even if the equivalent energy cost is high because the investment required is low. Energy needs of middle income villages using car batteries can be met with SBCS. Even high income families with gensets still use solar home systems for continuous availability of power. When the initial investment is subsidized, the capacity of the household to maintain the systems should be considered.

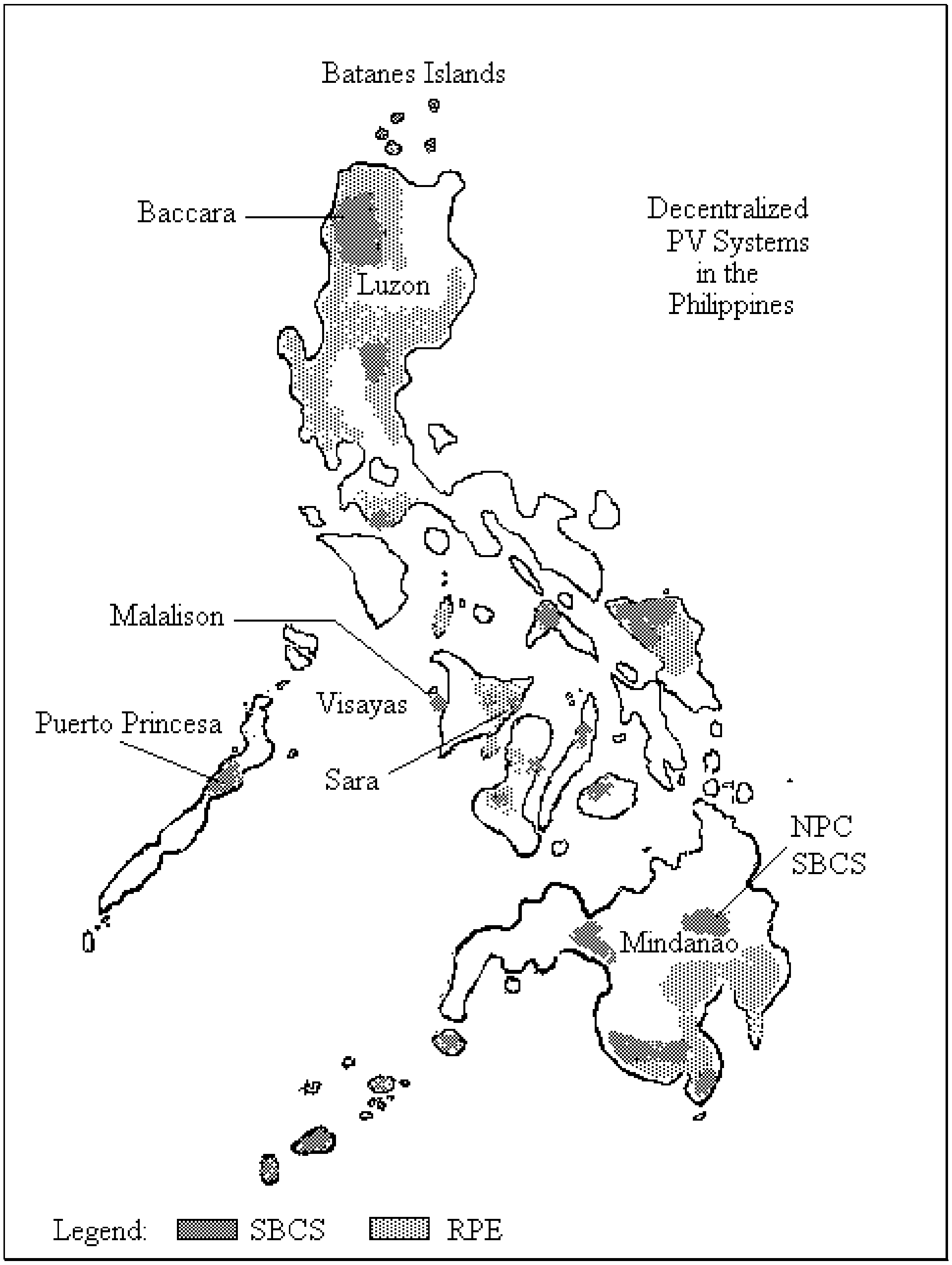


Figure 10 Location of PV installations

4. Access to financing

Renewable energy systems, particularly PV; is characterized with high initial investment and low operating cost. Diesel on the other hand has a moderate initial investment, operating and maintenance costs. Appropriate financing package should be adapted to the community to match their payment capacity. In the Philippines, loans for renewable are available to electric and people's cooperatives through NEA and development banks. This have been very helpful and effective in the dissemination and use of PV systems. Subsidies are needed initiate a project but should be gradually phased out for full commercial operation and sustainability.

5. Specific Applications

In applications where the load is small and the value of the service is high, photovoltaic systems are best suited. With such small electrical load that can be met by a car battery, PV battery charging is viable and could be the only practical way of replenishing the charge of the battery as in the situations of the underground river in Sabang, Puerto Princesa.

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Exchange rate: 1997 $1 = PHP 25
1998 $1 = PHP 40 DM 1 = $ 1.54

Acknowledgements:

1. Dr. Anne Hizon of Bacolod City for providing the secondhand solar modules for the test run of the SBCS franchising.

2. Benjamin Huelar for initiating the SBCS franchising in Sara, Iloilo.

3. Nonoy Aspera of Sara for the data on conventional battery charging.

4. Nelfa Macuja of Malalison island for the and information on the SBCS and accommodation during the visit.

5. Rani Rodriguez of Puerto Princesa, Palawan for the information on the SBCS at the underground river in Sabang.

6. Noel Hernandez and Herminigildo Manzano of NEA for providing the data on the present status of the RPE.

7. Congressman Florencio "Butch" Abad, the Batanes Development Foundation and the people of Batanes for the continued support for the implementation of PV electrification in the islands of Batanes.

8. Winrock International/ PEI for the data and reports on renewable energy in the Philippines.

9. Mr. Heinz Wolfgang Bohnke of Technosol, Germany for the collaborative work on SBCS.

10. Lyndon Azucena of Solar Electric Co., Inc. for the data on PV installations in Batanes.

11. NPC-SPUG, Dennis D. Barley of NREL for the report on proposed wind-diesel hybrid retrofits in Batanes Island.

12. DOE-NCED for the data on PV installation in the Philippines.

13. Carmelito Tatlonghari of USAID, Philippines; Jerome Weingart, Hagler Bailey and Undersecretary Cyril Del Callar for making this report possible.

Decentralized Renewable Energy Applications in the Philippines

by

Silverio T. Navarro, Jr.
Solar Electric Co., Inc.

Village Power '98
World Bank, Washington, D.C.

Introduction

- 4 Million HH in Philippines no access to grid electricity
- Only 27 of the 2,800 Inhabited Islands have local grids
- Cost of grid extension is high at $ 8,500/km
- Renewable energy sources available in rural areas

Energy Sources in Rural Areas

- Kerosene lights and dry cell batteries
- Rechargeable automotive batteries
- Diesel/ Gasoline generator sets

Entry of Renewable Energy Systems

- Solar lanterns and SHS for kerosene lamps

Entry of Renewable Energy Systems

- On site battery charging using Solar or Wind Battery Chargers

Entry of Renewable Energy Systems

- Solar Home System for domestic energy needs

Scale up Strategy: Rural Photovoltaic Electrification

- Solar Battery Charging Stations
  – Strategic operation of SBCS to build up loads of battery users
- Solar Home Systems
  – implemented by electric utilities, the National Electrification Administration with funds from GTZ

Solar Battery Charging Station

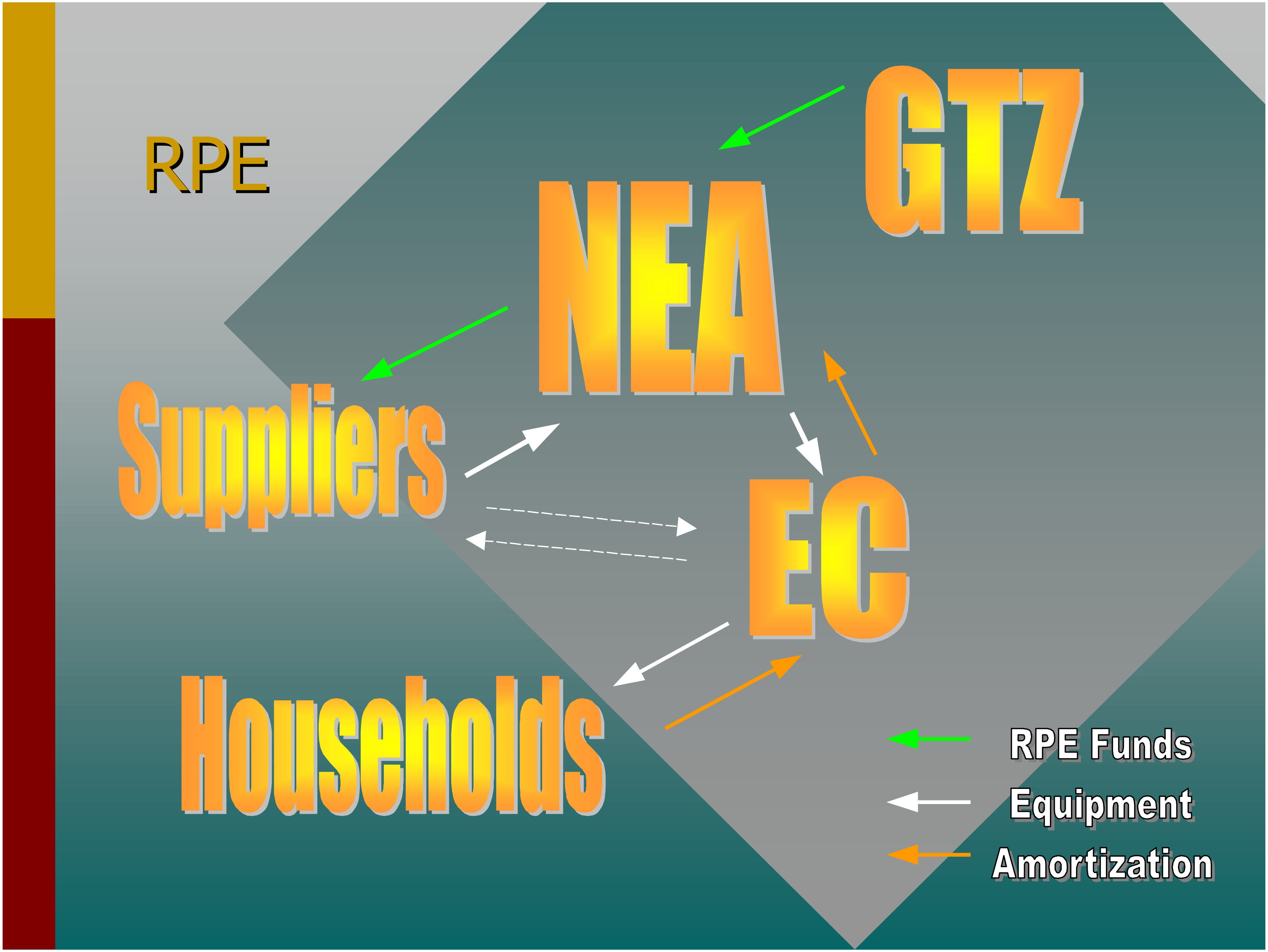
- Suits the current practice of charging batteries in remote areas
- PV can compete with cost of battery charging with grid electricity
  - Grid Battery Charging $ 1.04/kWh plus transport VS $ 0.97/kWh for SBCS

SBCS in the Philippines

SBCS for the Underground River in Puerto Princesa

Solar Home Systems

- Meets higher domestic energy demand for lights, radio and TV
- Autonomous operation of stand alone systems
- Expandable for increasing demand


RPE
GTZ
NEA
Suppliers
EC
Households
RPE Funds
Equipment
Amortization

Solar Generator $ 480

- 50 to 75 Wp solar module
- Mounting frame and post
- Charge/Discharge Controller
- Wires and Accessories

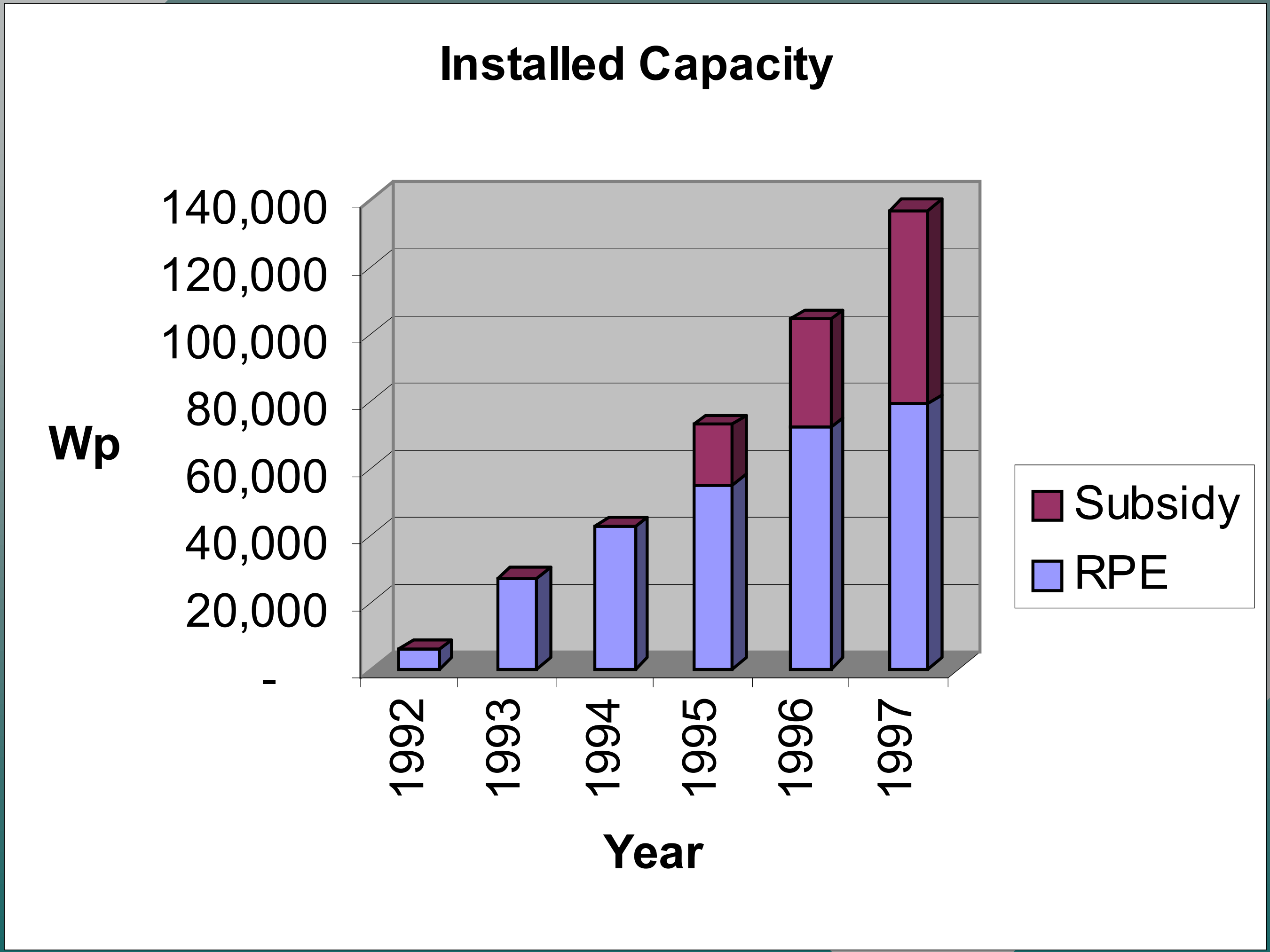
SHS Balance of System $ 108

- Battery 100 AH, 12V
- House wiring
- loads - lights, TV, radio, karaoke

Payment Schemes

- P 190/ month rental
  - P 12,000 at 12% for 10 years
- P 420/ month for 36 months
  - P 12,000 at 16% for 3 years

RPE Installations



Status of RPE

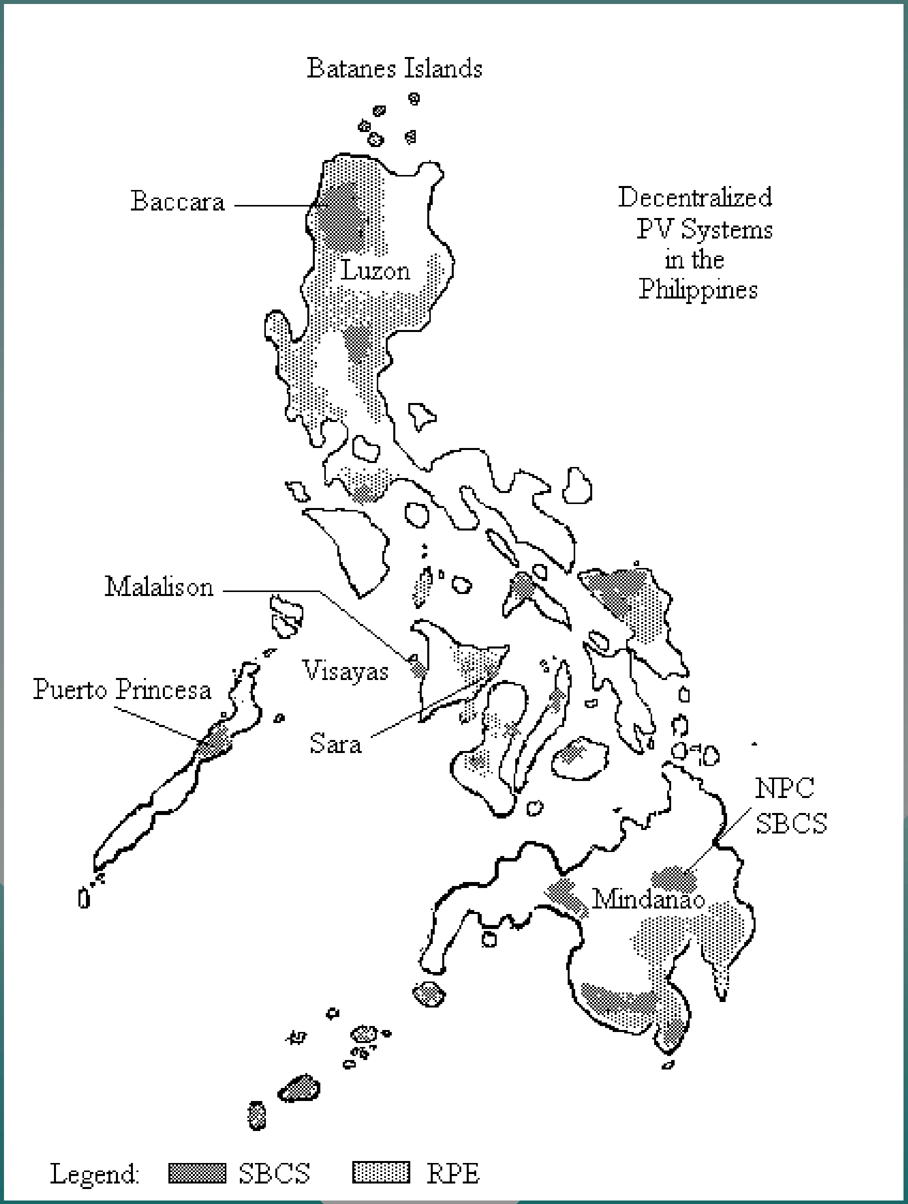
- 2,220 systems with 144.4 k Wp installed capacity
- 4,800 communities to be energized for CYEAR 2000 - 2010
- Funding requirement is $ 90 Million

PV installations in Batanes

- 1,3671 Wp PV installed by 1998
- 3 wind-solar Hybrid pumping systems
- SHS, Municipal buildings, hospitals, health centers, telecom, freezer

PV installations in Batanes

PV Installations in the Philippines



Factor Affecting the Use of RE Systems

- Density: Scattered HH tend to use SHS
- Access to Fuel: Remote & isolated areas prefer PV
- Income Level: Proportional to the demand

Factor Affecting the Use of RE Systems … continued

- Access to financing: Soft loan and Subsidy
- Specific Applications: Underground River

Municipal Solar Infrastructure Project

BP Solar

Village Power' 98

Oct.6-8,1998

The World Bank,
Washington,D.C.

Presented by:

Barry Greenwood
Bruce Robins
Katrina Ignacio

Philippines: *Facts and Figures*

BP Solar

- Population: 71.5 million
- Area: 300K square kilometers
- 7,100 islands (Luzon, Visayas, Mindanao)
- 16 regions; 76 provinces
- 1997 energy consumption: 231 Million BFOE
- Imported energy- 60%
- Indigenous energy-40%

MSIP: *Genesis I*

BP Solar

- March 1994 - discussions with DoE
- March 1994 - strong support, Congressman Bautista
- Identify DILG as appropriate implementing agency
- DILG requests BP to seek funding from Australia
- July 1994 - BP Solar submits application to AusAID
- December 1994 - AusAID "in principle" commitment

MSIP: *Genesis II*

BP Solar

- December 1994 - feasibility study requested by AusAID/ NEDA
- June 1995 - BP Solar completes FS
- AusAID and NEDA assess FS
- August 1995 - AusAID Appraisal Team visits Philippines
- January 1996 - AusAID Appraisal completed
- February 1996 - ICC Tech. Committee endorses MSIP

MSIP: *Genesis III*

BP Solar

- March 1996 - change of gov't in Australia, all DIFF projects cancelled
- April to July 1996 - intensive bi-lateral lobbying
- September 1996 - Australian gov't gives formal approval
- January 1997 - ICC Cabinet gives formal approval
- March 1997 - commercial contract w/ DILG signed
- June 1997 - loan agreement signed
- November 1997 - All preconditions met ; Notice to Proceed issued

MSIP: *Objective*

BP Solar

Improve the quality of life in remote barangays identified by Social Reform Agenda (SRA)

by

Upgrading/extending the level and quality of services offered by LGUs

MSIP: *Scope*

BP Solar

- Largest solar project in the world
- Approx. 1000 solar packaged systems
- 7 provinces
- 47 municipalities
- Approx. 400 barangays

MSIP: *SRA Provinces*

BP Solar

- Guimaras
- Eastern Samar
- Surigao del Sur
- Biliran
- Basilan
- Sulu
- Tawi-tawi

MSIP: *Major Stakeholders*

BP Solar

- Department of The Interior and Local Government
- AusAID; EFIC
- BP Solar
- Filipino People

MSIP: *How ?*

BP Solar

Using *solar technology* and compatible high efficiency equipment

as

the enabling technology

to

provide minimum basic needs

MSIP: *Why Solar Technology?*

BP Solar

- Modular for Immediate Needs
- Appropriate for Village Maintenance
- Sustainable
- Reliable

MSIP: *What Can Solar Do?*

BP Solar

- **Reliable and Sustainable Power for:**
  - Vaccine Refrigeration
  - Potable Water Supply
  - Communal Lighting
  - Community TV/Video
  - Rural Communications

MSIP: *Vaccine Storage*

BP Solar

- District Hospitals
- Rural Health Units
- Barangay Health Centres

MSIP: *Potable Water Supply*

BP Solar

- Municipal Centres and RHU
- District Hospitals
- Barangays
  and BHC

MSIP: *Area Lighting*

BP Solar

- Markets
- Fishermen's Wharf
- Communal Areas

MSIP: *Quality Lighting*

BP Solar

- District Hospitals
- Rural Health Units
- Barangay Health Centres
- Municipal Halls
- Barangay Halls
- Schools

MSIP: *Implementation*

BP Solar

Training facility in Cebu

- 16 Advance Teams in field
  - Prepare communities
  - Develop community management teams
  - Develop fund-raising schemes
- 6 installation teams
  - Installing systems
  - Training municipal engineers & barangay technicians

MSIP: *What Are The Benefits?*

BP Solar

- Health, Education, Community Welfare
  - Health Services Targeted at Women / Children
  - Community Participation and Awareness
  - Communication and Education
  - Community Health
  - Social Cohesion

MSIP: *Benefits*

BP Solar

- Rural Economy
  - Increased LGU Efficiency
  - Reduced Urban Migration
  - Commercial Activity
  - Productivity

MSIP: *Benefits*

BP Solar

- Energy and Environment
  - Environmentally Benign
  - Reduce Fossil Fuel

MSIP: *Benefits*

BP Solar

- Community
  - Improved Governance
  - Increased Community Awareness
  - Increased Community Participation

MSIP: *Differential Benefits*

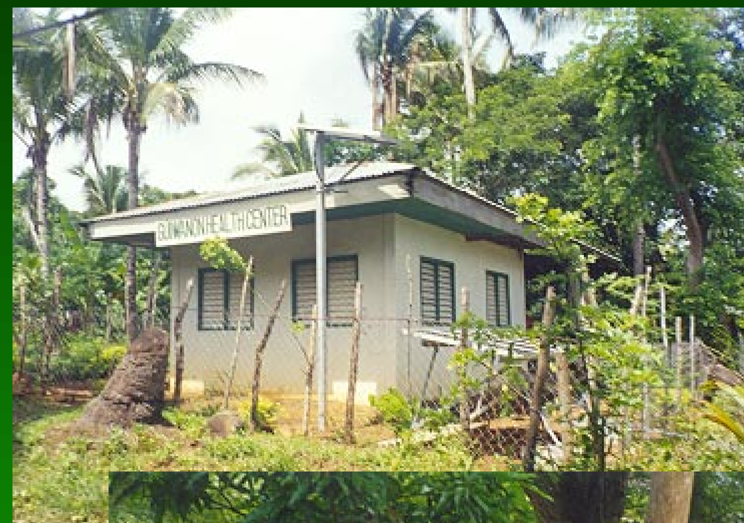
BP Solar

Women in Development

- Targeted Health Services
- Improved Security at Night
- Reduced Toil

MSIP: *Solar Power in Guimaras*

BP Solar



FINANCIAL SERVICES FOR DECENTRALIZED SOLAR ENERGY APPLICATIONS II
Harare, Zimbabwe 20-23 October 1998

FUNDING AND REPAYMENT MANAGEMENT OF PV SYSTEM DISSEMINATION IN SRI LANKA II

By Lalith A. Gunaratne, Rural Energy Consultant

Background

It has been two years since the first paper was written in October 1996 for the CDG Specialized Seminar "Financing Models of Decentralized Photovoltaic Energy Systems" held in Jakarta, Indonesia in November 1996. Many developments have taken place in Sri Lanka since then.

These developments hinge on the World Bank and the Sri Lankan government funded "Energy Services Delivery Project" (ESD). Apart from funds for other renewables, this fund has allocated finances for the installation of 30,000 SHS in the next five years through the private sector. The ESD was established in 1996. With the fund in place solar PV's role as a technology for off-grid electrification will be tested.

Currently, there are four solar home system (SHS) project developers in the market, with a few on the sidelines. However, less than 10% of the allocated funds have yet moved.

Why has the fund not moved faster in the last two years?

The answer lies in the fact that - lack of funds is not the only barrier for successful SHS dissemination, albeit a major one. Now that funds are available, and in this case with a US $ 100 per SHS GEF grant, one of the most important issues, being financing, is being addressed.

However, this does not take away the fundamental issues such as:

- the market is far away in remote areas of the country
- cost of doing business in rural areas is high
- the cost of SHS is relatively high for the target rural market
- the urban based banking system is uncomfortable lending in rural areas or for rural projects
- PV technology is relatively new to the financial institutions, policy makers and the market

The ESD funds coming in at the top creates pressure in the system of dissemination and all the above issues are being forced to be dealt with.

The next few years, Sri Lanka will be one of the places to watch as these unfold.

Introduction

Sri Lankan solar home system (SHS) market is estimated to be over 200,000. These are rural households not linked to the Ceylon Electricity Board (CEB) grid and earning more than US $ 100 per month. However, over the last 10 years less than 6000 systems have been sold. The one of the main reasons for this has been the lack of effective financing schemes for end users. The local SHS promoters lacked resources to offer credit themselves. Further, the existing mainstream financing institutions shied away from lending in rural areas for SHS.

However, the situation is changing with the recent establishment of the Energy Services Delivery (ESD) project, a joint Sri Lankan government - World Bank fund of US $ 55 million for the dissemination of renewable energy for rural areas of the country. Out of this, US $ 10 million is allocated for SHS. This paper will examine how the ESD has effected the market development of SHS so far.

1. A Brief History of Financing SHS

SHS dissemination in Sri Lanka began with a pilot effort by the utility, the Ceylon Electricity Board, selling systems out of its head office in the capital of Colombo in 1986. Over 700 SHS were sold for cash in two years. This fact followed by an extensive market and feasibility study prompted the author and the partners to establish Power & Sun (Pvt.) Limited (now called Solar Power & Light Company Limited) in 1988.

From the inception, the need for an effective credit scheme was well known. An investment of over US $ 200 for an average rural dweller who earned less than US $ 50 per month was deemed difficult. Power & Sun lobbied the government owned People's Bank (with an extensive network of branches in the rural regions) to establish a loan scheme.

On paper, the People's Bank scheme, which was established in 1989, showed much promise. However, in reality, except for a few branch managers who gave a total of about 40 loans, the scheme was not promoted effectively.

There was branch level apathy towards giving small loans to individuals. Further, the worry of a new technology compounded the lack of interest. A common concern among managers was the recourse available to them if the loan was defaulted. How and what to repossess in that event was not understood.

Nevertheless, Power & Sun continued to sell most of the SHS for cash through the rural dealer network.

However, there were certain dealers who operated their own informal credit programs. These dealers provided credit to only well known clients at interest rates of up to 48% per annum when the regular lending rates were between 20-25% per annum. Therefore, only a handful of such loans have been given.

In 1990, government embarked on aid assisted SHS project. The Pansiyagama 1000 Home Project was promoted by Sunpower Systems (another local company developing the institutional solar PV market) and BP Solar Australia using Australian aid and Sri Lankan government funds. The National Housing Development Authority (NHDA) administered the project. Power & Sun was subcontracted to assemble the BP modules in Sri Lanka.

Unfortunately, the "top down" nature of this project created a situation where bureaucracy and politics entangled with technology and financing. The end result was a project where the end users were not paying the low monthly payment. Close examination showed that the project did not involve the community in the planning and implementation process. The SHS were installed at give-away prices and monthly payments. The technical service was poorly administered as well as collection of repayments.

Overall, the project provided valuable lessons to all stakeholders. Technically, most of the SHS in Pansiyagama yet operate satisfactorily. It is now reported that the repayment rate is about 50% as it is too costly to follow-up and recover from all the users.

In 1990, two non-governmental organizations (NGOs), Sarvodaya and Solanka embarked on community based programs to install systems in selected areas. These projects used seed funds facilitated by the Solar Electric Light Fund of USA and Rotary International. Sarvodaya has installed over 250 systems and Solanka, over 100 systems with these funds.

Both these projects demonstrated successful SHS dissemination when the process links the technology with financing at the community level. This typical "bottom-up" approach empowered the rural community to understand the technology as well as manage the micro credit programs.
These serve as effective models. However, grant funds have been limited to sustain these types of projects and both Sarvodaya and Solanka have evolved to utilize commercial funds for SHS dissemination.

Sarvodaya was selected by the World Bank to install 300 SHS as the ESD pilot project. It has taken them well over 18 months to install 150 SHS, but this slow rate of installation has been due to a combination of external and internal issues for which Sarvodaya had little control over. At the moment Sarvodaya is developing an ambitious program to install 6000 SHS in 5 years. Sarvodaya has the infrastructure to achieve this through their existing rural credit network that provides loans mostly for agriculture.

Solanka has evolved into a private company called RESCO, a subsidiary of SELCO-USA. RESCO has already accessed funds to install 1000 SHS within 1998/9 period and is creating the rural level infrastructure to be a one stop shop for SHS in selected rural regions. This approach is consumer marketing oriented and the model is developed in a manner where franchise type standard operations can be established around the country as the business expands. The SHS will be marketed in a combination of cash sales, leasing and fee for service methods.

The fee for service concept will be, especially interesting to observe developing as it minimizes the risk to the end user.

Other private sector developers are also entering the SHS market to take advantage of the ESD credit line.

However, the most interesting development with the ESD project is attracting the mainstream financing institutions to the SHS business.

2. The Energy Services Delivery Project

Ms. Loretta Schaeffer, Program Manager of the Asia Alternative Energy Unit of the World Bank is quoted to have said on Sri Lanka at the Solar Energy Forum - Soltech 93 - held on 28th April 1993 in Washington D.C.: ‘the Bank may get involved in providing PV-powered household systems throughout the country as there is a strong private sector involvement and use of proven local experience in systems design, development, installation, operation and maintenance’.

This was a justification for the World Bank to examine establishing a fund in Sri Lanka to support SHS dissemination.

The Energy Services Delivery Fund was established in August 1997 with the Sri Lankan government, private sector and the World Bank contributing to make a total of US $ 55 million.

2.1 The Objective of the ESD

The broad objective is to promote the provision by the private sector, NGOs and co-operatives of grid connected and off-grid energy services using environmentally sustainable renewable energy technologies.

2.2 The Loans

The loans will be made available to private sector firms, non governmental organizations, village co-operatives or any other non government project developer.

The funds can be used for the following;
- grid connected mini hydros
- off-grid village hydros
- solar home systems
- wind power, biomass and other renewables

The funds are channeled to the project developers through mainstream commercial lending institutions which are private commercial banks. These are called Participating Credit Institutions (PCIs).

2.3 How the ESD Project Works - The Conceptualized Ideal Scenario

The fund is activated when a project developer (PD) requests for funds with a bankable proposal to the PCI.

The PD could be a private company, a NGO or a rural level cooperative.

The PD would have conceptualized a project after assessing the electricity needs of an off-grid community.

The assessment would be based on financial viability of installing a projected number of SHS in the given community.

The role of the project developer (PD);
• assess the market potential • possess technical capability to design, install and service SHS • provide consumer financing • market and promote SHS and financing scheme • develop a bankable proposal based on the market potential and project feasibility • negotiate with the PCI • implement the project • secure the GEF grant with follow-up documentation • monitor the project • repay the PCI

The above would be an ongoing process as a business venture.

A key component of the venture would be financing of the customer. The Business Plan would include the methodology of financing the customer as well as factor in the infrastructure costs for an in-house financing unit. This unit would assess potential customers, provide the loan to eligible people, and ensure that a system is in place for collecting the repayment. It should also have clear guidelines for recourse in case of loan default.

The other component is to cost the infrastructure that is required to market SHS and for the technical capability to install SHS that would meet the customer's need satisfactorily.

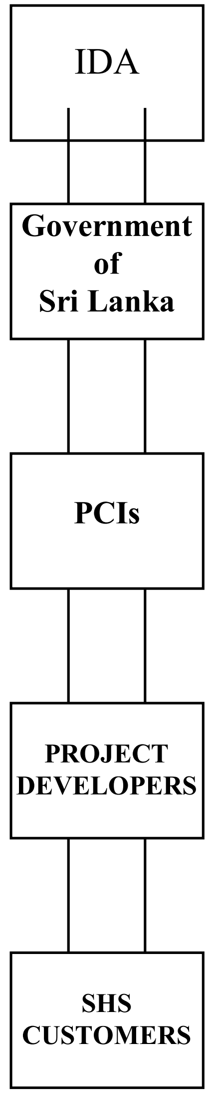
As the customer's monthly repayment is hinged to the system operating satisfactorily, the PD has to ensure that the after sales service capability is to a high standard. Ideally, it should be linked to the collection mechanism of the repayments. All these components have to be factored into the proposal.

The PD would be either one organization or a combination of organizations that bring together the specialized expertise in technical, marketing, and financing in order to develop the SHS market.

Finally, if the project proposal shows a positive return on the investment, the PCIs will entertain it. However, the proposal's viability has to be supported with collateral from the PD as with any company getting a loan from a bank. Once the PD gets the funds from the PCI, it can commence the business of developing the SHS market.

2.5 Getting the Funds to the Customer

The PD would promote SHS and the finance scheme to potential customers. Customers would present themselves and their electricity needs to the PD. If the customer requires financing, the process to evaluate and finance the customer will commence. Once the necessarily documentation is completed for financing, the SHS would be installed and PD - Customer relationship commences.



The ESD Financing Model

2.6 Making the ESD Project Work

The above is the how the ESD is designed to operate. However, this ideal situation is difficult to realize in reality for several reasons. First of there is a variety of entities who are potential project developers.

Types of project developers;

a) Private sector SHS vendors (i.e. Alpha Thermal Systems, Solar Power & Light Company)
b) Non governmental organizations (i.e. Sarvodaya)
c) Energy service companies (i.e. RESCO)
d) Rural cooperatives and banks (Thrift and Credit Cooperatives - SANASA)
e) Private Finance companies (i.e. The Finance Company)
f) Private consortiums
g) PCIs ** (i.e. Hatton National Bank)

a) Private Sector SHS Vendors

These are companies that are importing and selling solar PV systems. These developers have their strengths in the technical, marketing and after sales areas. However, they do not have the expertise to provide financing to end-users. Therefore, if they are to access the ESD credit line to install large numbers of SHS, it is best to do so in partnership with organizations that have rural lending expertise and preferably, the infrastructure.

However, these partnerships are difficult to create due to the different operating cultures. For instance, entities involved in rural lending are generally non-governmental organizations or co-operatives like Sarvodaya and Thrift and Credit Cooperatives.

Nevertheless, companies such as Solar Power & Light Company (formerly Power & Sun) and Alpha Thermal Systems have been borrowing small amounts from the PCIs to install manageable numbers of SHS in a few areas.

For instance, Solar Power & Light Company as a project developer has borrowed ESD funds to install 150 SHS since June 1997. The company has been installing SHS in partnership with its dealers in the regions. Here, the dealers take the company one step closer to the customers. The collection of repayments are, however, proving to be difficult as the company is not geared for that.

Alpha Thermal has installed 100 SHS with ESD funds and they are also having problems in collecting the repayments from many of the customers.

Following are typical steps in the private project developer process (i.e. Solar Power & Light);

- Dealer and an agent would identify a number of potential customers in an area.
- Company then provides the dealer with credit for the hardware based on a guarantee for one year.
- Dealer in turn lends to the customer for up to one year.
- SHS is installed by the company using its technicians and ensures after sales service
- collection of repayments are done by dealer but in cooperation with the technician

Therefore, with the dealer in the middle, the lending risk is minimized somewhat.

However, this method is difficult to practice on a consistent basis for the following reasons;

- commitment to SHS and lending varies from dealer to dealer (not every dealer likes financing)
- varying levels of capability of dealers to market and finance SHS
- lack of a universal system to market SHS with financing makes it difficult to develop an islandwide program

There are other opportunities for these companies where they could create partnerships with, for instance, plantations companies. They could apply for ESD funds jointly to provide lighting for plantation employees who live in remote areas. These are being explored.

However, the linking with existing NGOs doing micro credit in rural areas would provide a strategic advantage to private project developers. They would have the specialized expertise in the technology and marketing and the NGO has its focus on financing.

b) Community Based Non Governmental Organizations

There are many small NGOs scattered around Sri Lanka who have effective micro credit programs. These are regionally based and focused organizations with community involvement. These could become involved in rural lending for SHS as long as they create partnerships with organizations that specialize in the dissemination of the SHS technology.

However, there are not many NGOs in Sri Lanka that serve all corners of the country. There are also not many NGOs that have diverse capabilities to provide financing in rural areas as well as have the capacity to promote a technology such as solar PV. Sarvodaya Shramadana Society is an exception.

Sarvodaya is one of the largest NGOs in Sri Lanka. It has an extensive rural network and is involved in social, educational, health care, agricultural, financial and energy related activities.

Sarvodaya Rural Technical Services, the technical division of Sarvodaya, has been involved in SHS since its initial demonstration projects with the Solar Electric Light Fund (SELF) of USA.

The other advantage Sarvodaya has is its rural lending program administered by the Rural Enterprises Program (REPS). Through its village level organizations, which are managed by the people themselves, micro credit is provided for agriculture, home improvement and small businesses.

The initial SELF seed funded project acted as a pilot project utilizing the existing infrastructure to lend to SHS customers.

The World Bank's Asia Alternative Energy Unit (ASTAE) subsequently selected Sarvodaya to do the ESD pilot project for 300 SHS in February 1997. Here, two divisions within Sarvodaya coordinate to implement the SHS project. The Rural Enterprises Program (REPS) deals with the PCI to secure the funding. SRTS markets, installs and services the SHS. Both SRTS and REPS ensure that the repayments are made in time.

Currently, 150 SHS has been installed. The slow progress is due to several factors which have been beyond the control of the implementors of the project. (One problem stemmed from political influence which was enabling the grid to the be extended or at least promises to be made in the same area the SHS project was targeted in. A different project area has been selected since)

Nevertheless, Sarvodaya is one organization, due to the extent of it's developed rural infrastructure, that has the potential to market a large number of SHS in Sri Lanka. This would be possible once it gets further technical and marketing capability to do so.

Also, the social oriented culture of Sarvodaya is changing to keep up with the demands of the modern economic systems. Therefore, Sarvodaya as an organization is moving towards more sustainable commercial areas. Therefore, the SHS business fits well into the new emerging culture of Sarvodaya.

The Sarvodaya SHS project operates in the following manner;
• SRTS and REPS identify a project area • Develop the bankable proposal for PCI • REPS negotiates with PCI and accesses ESD Fund • SRTS/REPS establish area Solar Office • SRTS officers markets, install and service SHS in the area • REPS officers evaluates the customers for financing, finances and collects repayments • REPS repays ESD loan to PCI

Apart from Sarvodaya, a few NGOs are interested in the energy area.

With the planned marketing campaign for the ESD project, such organizations are expected emerge to access the fund to install SHS and other renewables at varying levels.

c) Energy Service Companies (ESC)

The concept of energy service can be defined as "fee for the service for electricity", just as the utility provides from the grid.

However, in the case of SHS, the system will be installed in a household, but it will belong the ESC. The customer will pay a monthly fee for the service, in this case based on the system size.

The ESC has to focus in areas where the rural households are relatively closely located in order to provide the service economically.

The ESC would have the infrastructure to have a "one stop shop" for the service. For instance, a customer from the ESC operational area could sign a contract with the ESC to receive a stipulated number of watts or watt/hrs of electricity in the . The SHS would be installed after this.

This methodology is the ultimate in minimizing the risk to the end user.

However, the risk to the ESC escalates in the following areas;.

- the SHS hardware is ESC's responsibility, but the way it is used or abused is out of its control
- dispersed nature of the rural population creates logistical problems in managing client base (maintaining SHS and collecting payments)

However, RESCO is a Sri Lankan company and a part of the SELCO-USA network which will practice this concept as a portion of their business. RESCO has already accessed the ESD to install 1000 SHS and part of the funds will be used to lend to end users and the other part to operate as an ESC.

This will be an interesting model to monitor as it develops.

d) Rural Cooperatives and Banks

Rural cooperatives are an ideal mechanism to provide financing to SHS customers. Most of these organizations are managed and operated by the community themselves.

However, the quantum of money that is leant in micro credit programs are typically low as the focus is agriculture for farmers to purchase fertilizer and seed. (For larger quantum of borrowings, for instance for tractors etc. the farmers have to deal with either commercial banks or private finance companies which are located in regional centers.)

The most prominent specialized rural lending organization is the Thrift and Credit Cooperative (or SANASA which is the better known acronym in Sinhala). This movement was established in 1906 and now boasts over 7 million member households. The organization has three tiers, being the village co-operative, regional centers and the country level federation. The unique feature of SANASA is the autonomy the village level cooperatives have in its operation. All the savings that is collected also only get utilized in the village, except for the membership fees for the federation. The federation, in turn provides the financial management systems, training and other infrastructural inputs.

Further, the federation brokers various outside project funds that maybe relevant for utilization in rural areas. The ESD may have a role to finance SHS through the SANASA system.

The latest development with SANASA is the establishment of the SANASA Development Bank which is now even a more legitimate entity to access the ESD funds even as a PCI.

Discussions have just got underway to develop these areas between SANASA and the Administration Unit of the ESD, the DFCC Bank of Sri Lanka.

Various partnerships between SHS vendors and project developers can be envisioned when SANASA has access to ESD funds wither directly or indirectly.

There are other rural banks that are emerging and these also have the potential to lend for SHS.

When the national awareness campaign commences, it will become easier to convince these rural bankers as well as others that Solar PV has an effective role in the rural energy mix.

e) Private Finance Companies

Several private finance companies have been operating in Sri Lanka for the last 25 years. Most of these concentrate on vehicle and land sales. One company, The Finance Company (TFC), however, has a strong presence in rural areas financing consumer goods. TFC has an extensive regional network and operates with extension officers to remote regions. Currently, TFC continues to finance SHS through the local dealers of Solar Power & Light Company. Ironically, the TFC financing of SHS does not have the sanction of the head office and the decision to finance is taken by the regional offices. As such, it does not get publicity. TFC management has expressed interest in participating in the ESD, possibly with a private SHS vendor in the initial stages. However, developments have been slow.

In general, the lending culture of TFC is urban oriented. This needs to change if TFC or any other finance company is to embark on a larger scale SHS lending program. The urban lending culture does not take into consideration the rural culture where defaulting debt, in properly administered programs is a social stigma.

Once again, as awareness of SHS increases with the ESD campaign, more interest maybe forthcoming from TFC management as well as others.

f) Private Consortiums

As opportunities arise both in the market place and with finance availability, SHS is getting more attention of larger conglomerates that operate in Sri Lanka. These companies are diverse in their activities from being involved in consumer electronics, tourism to plantations. Interest has been expressed by such entities looking to link up with finance companies within the group or out side to develop the SHS market. In some cases there is interest from international solar PV companies to link with these larger companies to develop the local market. Tata BP Solar of India is one such company.

Even though these organization have wide resource bases in terms of both financial and human capitol, they have very little knowledge of doing business in remote rural areas. For many, it is yet not very clear that, SHS customers are typically many more kilometers away from even the village center.

This interest has not turned into action as yet. However, the ESD awareness campaign may provide more incentive for these companies to explore the both the possibilities and challenges more closely.

g) Participating Credit Institutions (PCIs)

According to the established procedures for the ESD, PCIs cannot act as project developers (PD). In effect, if they lend directly to SHS customers, they would become a PD.

As some of the PCIs such as the Hatton National Bank has existing rural credit programs, it would be natural to channel ESD funds directly to SHS customers.

In this case, Hatton National Bank has started to lend directly to SHS customers, with a SHS vendor supporting the marketing and technical side of the operation.

For instance, the vendor, Solar Power & Light has identified many interested SHS customers from an area in proximity to a HNB branch. HNB has agreed to lend to 10 customers as a pilot. The potential customers have to

be a HNB customer or open an account with the branch. Then the bank, after doing the necessary credit evaluation, finances 70% of the SHS cost of qualified customers.
The ESD project's US $ 100 grant per system provided by GEF will be passed onto the customer. However, it is proposed that this amount be held in the Hatton National Bank branch in the customer's account until the loan repayment is complete. This amount gives the bank some financial guarantee, as well it acts as an incentive for the customer to pay the loan. Having this amount at the end of 3 years is a bonus for the customer as part of it could be used to replace the existing battery. The other option is to discount the capital cost of the SHS by US $ 100 in the first place.

Further, the Hatton National Bank has secured a guarantee from Solar Power & Light which ensures that the PV module will be repurchased by the company in the event of a customer default.

The above scenario, shows that commercial banks are moving forward, even if it is with a lot of caution.

As the program evolves and if it is successful, the Hatton National Bank may increase its exposure and other private vendors will be able to work in partnership to increase the SHS market.

3. The Future of the SHS Financing

The above activities clearly show that the financing of SHS is well on its way. However, there is yet more confidence building of the financing community that is required, if the lending levels are going to be increased to the 1000s of SHS instead of the current few hundreds.

A few interesting models are also emerging as the existing rural lending programs are moving towards SHS lending. With the distinct differences between rural and urban lending cultures, it is easier for these grass roots level organizations to extend credit for SHS rather than getting the mainstream commercial lenders and private companies to operate.

However, SHS marketing programs have other implications that complicate the process. They include:

- ensuring the SHS hardware meets certain quality standards to ensure effective operation
- ensuring the installation is done to meet standards
- training the customer to manage the system and do simple maintenance
- providing customer support services and making parts such as bulbs available
- having infrastructure to collect the monthly payment

These additional activities, most of which are highly technical in nature require the organization to learn a new discipline. For an organization specializing in rural lending, this could be a challenge.

That is where ***strategic alliances*** have to be formed between specialists in the technology (such as SHS vendors) and rural level organizations.

Conclusion

The ESD in Sri Lanka has changed the balance of the equation for SHS dissemination with the availability project financing. As a such a major barrier has been lifted. However, in the process of moving this fund through the channels to SHS customers, there are yet many barriers left. This is to do with the intermediaries such as the commercial banks (the PCIs) not being in the comfort zone yet, when it comes to lending in rural areas and with the Solar PV as a technology. This is bound to change with time, as more and more ESD loans are taken, SHS installed and most importantly, the PCIs are repaid by the project developers.

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Lessons Learned in Small-Scale Renewable Energy Dissemination

A Comparison of China and Thailand

National Renewable Energy Laboratory

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September 1998

Introduction

In the last two decades, governments, multi- and bi-lateral organizations, and non-governmental organizations throughout the world have tried to disseminate small-scale renewable energy technologies as an alternative to grid connection in rural areas. However, despite the large number and extensive history of *individual*, "one-off" projects, the international community is only beginning to understand how to *sustainably* disseminate these technologies. There are success stories in Kenya, for example, where 80,000-100,000 small solar systems have been commercially disseminated through the private sector, or in Mexico, where some 40,000 solar home systems (SHS) have been installed as part of a government-subsidized program. In this report, we examine the dissemination of small-scale renewable energy technologies in Thailand and China and discuss the lessons learned.

In commercial or near-commercial dissemination of household-scale renewable energy systems, China has been perhaps the most successful in the world. They have disseminated about 150,000 small wind turbines, 60,000 micro-hydro units, 5.4 million biogas digesters, tens of thousands of solar home systems, over 120 million improved biomass cookstoves, and 3 million square meters equivalent to 1.5 million typically sized panels) of solar water heaters. All of this has been accomplished through minimal subsidies, a decentralized network infrastructure, and extensive training and marketing.

Thailand has been very successful in deploying photovoltaic systems for battery charging and water pumping in its rural areas. As a result of three government programs, Thailand now has more photovoltaic battery charging stations (over 1000 installations) and probably more PV water pumping stations than any other country. Their extensive dissemination activities now service much of the rural, unelectrified population.

The Thai and Chinese approaches to disseminating small-scale renewable energy systems have been very different, and tailored to the unique conditions of their countries. Thailand's small unelectrified population and relative wealth has resulted in a heavily subsidized, government-driven program approach. China's large unelectrified population, limited financial resources, and industrial capabilities have led to a market-based, government-enabled approach. In both countries, the role of entrepreneurs or local government agencies to push dissemination and drive the programs has been essential.

Thailand

There are approximately 66,000 villages in Thailand. Despite a successful and effective grid-extension program, 1-2% of the population is too remote or otherwise unable to be grid-connected. Two government agencies run photovoltaic battery charging station (PV BCS) programs to provide electricity services to these villages: the Public Works Department (PWD) and the Department of Energy Development and Promotion (DEDP). Additionally, PWD has a PV water pumping program. Figure 1 shows the cumulative installations of PV BCS through both agencies over the last decade.

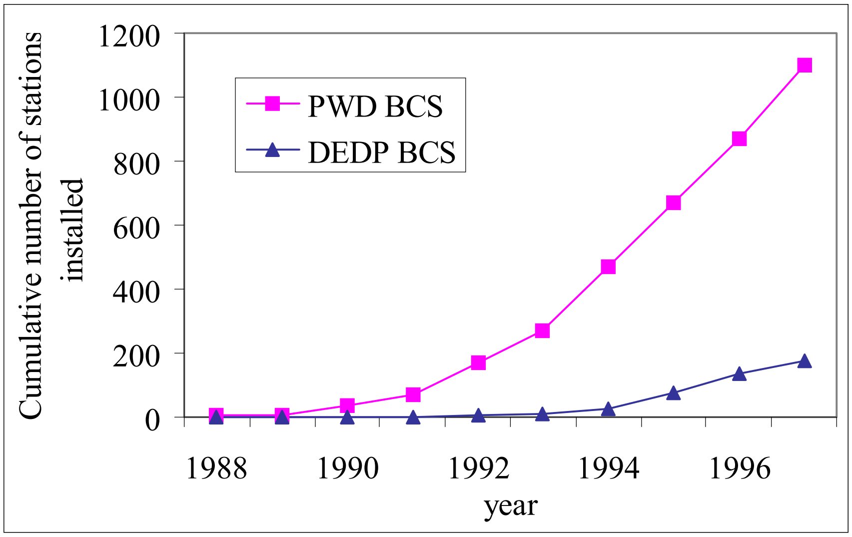

Figure 1. Cumulative installations of photovoltaic battery charging stations in Thailand[1]. The squares represent 3 kW installations by DEDP; the triangles represent 795 W installations by PWD.

Solartron

Khun Wandee Khunchornyakong, managing director of Solartron, Inc., is the main driving force behind Thailand's PV BCS dissemination programs[2]. She was introduced to PV technology in 1981, and decided to market this technology in Thailand, where the solar insolation remains relatively high year-round. Initially, Solartron targeted Bangkok customers, but they soon found that the urban market was largely limited to research and education applications.

In 1985, Khun Wandee turned to the rural areas, where the PV technology would be able to fulfill electrification needs for villages that were not yet grid-connected. Solartron hired technicians, bought trucks, visited villages that were easily accessible, and demonstrated applications that would be desirable in rural areas: water pumping and TV. However, despite great interest in the SHS, the villagers had on hand only a fraction of the 10,000 Baht (US$400) cost of the systems. Khun Wandee tried to obtain PV loans for the villagers from local banks, but while the Agricultural Bank was willing to loan for this technology, the villagers had no collateral: they had already given their land deeds as collateral for fertilizer and other loans.

Solartron decided to provide the financing themselves through a leasing program. The arrangement consisted of down payments of 1000 Baht, with the remainder paid monthly over

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[1] Amnuay Thongsathitya, "The Application of Photovoltaic Use in Thailand", *Investigating Directions and Procedures to Support Photovoltaic Application and Policy Formulation in Thailand*, Phuket, Thailand, 10-12 May 1997.
Sophon Phan-i-nakul, "Photovoltaic Program of the Thai Public Works Department", Public Works Department, Thailand, 1997.
[2] Wandee Kungchornyakong, "PV Project Development: Approaching Grassroot Groups to Policy Makers for 15 Years", *Institutional Cooperation for Solar Energy in the Mekong Riparian Countries*, Hanoi, Vietnam, 11-16 May 1998.

the next two years. One hundred 50 W systems were distributed with this payment scheme. Solartron opened a temporary office in Nakhon Ratchasima, the nearest city, and sent a salesman to collect the fees every month. However, it was difficult to collect the monthly payments: the salesman might be forced to go out to the rice fields to find the farmers or to return when the farmers had enough money. The company spent more money trying to collect the fees than the fees were worth. It was also difficult to deal with nonpayment: Solartron staff found it nearly impossible to remove PV systems from the homes of impoverished villagers, for whom the energy services were so important. They ultimately gave away many of the leased systems to the villagers.

Finally, Khun Wandee decided to take a different tack. The Thai government had a mandate to provide basic infrastructural services to the rural people. Khun Wandee drew up petitions which asked the government leaders for PV systems for electricity and water services. Solartron went out to the villages again and had the villagers sign the petitions, which were then brought to a Member of Parliament from Nakhon Ratchasima, General Chatichai Choonhavan[3]. In return for votes from the rural people, Khun Wandee asked the General for donations for PV systems. He was convinced and bought 100 modules.

Simultaneously, Khun Wandee's petition expanded her program to the national level and thousands of letters flooded into the government, requesting PV water pumping stations and PV BCS. While political will was being cultivated, it wasn't clear which government agency would be most appropriate for implementation. The Provincial Electricity Authority (PEA), the distribution utility serving all areas outside of Bangkok, wasn't interested in PV, because it was purchasing subsidized electricity from the generation utility. The Director-General of the National Energy Agency (later to become DEDP) was interested in using PV for water pumping, but in the end it was the PWD which was most amenable to PV and ready to take a proactive role.

It took three years for the government to allocate the budgets but in 1988, Solartron and the PWD were able to secure 600,000 Baht and establish 5 PV BCS as a pilot project. Evaluation of the pilots took place in 1989 and the dissemination phase of the program began in 1990. Later studies showing that PV lighting was a major factor in declining birth rates in the villages helped to persuade the government to continue these programs.

Installed PV capacity in Thailand reached 3.4 MW in 1998. The PV water pumping stations and PV BCS are responsible for 2/3 of this capacity[4]. The PV BCS alone make up nearly half of the total installed PV capacity in Thailand Solartron, with a production capacity of 2 MW/year, is the largest of the three local companies which assemble modules and integrate systems. There is not yet PV cell manufacturing in Thailand, but the government is currently funding the development of an amorphous silicon PV cell manufacturing facility.

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[3] General Chatichai was elected the Prime Minister of Thailand in 1988.

[4] Other applications of PV in Thailand include communications, grid-connected PV rooftops, hybrids, individual home systems, and education.

PWD PV Battery Charging Station Program

The PWD estimates that there remain about 3000 villages in extremely remote areas, for which grid connection is not viable[5]. The PWD sees solar PV systems as a possible approach to supplying small-scale energy for lighting, TV, and water pumping. PWD, a technical department under the Ministry of Interior, has been responsible for rural development activities such as road-building and drilling water wells. PWD has a mandate to provide basic rural infrastructure to improve the living standard of rural people.

Persistent droughts at the end of the 1980's especially affected the rural people and resulted in migration to Bangkok and other big cities. The King of Thailand asked all government agencies to mobilize resources to alleviate immediate hardship and to find sustainable water supplies for rural areas. PWD responded to this request by beginning two national rural service programs using PV: the water pumping and BCS applications. Each year PV water pumping and BCS were to be installed in 50-100 villages. The PV BCS program were to be implemented during the Sixth (1987-1991), Seventh (1992-1996) and Eighth (1997-2001) National Plans.

Already, PWD has installed over a thousand of the PV BCS throughout the country, especially in the northern region. The systems are installed by PWD and then turned over to the village to operate and maintain. The village determines how the station will be run, how much will be charged, and how the income will be spent. The village also must maintain and repair the systems by themselves. Because there is little or no follow-up, some systems still exist in villages which were later grid-connected and some systems are no longer performing optimally.

Due to the 1997 economic crisis, PWD's budget for the PV BCS has been decreased by an estimated 40%. This affects installations from 1998 on.

DEDP PV Battery Charging Station Program

DEDP estimates that of the 6,000 villages which had not been electrified by 1996, 5,500 were to be electrified by the Provincial Electricity Authority (PEA) through conventional and non-conventional means: grid-connection, diesel mini-grids, wind/diesel hybrids and PV/diesel hybrids. They see the remaining 500 villages as opportunities for PV BCS.

The DEDP PV BCS program is modeled on a 4 kW PV BCS demonstration project, jointly implemented in 1992 by DEDP and the Japanese New Energy and Industrial Development Organization (NEDO). In this project - "Demonstrative Research for Photovoltaic Power Generation Systems in Thailand" - a 4 kW PV BCS and a larger PV village system of 40 kW were installed.

The 4 kW PV BCS was installed in a village of 147 households (about 500 people) in Kanchanaburi Province, about 250 km northeast of Bangkok. The village is located inside a national park. Despite nearby high-voltage transmission lines from a hydro power plant, the village had not been electrified because grid connections are forbidden within the park. The PV BCS was installed in April of 1993, and is still operational. The village was divided into ten groups, each with a leader. A project management committee, consisting of a chairperson, vice-

[5] There does not appear to be coordination between these plans and PEA's electrification program.

chairperson, the ten group leaders, and a DEDP technician, was established. The committee is responsible for overseeing the system, setting charging fees, and allocating funds. The group leaders are responsible for hooking up the batteries and day to day operations and maintenance.

Charging of the batteries occurs on a rigid schedule. Each group can charge their batteries every ten days and every household is allowed only one battery. NEDO provides maintenance and checks up on the system every 4-5 months.

As a result of the success of this PV BCS demonstration, DEDP used it as a model for their PV BCS Program which began in 1995. The program's goal is to provide basic electricity services, for some of the poorest, most remote villages. This program will benefit 24,000 households in 300 villages over 5 years. This program is in conjunction with the King's decree that for the 50th anniversary of his ascension to the throne (1996), all villagers will have access to 50 W of electricity.

The DEDP program learned from lessons in the NEDO demonstration project and incorporated improved and less expensive technologies into their designs. The charge controllers and inverters are locally made and can be easily serviced through universities and DEDP. DEDP has six Regional Energy Centers throughout the country which implement and service the program as part of their assistance activities in rural energy development.

Unfortunately, due to the 1997 economic crisis, new installations have been halted. DEDP continues to provide limited service to existing stations, however.

Both of these PV BCS programs are completely subsidized by the national government. The capital subsidy includes the PV modules, chargers, balance of system, installation, initial set of batteries and basic training. In the DEDP program, follow-up maintenance is provided and training is more extensive. Villagers are also given charge indicators which allow them to determine when the battery should be recharged. The stations are run by committees with fixed rules; and the charging fees are deposited into village bank accounts. The PWD program turns the stations over to the villages as infrastructure projects in a more laissez-faire fashion, and leaves the villages to organize themselves and operate the station.

Despite the similar nature of the two programs, the two government agencies do not collaborate on technical designs, program implementation or even site planning. As a result, some villages have one PV BCS from each agency.

The Future of PV for rural Thailand

The 1997 economic crisis has suspended or decreased the activities of many government-subsidized programs. Rural electrification programs are no exception. Because commercial markets for PV rural electrification have not been developed, there are now few new installations. In existing installations where demand has grown, there are no mechanisms to overcome the significant cost barriers to increase the site capacity. The shrinking government budgets may now be forcing policy-makers to turn to new market-based approaches with less dependence upon government support.

For example, at the Ban Huay Ta village in Uttaradit Province, increasing incomes and a productive use weaving program set up by the Queen has led to a demand for a higher level of electricity service. The village already has one DEDP and one PWD PV BCS, but the villagers would like to be able to power fans and refrigerators. The PV BCS operator has surveyed the village and finds that about 45 households in the community would like to purchase a SHS, and that their annual incomes are approximately 7,000-10,000 Baht (about $175-250 in 1998). However, because the two existing PV BCS in the village are virtually free (charging fees are 40-60 Baht/battery/year or $1-1.50/battery/year), the typical 4800 Baht/year ($120/year) payments for a SHS may seem prohibitively expensive. The PV BCS operator has investigated costs and thinks he (and other villagers) would need a 50% subsidy in order to afford a SHS.

One option currently being investigated for this and other villages is the establishment of a rural energy service company (RESCO) which sells energy *services*, as opposed to PV panels, to households[6]. In this setup, the RESCO would own, operate and maintain the solar home systems and the households would agree to pay monthly fees based upon their energy consumption. This RESCO concept eliminates the problems of broken or poorly maintained components and gives the customers what they really want: electricity (not PV panels). In Kiribati, this service approach has proven to provide much higher customer satisfaction than the conventional PV sales approach[7].

China

There are some 100 million people in rural China who lack access to electricity. The combination of dispersed rural populations, expensive grid extension, and low energy consumption in rural areas means that distributed small-scale systems may be the best way to electrify the farmers and herdsmen. China's goal is to provide electricity access to 95% of the farmers by the year 2000. To do this, the national and provincial governments have implemented a number of programs to electrify rural areas with renewable energy. Many of these programs are largely commercial or near-commercial. For example, the micro-hydro turbines, some of the wind turbines and many of the solar home systems are sold without any end-user subsidy.

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[6] Anil Cabraal, Mac Cosgrove-Davies, and Loretta Schaeffer, *Best Practices for Photovoltaic Household Electrification Programs: Lessons from Experiences in Selected Countries*, World Bank Technical Paper Number 324, World Bank, Washington DC, 1996.

[7] Terubentau Akura, "Compare Sales Approach and Energy Service Company Approach for PV in Kiribati for the Past 15 Years", *Institutional Cooperation for Solar Energy in the Mekong Riparian Countries*, Hanoi, Vietnam, 11-16 May 1998.

In this report, we detail the dissemination of solar home systems and small wind turbines for rural electrification in two provinces. We present the work of one Gansu province entrepreneur, who has taken a market-based approach to dissemination, and the program of the Inner Mongolian government, which is a government-enabled, market-based approach.

Solar Home Systems in Gansu Province

Gansu is one of the poorest provinces in China. It is located in the northwest, and separates the central, densely populated areas of China from the remote deserts, mountains and plateaus of the west. Average annual household (one household contains approximately four people) incomes range from 2200 to 4500 Yuan (~$265-542). The Gansu utility reports that in 1996, 696,718 households in 1946 villages and 26 townships lacked grid access, although local estimates of the number of unelectrified households are up to 1 million.

In this region, it is estimated that some 10,000 solar home systems (SHS) have been sold to rural customers. Although there have been credit and subsidy programs by the Solar Electric Light Fund (SELF) and the US National Renewable Energy Laboratory (NREL), most of the systems have been sold commercially as cash sales.

Gansu PV Company is a large, regional PV systems integrator and distributor. We will detail lessons learned from their history of trial and error with subsidies, credit, and village power projects. Their experience has led them to sell small individual systems at full cost as cash sales.

Large versus individual energy systems

In 1986, Kyocera donated a 10 kW PV system to the Gansu government. It was installed for rural electrification in a remote part of Gansu province. The villagers were instructed to use their lights and their TV or cassette player for only four hours per day. However, in practice one household might leave their lights on for six or eight hours, complaining that their neighbors had left their lights on for longer than four hours the night before. In response, another household would leave their lights on all night. This mismanagement of loads eventually led to system failure after 4 years of service. After this difficult experience, no one else wanted the system, so it was eventually moved to an experimental center. This problem recurred in Linjou county, Tibet, where a 1.4 kW PV system was set up for rural electrification. This system was functional for only 6 months, and failed for similar reasons. In this village, households damaged the system by leaving their lights on 24 hours a day.

Some systems integrators have turned to individual meters to overcome problems with energy wastage. However, meters for each household are expensive. Instead, Gansu PV Company decided to focus on individual systems for the additional reason that individual systems are more easily affordable and can be commercially purchased. They began with 100W systems, but finding that these were still too expensive for the rural areas, they decreased the system size first to 50 W, then to 36 W, and finally to 20 W and below[8]. They found that the 20 W size is quite suitable, because it is affordable and people will conserve energy if necessary. In addition, the higher cost of larger systems requires subsidies, but the very small systems could be bought on a purely commercial basis. Gansu PV Company typically sells 16W, 18W, and 20W systems.

[8] The 20 W and below size range is also found to be the most popular size range in Kenya, with one vendor estimating 1998 sales to be over 20,000 systems.

Although conventional wisdom and experience from other areas indicates that 16-20W systems may be too small or outgrown too quickly, Gansu PV Company has not found this to be a serious problem. The solar insolation is quite high, ranging from 4 to 6 kWh/m^2/day in the province. They have focused on designing high-efficiency electronics and lamps. The systems are designed to power one TV and two lights for up to three cloudy days in a row. One user reported that during the past winter, he was reliably powering one TV, three lights and occasionally charging his son's battery! In addition, as the user's demand increases and the user's demand outgrows his system size, Gansu PV Company provides a trade-up policy, described below.

Working out the technical bugs

Gansu PV Company gives small payments to some end-users and local "technicians" to work part time or on occasion for Gansu PV to provide technical service. The local technicians are trained for 1-2 weeks by the company and have very basic technical skills. They fix systems, help to sell systems, and log problems.

Through this continuous monitoring of system performance, Gansu PV Company has been able to solve recurring technical problems. About three years ago, their main system failures were due to the batteries, controllers and lamps. Through trial and error they have found good, local batteries. They now estimate a typical battery lifetime of five years and lifetimes of up to eight years under careful operation. Controllers are now manufactured by Gansu PV Company with high quality elements that are bought directly from specific factories. Originally, the lamps, including the energy saving lamps, suffered extremely short lifetimes of two weeks. They discovered high-frequency transients in the waveform which caused these early failures and refined the circuitry so that they are now able to use standard fluorescent lamps which are available in most local town centers.

No capital subsidies

Subsidies for capital equipment purchases are often used to make systems more affordable for rural poor. However, Gansu PV Company's experiences show that such capital subsidies may not reach the target groups and may also lead to corruption. Implementing a subsidy program adds an extra layer of administration and middlemen, who may take money from both ends of the market chain. For example, the middleman might charge the user a fee for selling him a subsidized system; and the middleman might charge the funding agency a fee for distributing and marketing the systems. The subsidies themselves provide a financial cushion that allows the middleman to undercut market prices and still make a healthy profit.

In addition, the subsidies often led to corruption. In one instance, the middleman switched out the expensive imported equipment for cheaper, local components and passed them off as foreign equipment. It is likely that the original imported equipment was sold off at a profit by the middleman. Subsidized systems were often earmarked for politically powerful people. In one village, they found that the village leader owned three of the subsidized systems, despite the project's limitation of one system per household.

Finally, Gansu PV Company found that the use of subsidies distorts the playing field and hurts local suppliers who are not part of the subsidy program and who cannot compete with the subsidized systems.

Credit doesn't work in this region

Many multilateral, international and non-governmental organizations are promoting credit schemes to make the systems more affordable for users. However, Gansu PV Company found that the people in their region lacked an understanding of credit. There is no law in China which allows creditors to collect money which they have loaned. Because Gansu PV Company had no legal right to collect money for systems which are bought on credit, their collection rate was abysmal in the first year of their credit program. It may also be that rural villagers are so accustomed to hand-outs from the government, that they assume that the solar home systems are or should be free.

Trade-up program

As a way to deal with the affordability, finance and demand growth issues, Gansu PV Company turned instead to a trade-up mechanism. In this way, households start with the smallest system that they can afford. As they save up more money and as their energy demand grows, they can trade in the smaller system for a larger system. This concept requires that the product quality be high. As Gansu PV Company says, "you can cheat people once, but not three or four times." This is the third year of the trade-up program and a significant percentage of their customers have engaged in trading their systems in for larger ones.

Marketing

Gansu PV Company believes that advertising and word of mouth are essential to their business. They advertise on the radio, hand out flyers along the roadsides, and use their part-time workers to help spread the word. Gansu PV Company believes that advertising is so important to commercial dissemination that they recommend that potential international donors fund marketing activities rather than direct equipment subsidies[9].

[9] There are other examples of the power of marketing in renewables and energy efficiency. The Thai demand side management (DSM) program has been quite successful also because of the extensive marketing. Much of the $15.5m GEF loan to program is for marketing and EGAT has the largest nationwide TV advertising account, most of which is for DSM. In Greece, a government-driven solar water heater program was started by several years of capital equipment subsidies, but grew most rapidly when the government replaced the capital subsidies with subsidized advertising on television during evening hours. Sales reportedly rose 50% per year during the two years of this advertising campaign.

Gansu PV Company's success appears to be a function of their persistence, adaptation and innovation. Adaptation to local conditions is essential, because even mechanisms, such as credit, which are widely and successfully used around the world[10], may not be applicable for all cultures or regions. Gansu PV Company's trade-up system demonstrates the need for developers and suppliers to be flexible and innovative.

Small-scale wind power in Inner Mongolia

One of the big successes in deployment of household renewable energy systems is the dissemination of small wind turbines in China. The Chinese have a long history of using wind energy, beginning with the use of windmills for pumping water 2000 years ago. By 1959, there were 200,000 canvas windmills pumping water, mostly in north Jiangsu province. In the 1950's the Chinese government began research on wind electricity generation and by the 1970's they were able to begin a campaign to electrify rural areas with small-scale distributed renewable sources, including wind and photovoltaics.

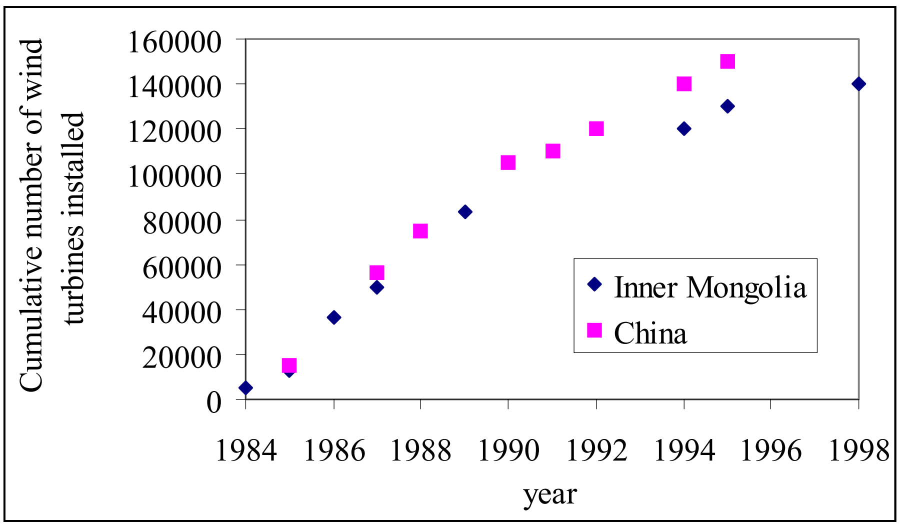


Figure 2. Cumulative number of installations of small-scale wind turbines (typically 50-300 W) for rural electrification in Inner Mongolia and China.

Although the central government provided research and development of wind technology, they played a relatively minor role in this success story of small-scale wind turbine dissemination. Local governments in some rural, windy provinces - Xinjiang and Qinghai, for example - have only been mildly successful in disseminating small-scale wind turbines. It is the local government of Inner Mongolia that has had the most aggressive policy of wind power expansion and this is reflected in the tremendous number of wind systems installed in this region. Figure 2 shows that over 80% of the small-scale turbines in China are located in Inner Mongolia.

[10] The Grameen Bank has been one of most successful micro-lending institutions for the poor. Their housing loans are most widely known but they also lend for micro-enterprise and small-scale renewable energy systems. Projects by Solar Power & Light Company in Sri Lanka and by the Solar Electric Light Fund/Vietnam's Women Union in Vietnam are other examples of successful use of credit to make solar home systems affordable for rural people.

Inner Mongolia is an autonomous region in northern China, bordering Mongolia. Inner Mongolia has about 1/8 of the total area of China, but less than 2% of the total population. Most of the land is grassland, and many of the rural people are herdsmen and farmers. Average per capita annual incomes are about 2000 Yuan ($240), which is fairly rich for a rural, unelectrified population in an underdeveloped province. This is 2-3 times higher than Gansu province, and may account for the proliferation of small-scale energy systems. It is estimated that there remain 300,000 households in 1100 villages and 198 townships that currently lack electricity[11].

Policy and Planned Development

In 1980, Inner Mongolia's Science and Technology Commission made renewable energy development and utilization a priority program. They emphasized local development and implementation of this program with these guidelines:

- The primary objective of new energy development and utilization is to solve the energy problems of remote areas, and the top priority is to develop small-scale wind turbines, PV cells, and balance of system components for stand-alone applications.
- The basic principles of new energy R&D are "reliable to use, convenient to maintain, and affordable to herders".
- Small-scale products and energy use for daily life are the main focus, and the needs of production and daily life should be integrated.
- Local people should be in charge, with the state providing appropriate support.

The local government integrated the research, production and outreach components of their program into a single continuous system. In 1984, the New Energy Office was established to manage the renewable energy work. This agency set policies for renewable energy development, conducted near- and long-term planning for renewable energy, and coordinated activities in research, production and dissemination.

In the 1990's Inner Mongolia began collaborations with international partners to advance their technologies, especially in hybrid and centralized systems. Utility-scale wind farms and other renewable energy technologies also became more widespread during this time. The long-term goals for the region are to disseminate a total of 150,000 small wind turbines, 150 kW of PV, and 150,000 m^2 of passive solar buildings by the year 2000. By 2010, electrification of remote areas in the region is planned to exceed 50%[12].

Wind Turbine Technology Development

The State government assisted wind power development by supporting R&D and preferential loans for manufacturers under the Sixth, Seventh, and Eighth Five-Year Plans. The local Inner Mongolian government has long viewed wind power as an exploitable energy source, boost to the local economy and solution to rural electrification. They had a heavy hand in promoting the technology, to the point of specifying production output and price of the wind turbines. For example, to their specification, in 1985, Shangdu Livestock Machinery Works produced 4400 turbines, which were sold at an average of 518 Yuan/turbine, at a 23% profit.

[11] John Byrne, Bo Shen and William Wallace, "The economics of sustainable energy for rural development: A study of renewable energy in rural China," *Energy Policy*, Vol 26, No. 1, pp. 45-54, 1998.

[12] Lin Li, "The Development and Utilization of New Energy Sources in the Inner Mongolia Autonomous Region: Review and Outlook", *Inner Mongolia Science, Technology and Economy*, No. 4, pp 27-30, 1997.

The Shangdu Livestock Machinery Works began cooperation with many research institutions and universities in 1975 to develop wind electric generators. They acquired technology from the SVIAB Company in Sweden in 1988 and have been improving the technology and simplifying the structures over the years. Today they produce the largest number of wind turbines in China.

The small Chinese wind turbines have been designed to perform well at the low wind speeds found at the typical hub height of less than 10 m. Figure 3 compares the power curves of the Chinese turbines with those of similarly sized turbines from abroad, showing that the Chinese turbines begin producing power near their rated power output at much lower wind speeds than typical small turbines from the US and Germany.

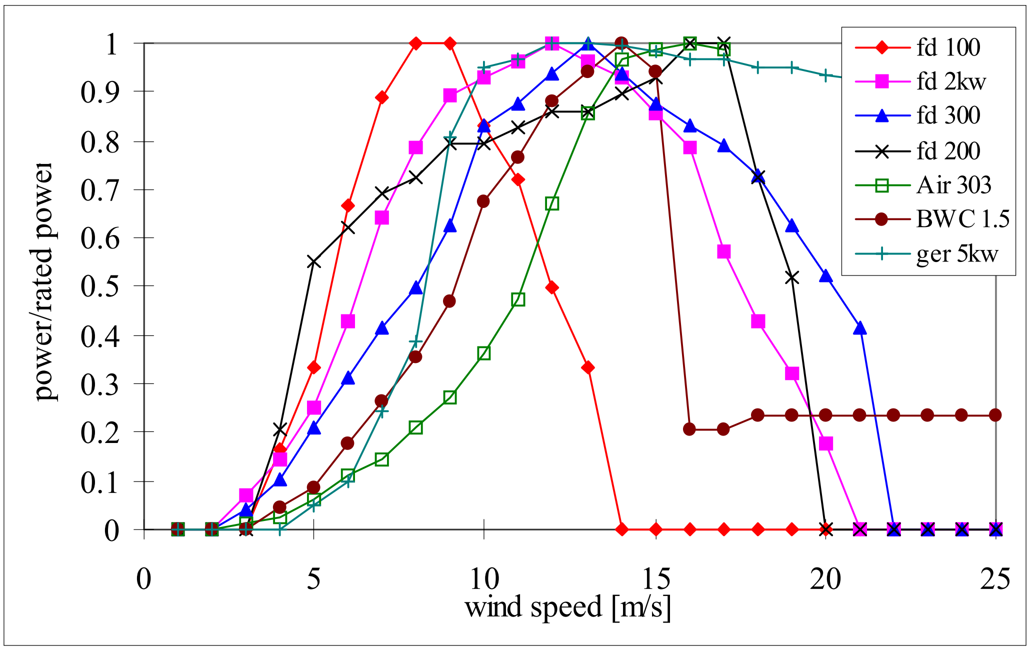


Figure 3. Comparison of scaled power curves from small wind turbines manufactured in China, US and Germany.

Since 1990, the German technical aid agency GTZ has sponsored a project in Inner Mongolia to transfer technology of small-scale wind turbines and electronics for hybrid systems. They have successfully transferred the know-how for production of their equipment to the joint venture Hua De New Technology Company, who now replicates and sells the equipment. To go the next and very challenging step of transferring a deeper understanding of the design such that the local company could improve upon and modify the original design would require much more training of and experience by the joint venture[13].

Hybrid Systems

The systems used in Inner Mongolia, although widely disseminated, suffer from low winds during the summer. The power of the wind increases as the cube of the wind speed, so that the

[13] Hubert Klapheck, FGU Consulting, personal communication, 21 April 1998.

power available in the high wind months of winter can be 3-4 times greater than that in the low wind months of summer. Since the *solar* resource peaks during the summer, the addition of PV provides a means for electricity production year-round.

The second major problem with wind-only systems is that they are typically used with automotive lead-acid batteries. These batteries are designed for continuous charge, for low depth of discharge and for providing a large amount of power over a very short period of time. However, in use with wind electric chargers, the batteries are discontinuously charged and are severely discharged over a long period of time. In this mode of use, the batteries only last 1-2 years, and thus comprise a significant expense. Rising battery costs further aggravate this problem. In comparison, when used in solar chargers, these batteries typically have lifetimes of 5-6 years.

The Chinese herdsmen have already recognized the limitations of the wind-only systems and the advantages of hybrid wind/PV systems and have begun adding photovoltaic panels to their wind systems. The relatively high cost of PV is currently the greatest obstacle to their widespread use. The local government has begun collaborations with the US, Germany and the UNDP to study the design and application of hybrid systems in the region.

Infrastructure

The central and local governments have established an extensive network of rural and new energy offices which disseminate information and provide technical training and service at the county level. These offices have been instrumental in deployment of the small-scale renewable energy technologies.

The Ministry of Agriculture established the management system of rural energy offices in 1979. These rural energy offices now exist in 1800 of the 2200 rural counties in China. The original programs of the early 1980's focused on single technologies such as improved biomass cookstoves, biogas digesters and small hydropower. In 1983, they began a pilot project for integrated rural energy development in six counties. The success of the pilot led them to expand it to twelve counties during 1986-90 and then into the "One hundred counties" program during 1991-95. These integrated rural energy development programs focused on the interdependence of the energy and environmental sectors as well as social, economic and environmental development[14].

In addition to the central government's rural energy offices, the local Inner Mongolian government has set up new energy service stations in over 60 of their region's 88 counties. These provide information and subsidies specifically for renewable energy systems. Their technical and training sites provide additional technical support.

Subsidies

In 1986, the Inner Mongolian government began offering a subsidy of 200 Yuan ($24) per turbine (or PV panel) and 50 Yuan ($6) per battery for components manufactured in Inner Mongolia. The process for obtaining the subsidy was quite simple: the herdsmen went to their

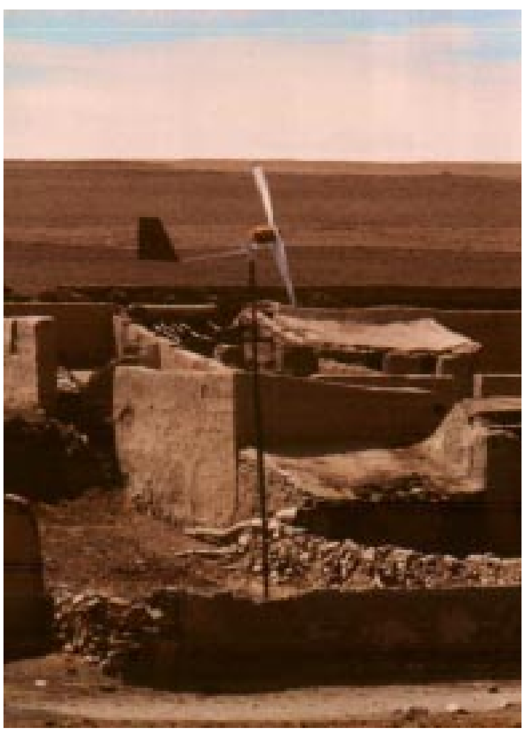
[14] Deng Keyun, Gu Shuhua and Liu Wenqiang, "Rural energy development in China", *Energy for Sustainable Development*, Vol, 3, No. 3, September 1996.

local new energy office and obtained a coupon which they brought to the Inner Mongolian turbine manufacturer of their choice. This helped to build up the local industry. The local government and utility each provided 5 million Yuan annually for these programs. Currently, subsidies are about 100 Yuan per 100 W rated capacity for the wind turbine and they do not apply for batteries. This program was completely driven by the local government until 1990, when the central government began contributing about one-third of the wind power subsidies.

There has been little experience with financing of systems. While there is now a revolving credit program underway, nearly all installations to date have been cash sales. The relative wealthiness of the rural population and the relative inexpensiveness of the locally manufactured equipment has made the systems affordable for the users. However, in order for the dissemination program to reach less affluent segments of the population, financing may become an important component of future programs.

Domestic industry

These programs have been successful in creating a domestic industry of wind turbine manufacturers. Today, China produces more turbines than any other country through its 42 local manufacturers. These are mostly 100 W units used in single households, although 300 W units have now become very popular. Shangdu Livestock Machinery Works reports production growth of about 58% per year to about 10,000 units in 1996[15]. In 1996, total annual production in China was estimated at 20,000 units. China also exports these turbines to various Asian countries including Mongolia, Malaysia, Vietnam, Pakistan, Sri Lanka, and Japan. In addition to creating a manufacturing industry, over 10,000 people were trained for construction, installation or maintenance of turbines.



In 1993, it was estimated that of all wind turbines in Inner Mongolia, 85% were in good condition and 78% were in operation. This is remarkable in light of the fact that these wind turbines have reported lifetimes of 10-12 years, and that parts of the turbines are often of poor quality (especially the blades, which must be replaced every 5-7 years). More recent anecdotal evidence suggests that this is an overestimate and that many turbines are now inoperational[16]. However, no survey has been done to ascertain the performance of these turbines.

By 1995, there were about 150,000 small turbines in rural China, providing electricity for lighting, radios, televisions and small appliances. Today, approximately 140,000 small wind turbines (and about 10,000 PV systems) are located in Inner Mongolia, and about half a million people receive electricity from

[15] Yang Bing, *Small Scale Wind Energy Systems,* March 1997.
[16] Personal communications from program managers at the Chinese Academy of Sciences, with the US DOE/China collaboration and with the GTZ/China collaboration.

these small wind or solar systems[17]. These small turbines contribute over 17 MW to installed capacity.

The Chinese small wind story is one of excellent policy and planning, well-established infrastructure, development of domestic industry, and a target population which could afford the systems. Minimal subsidies were used to stimulate both the industry and sales, but it is likely that the dissemination has been mostly to the wealthier households. However, the resulting development of a domestic industry has been that low-cost turbines are now widely available and come closer to the reach of the middle-class households.

Lessons Learned

Subsidies – Degrees of market distortion

Various kinds of subsidies and various levels of subsidization have been used in Thailand and China. In this section, we examine some of the end-user subsidies and the degree to which the subsidies distort the markets.

Subsidies from in-country

In Thailand, the traditional government-subsidized approach has resulted in renewable energy programs which subsidize renewable energy technologies by 50-100%. In addition to the 100% subsidies on PV BCS through the DEDP and PWD programs, there are 50% subsidies on PV through a proposed PEA program and 30-40% subsidies on solar water heaters through a National Energy Policy Office program.

The large market distortions may make it difficult to move to a market-based dissemination program. The Ban Huay Ta villagers interest in moving to a higher level of electricity service may be thwarted due to the fact that their current costs in the subsidized BCS are only 1% of the costs of commercial SHS.

Another factor which may make the cost of a SHS less attractive in rural electrification is that the distribution utilities' rural electricity prices are cross-subsidized by urban electricity prices. Because of the subsidies for rural users on both sides of the SHS market, completely commercial dissemination of SHS faces large barriers.

Subsidies from multilateral institutions

The international development world is fraught with the misuse of subsidies in the form of grants and loans which distort the market. The more benign of these is the multilateral development bank (MDB) loans, which sometimes compete with private investors by lending money for projects which are easily financed in commercial markets[18]. The 6% interest rates offered by the World Bank, for example, are far below commercial rates and thus far more attractive to developers.

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[17] Long Zequiang, *Small Scale Wind Energy Systems*, December 1996.
Ma Shenghong, Hua De New Technology Company, personal communication, 31 May 1998.

[18] *Asian Wall Street Journal*, "The World Bank is Edging Out Lenders in China", by Craig Smith, p 1, June 11, 1998.

In some cases the MDB's are even at odds with each other. A recent Asian Development Bank study of optimal financing for a 1.8 GW power plant in Shanghai recommended a bid invitation to private investors. However, when Shanghai checked with the World Bank, which was willing to finance the loan, the competitive bidding option became uncompetitive.

Subsidies from bilateral donors

Subsidies from bilateral donors may provide an even greater market distortion than the MDB's in that they subsidize the technologies from one country only, in a move to take over market share from competing suppliers of other countries.

Recently, new bilateral subsidy programs for renewable energy technologies have been proposed. These include the soft loans for utility-scale wind turbines in China as well as subsidies for PV solar home systems (SHS) in several Asian countries.

Soft loans for wind turbines

DANIDA recently announced their most favorable soft loans to date for China: $150M over 3 years for wind turbines at zero interest over ten years. It is estimated that 90% of wind power installations in China were funded through concessional finance. While the Chinese argue that there is limited capital available in-country, the availability of concessional finance means that the only development which occurs in China will be that which has access to concessional finance. Other bilateral aid agencies have provided concessional loans in an effort to compete in the subsidized loan market to promote their own countries' technologies. Since not all concessional terms are equal, those countries with the most favorable loan terms will be the ones who will be able to sell turbines in China.

By making soft loans available, foreign governments have destroyed any hope of commercial wind markets and privately financed wind development in China for the near term. In the 1995 Beijing International Conference on Wind Energy, one of the largest Danish wind turbine manufacturers noted that the fledgling commercial market which had existed prior to the concessional finance programs had vanished. As a result, no turbines had been sold on commercial terms in China in 1994[19]. It is generally agreed that when the current round of soft loans run out, the Chinese will wait again for more of the same. The availability or even possibility of subsidized loans has reduced the Chinese willingness to pay full cost for commercial machines. Unfortunately, the Chinese do not have domestic production of large turbines, so this means that wind power development will be stalled.

Subsidized solar home systems

The markets for SHS are rapidly expanding throughout the developing world, with new suppliers and developers being established. In an effort to develop PV markets, the Dutch government has proposed donor aid to subsidize their SHS in the Philippines, China and Sri Lanka. In addition to distortion of local markets, there is concern that this aid may hurt local distributors and dealers and, in the case of China, local PV manufacturers.

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[19] Hans Buus, "Large Scale Wind Power Plants in China," *Beijing International Conference on Wind Energy*, Beijing, 9-13 May 1995.

In Sri Lanka, the Dutch government is offering 35% subsidies for their SHS to local distributors. While this program may initially seem enticing, due to the large subsidies and numbers of systems involved (about 30,000 are eventually planned), it may distort future markets by eroding the willingness of later end-users to pay full price for systems after the subsidies end. In practical terms, the local distributors have no choice but to join the program, if they want to compete in what will be a subsidized and distorted market.

In the Philippines, local developers and systems integrators have been cultivating local commercial markets for SHS for several years. Their largest project to date is about 1000 systems. The Dutch aid would subsidize 15,000 SHS to the Philippines government for rural areas. There is great concern that the donor aid may harm the fledgling commercial markets and create subsidy dependencies.

In China, the World Bank has been packaging a 200,000 SHS project for rural areas in five remote provinces. If the proposed Dutch aid for SHS in one of these provinces is implemented, then the World Bank will be forced to pull their project out of this province because they will not be able to compete with the large proposed subsidies of the donor aid program[20].

There are ways in which host countries can avoid these problems. Host governments can channel all aid through their own rural electrification/renewable energy programs or agencies, such as the MDB funding through the Indian Renewable Energy Development Agency. Or they can carefully segment the population and target various aid programs based on geography or affordability, such as Indonesia's handling of German, Australian, and World Bank aid. Since bilateral aid subsidies have proven to be so powerful and since governments have been so aggressive about using them, it is imperative that both government recipients and donors alike be educated about the need to create sustainable, commercial markets and the long-lasting havoc that market distortions can wreak in the marketplace.

Market-based versus government-driven dissemination

Many Asian developing countries are interested in using small-scale renewable energy technologies to provide basic electricity services for rural people. However, most governments are not familiar with the latest methods in market-based dissemination that have resulted from the lessons learned in government-driven dissemination. Many of the newest ideas of market-based dissemination, such as rural energy service companies or elimination of end-user subsidies, are only beginning to be discussed in Asia. Therefore, many governments still opt for the traditional government-driven and government-subsidized approach.

In the industrialized countries, however, the current conventional wisdom is to move away from traditional government-driven dissemination and to pursue a market-based approach. This is in line with worldwide trends towards privatization of many government operations and competition in sectors such as telecommunications and power. One of the reasons why the development community has come to this conclusion is that government and international aid is limited and only the private sector can source the levels of funding that will be necessary to provide electricity services to the some 2 billion people still unserved. Perhaps a more important

[20] Thomas Reindl, "Private Sector Initiatives to Commercialize Photovoltaics without subsidies", *Institutional Cooperation for Solar Energy in the Mekong Riparian Countries*, Hanoi, Vietnam, 11-16 May 1998.

reason is that the private sector typically provides services more cost-effectively and more efficiently than the government.

Today competitive, commercial markets are viewed as the most reliable and cost-effective structures for sustainable dissemination of new technologies. Subsidies come and go as political will changes. Government funding dries up during economic hard times. The challenge is to create these competitive, commercial markets for renewable energy technologies in developing countries.

However, it is hard to ignore the success of Thailand in its government-driven dissemination of over 1000 PV BCS. For nearly a decade, Thailand has been able to provide electricity services to a growing number of rural villagers at practically zero cost to the end-user. Can these successes be applied elsewhere?

Thailand is a unique case in the developing world. It is a relatively rich country which has graduated from many donor aid programs. A small fraction of their petrol tax is deposited into the Energy Conservation (ENCON) Fund, which is then allocated towards energy efficiency and renewable energy programs. Before the 1997 currency devaluation, the ENCON Fund totaled $600M. The government is committed to energy efficiency and renewable energy; and environmental protection and indigenous energy use are high priorities for the country. In addition, approximately 98-99% of the population is grid-connected. Thailand therefore finds itself in the unique position of being able to afford and having the political will to completely subsidize electricity services for their unelectrified population.

However, the economic and currency crisis of 1997 has had huge repercussions on Thailand's programs. DEDP has completely halted installations of PV BCS and only limited funding is available to ensure that existing stations remain operational. PWD's installations of PV BCS and water pumping stations have declined substantially. Some of the ENCON Fund was diverted towards non-energy government needs and at one point during the economic crisis, the government was seriously considering usurping the Fund to make up for budget shortfalls during the economic crisis.

With current funding limitations and increased electricity demand in many villages which would require much more money than is currently spent per villager, Thailand may now need to move to a more market-based approach in order to meet the needs of the rural populations.

The commercialization and government-enabled market-based approaches of China may be better suited as a model for other developing countries. Indeed, China is similar to much of developing world in that a large percentage of their population (about 10% or some 100 million people) lacks electricity access. Like most other developing countries, China doesn't have enough money to completely subsidize electricity services for all of their unelectrified population.

However, China is unique in that it has a relatively mature small-scale renewable energy industry. This, combined with a huge demand for decentralized energy systems, has conspired to drive prices down. China is one of the few developing countries that manufacture PV systems from cells to modules to solar home systems; they have mature wind turbine, micro-hydro and solar water heater industries with an extensive local manufacturing base. The high demand and resulting large production scales means that prices are among the cheapest in the world, per kW or per kWh. Their technologies have a reputation for inferior quality, however, and thus China is not able to export their products to many parts of Asia, notably Southeast Asia.

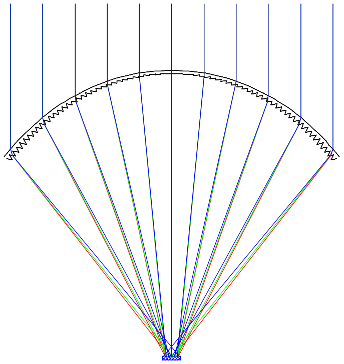
New projects in China may help to accelerate current efforts. The World Bank is starting work in China that may accelerate the development of SHS use. The United Nations Development Program is starting a project to transform the renewable energy market into a demand-driven market, to attract investors by offering business opportunities, and to coordinate the local industry by creating renewable energy industry associations.

Conclusions

In conclusion, both Thailand and China have been successful in disseminating large numbers of small-scale renewable energy technologies to provide electricity in rural areas. They have utilized very different strategies in approaching the problem: the Thai government has directly disseminated the technologies in fully subsidized programs and the Chinese government has provided infrastructural, technical, and financial support so that local industries could disseminate the technologies. Despite Thailand's successes, the recent economic crisis has had huge repercussions on their programs, revealing their current dissemination strategy to be unsustainable. New market-based approaches with less dependence upon government support may be useful in filling the gap caused by shrinking government programs. It is hoped that the near-commercial renewable energy markets in China are independent enough of government budgets to suffer fewer repercussions than those in Thailand, if the Asian economic crisis should spread to China. The World Bank, UNDP and GEF are also implementing projects to support and expand market development in China.

In addition to the sustainability issues, it is not recommended that other developing countries adopt Thailand's model because the conditions which made Thailand's strategy successful – relatively large government funds and relatively small unelectrified population – are not found in most developing countries. Few developing countries are rich enough to be able to subsidize electrification for all of their remote, rural areas.

Finally, the development of sustainable markets for dissemination is generally hindered by end-user subsidies which tend to distort markets and often result in a boom-and-bust dissemination pattern. The long-lasting effects of these distortions are often underestimated by the governments and institutions who provide the subsidies. Some of the most flagrant abuses of subsidies have been the recent efforts of bilateral aid agencies to expand export markets for their countries under the guise of development aid. Education for both donors and recipients alike about the long-term effects of these subsidies is essential if governments are to craft policy for sustainable dissemination of renewable energy technologies.



PV Technology For Global Village Power

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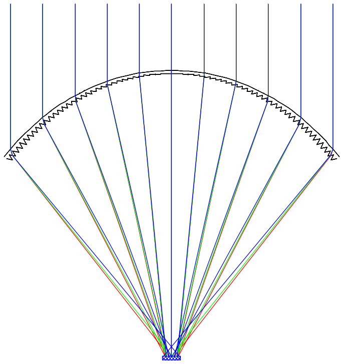

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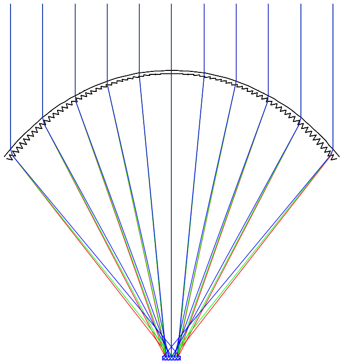
- ***SolarRow***
  - **Solar Photovoltaic System That Uses Sunlight To Produce Power For Multi-kW To Multi- MW Users (DC or AC), For Villages to Utilities**
- **Licenses**
  - **ENTECH Is Developing Local Industry and Jobs by Licensing Companies In-Country to Manufacture and Sell These Products To Provide Local Village Power, As Well As for Other Independent and Sustainable Power Applications**

ENTECH, INC.



- Power Output: 800 Watts (DC)
- Two 4th-Generation Concentrator PV Modules
- Solar-Charged 12 VDC Battery Powers the Micro-processor Controller and the Sun-Tracking Drives for Both Tilt and Roll Axes
- All-Galvanized Structure Can Be Fabricated In-Country And Fully Assembled in Local Factory for Easy Field Installation

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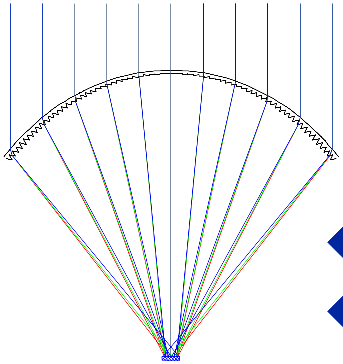
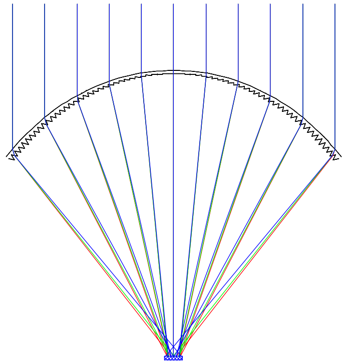


SolarRow PV System Product

- Four *SolarRows* at CSW* Solar Park, Fort Davis, Texas
- Power Output: 25 kW Per *SolarRow,* 100 kW For 4 Rows

* CSW - Central and South West Company - Major Electrical Utility In USA



ENTECH's Technology Licensing Program Outside U.S.

- **License Agreement Gives In-Country Company (Licensee) Right To Manufacture & Sell *SunLine* & *SolarRow* Products For Village Power And Other Sustainable Power Markets**
- **License Program:**
  - **ENTECH**
    - **Receives Up Front Fee To Cover Technology Transfer & Training**
    - **Ships Fresnel Lenses, Solar Cell Assemblies & Other Specialty Components To Licensee For Life Of Agreement**
    - **Makes Available To Licensee On-Going Tech. Support & Consultation**
  - **Licensee**
    - **Builds Aluminum & Steel Components In-Country**
    - **Assembles Modules, Structures, Controls, Drives & Inverters In-Country**
    - **Sells, Installs, Maintains, And Operates Systems As Desired**

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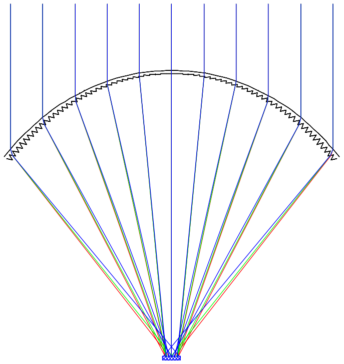
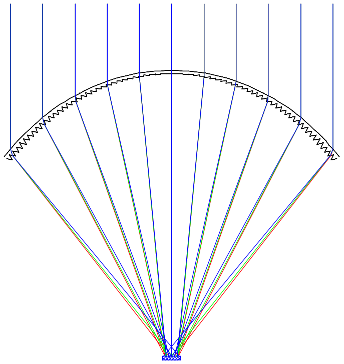


ENTECH PV Product Advantages

- Can Achieve Lower Product Cost Than Competition With
  - Moderate Production Volume
  - Minimal Technical Risks
- Ideal For International Licensing
  - Creates In-Country Jobs & Local Economic Development Through Manufacturing, Assembly, Installation, Operation & Maintenance
  - Creates U.S. Jobs - Manufacture Specialty Components In USA
  - Allows For Rapid Market Expansion
- Provides Predictable Energy Costs For 30 Years Or More

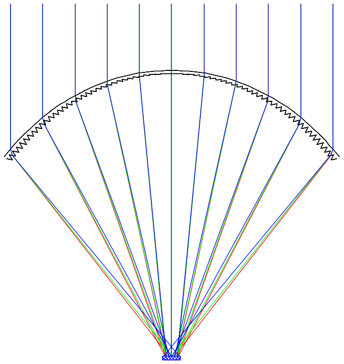
ENTECH, INC.



ENTECH PV Product Advantages (Continued)

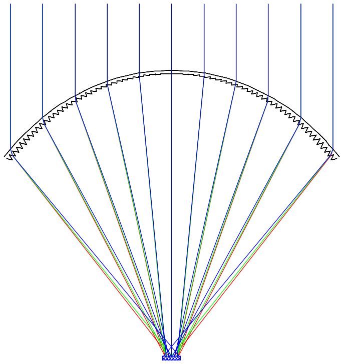
- Long Term Performance & Reliability Verified By Numerous Third-Parties
- Technology Protected Internationally Through Key Patents
- ENTECH's Solar Power Systems Can Provide:
  - Electricity, Hot Water And/Or Distilled Water For Villages, Homes, Hospitals, Schools, Apartments, And Businesses
  - Electricity For Remote Water Pumping
  - Electricity And/Or Process Heat For Local Industries
  - Electricity For On-Grid or Off-Grid, DC or AC Applications
- Can Rapidly Expand Production To 100's of Megawatts Per Year

ENTECH, INC.



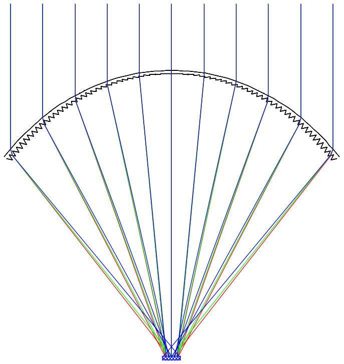
Experience

High-Performance & Reliability



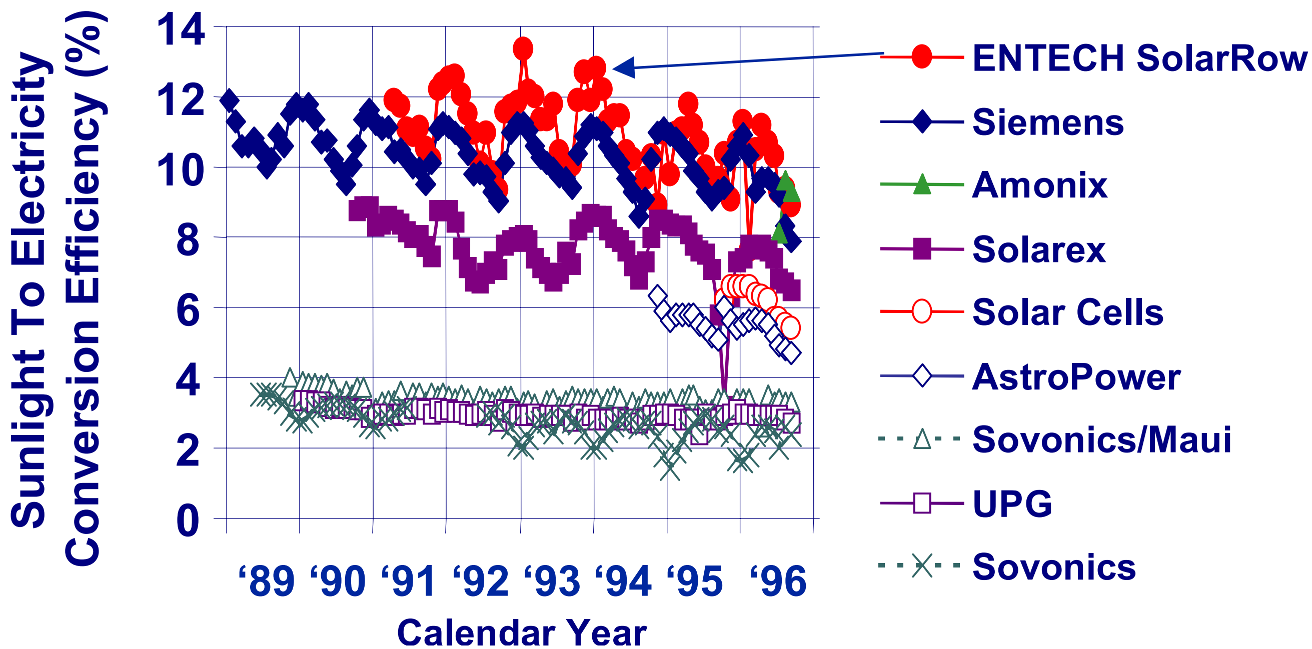
ENTECH Experience

- Technical and Management Team Together Since 1977
- Four Generations of Terrestrial Concentrator PV Technology
- More than $30 Million of R&D Investment to Date
- Prior Successful Contracts:
  - Government - U.S. Dept. of Energy, Sandia National Laboratories, National Renewable Energy Laboratory, Jet Propulsion Laboratory, NASA
  - Utilities - Bechtel/Pacific Gas & Electric Company, Texas Utilities Company, Central and South West Company, Northern States Power, City of Austin Municipal Electric Department, Tennessee Valley Authority
  - Companies - 3M and Overseas Customers
- ENTECH Has Received Over 11 Patents On This Solar Technology
- Recognized as the Leader in Concentrating Photovoltaic Technology for Terrestrial and Space Applications



High Performance & Reliability

ENTECH Is the Long-Term Leader In Independent PV Tests Of U.S. Manufacturers' Photovoltaic Systems At PVUSA*



* PVUSA - PhotoVoltaic for Utility-Scale Applications Program (Davis, CA USA)

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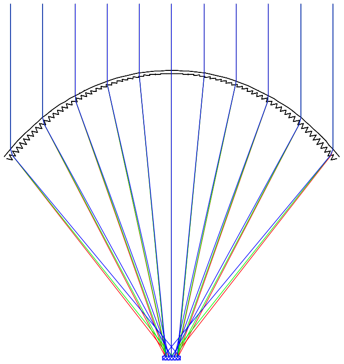
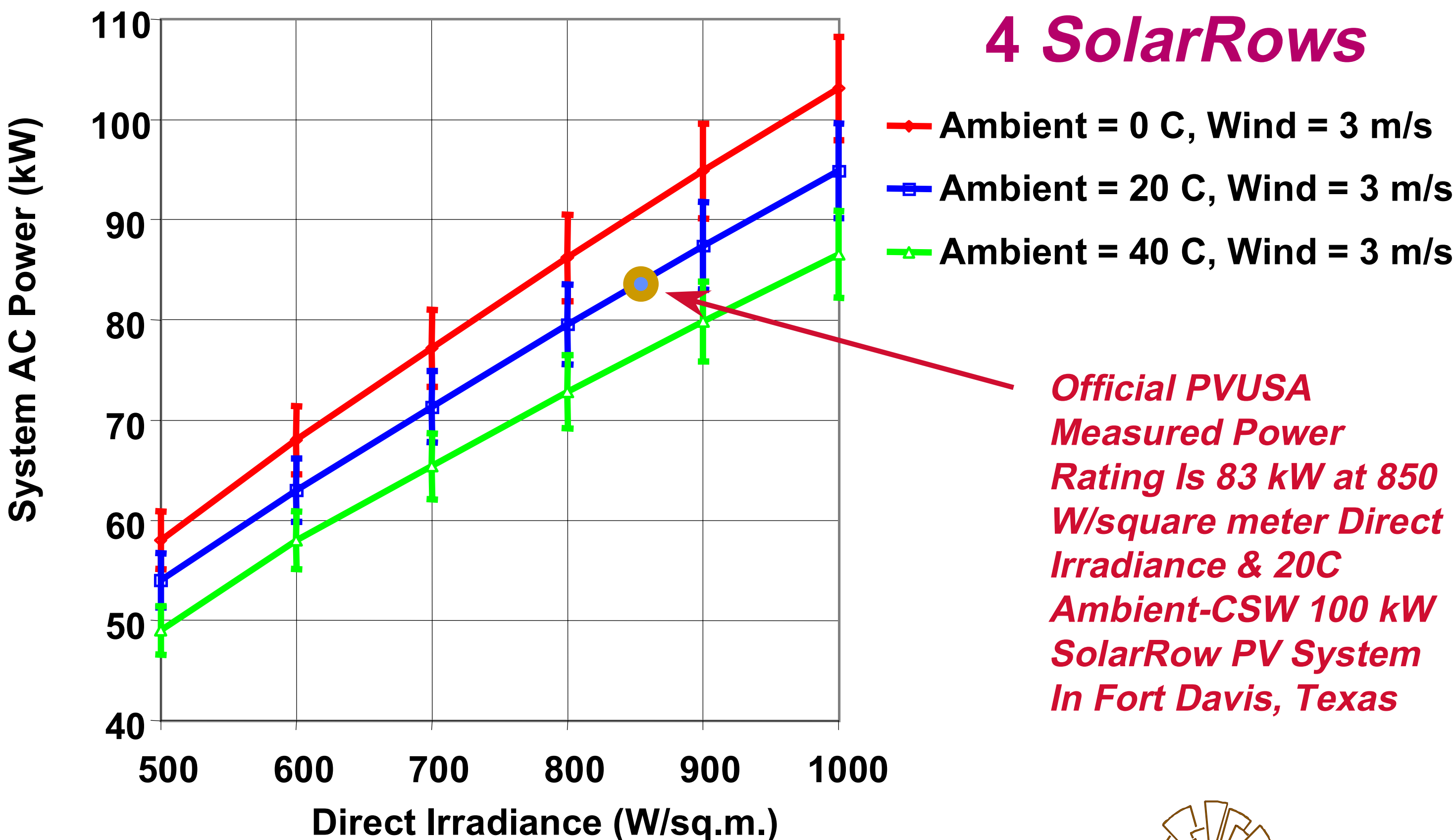


High Performance & Reliability
Predictable PV System Power

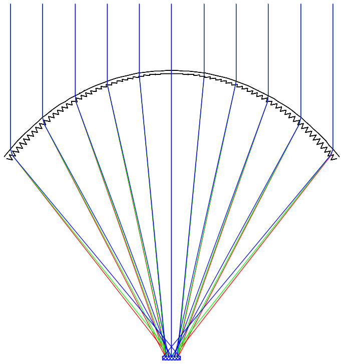
Curves Are Predicted Based on Sandia Module Test Data Correlations with 95% Wiring/Mismatch Loss and 94% Inverter Efficiency



Official PVUSA Measured Power Rating Is 83 kW at 850 W/square meter Direct Irradiance & 20C Ambient-CSW 100 kW SolarRow PV System In Fort Davis, Texas

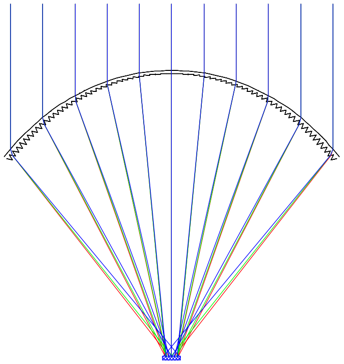
ENTECH, INC.

High-Performance & Reliability
SunLine PV System In Minnesota



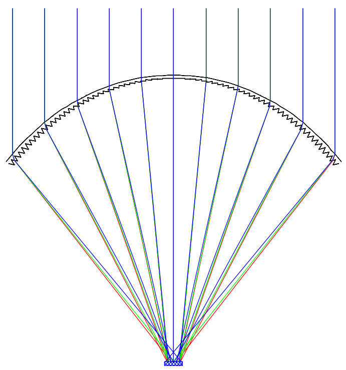
- Customer: Northern States Power Company
- Location: 3M Center, St. Paul, MN
- Operational Since July 1995
- Survived 3 Minnesota Winters
  - Ice Storms
  - Snowstorms
  - Minus 35C Ambient
  - Many Meters of Total Snowfall
- Survived Severe Wind Storm
  - >30 meters/second Speed
  - Over 250 Mature Trees Blown Down at 3M Center
- Lenses Never Cleaned
- Negligible Degradation
- Automatic, Unattended Operation

ENTECH, INC.



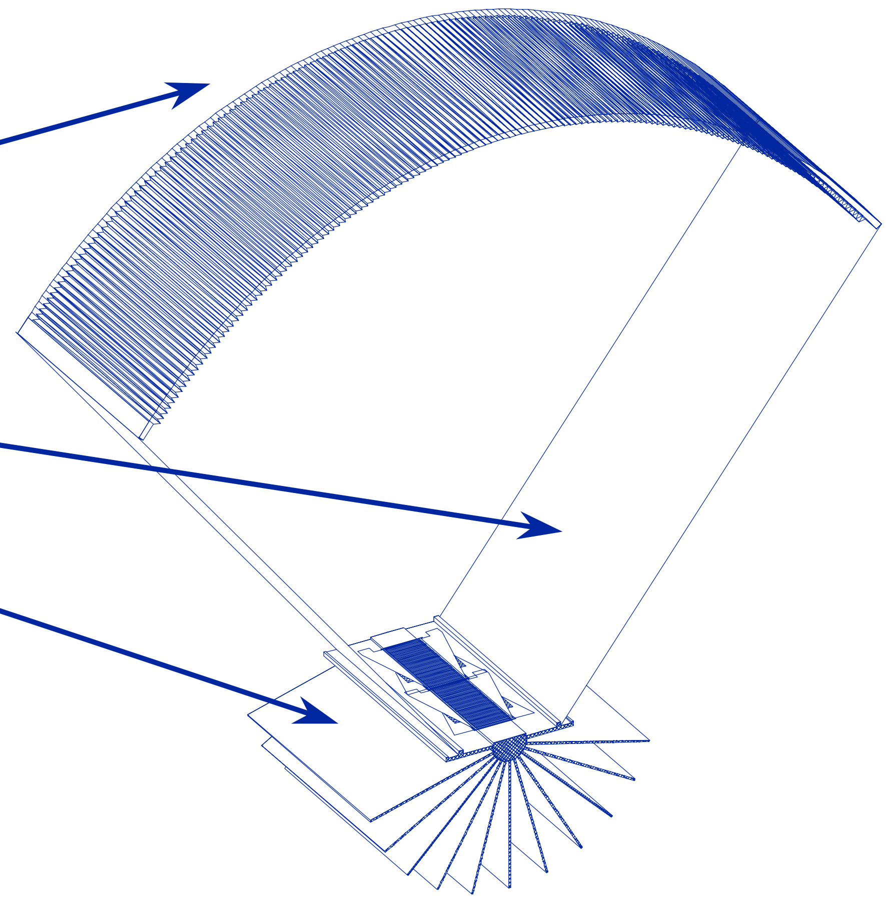
<u>PV Technology Designed For In-Country Jobs & Industry</u>

ENTECH, INC.



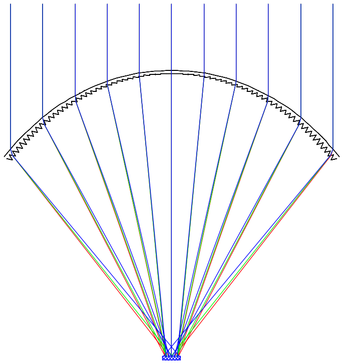
4th-Generation Concentrator PV Module

One-Foot Cross Section



- **Fresnel Lens:**
  - ENTECH Supplied/3M-Produced Acrylic Lens
- **Marine Aluminum Housing**
  - Licensee Supplied
- **Photovoltaic Receiver:**
  - ENTECH - PV Cell Assemblies (U.S. Patent 4,711,972)
  - Licensee - Receiver Assembly (US Patent 5,498,297)
  - Licensee - Extruded Aluminum Heat Sink

ENTECH, INC.



Photovoltaic Receiver Assembly

Assembled In-Country Under License Agreement

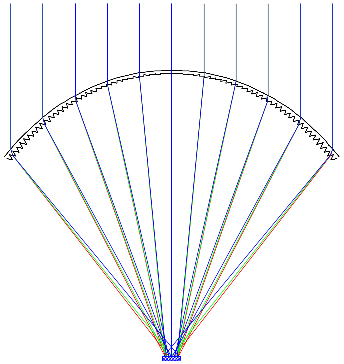
U.S. Patent 5,498,297 for New, Streamlined, Dry Tape & Film Receiver Assembly Approach

- **37 Cell Assemblies**
- **1 Extruded Heat Sink**
- **Dielectric Tapes/Films**
- **430-480 W Output**

Heat Sink Fin Area Is 4X Larger Than Lens Aperture Area

<u>Result</u>: Cells Operate As Cool As Cells In Flat Plate PV Modules

ENTECH, INC.



SolarRow Hardware

Aluminum & Steel For SunLine & SolarRow Fabricated & Assembled, Along With Other Components, In-Country Under License Agreement

* CSW Solar Park, Fort Davis, Texas USA

- ***SolarRow* Comprises:**
  - **14 Concrete Piers**
  - **13 Galvanized Posts**
  - **One Galvanized Bolt-Together Frame**
  - **72 ENTECH PV Modules**
  - **12 VDC Roll/Tilt Drives, Controls, & Batteries**
  - **DC Combiner Box with Fused Disconnect, MOV's, and Blocking Diodes**
  - **Two Wires Carry 63 Amps at 400 VDC to the DC/AC Inverter**

ENTECH, INC.

Solar Photovoltaic in Rural Electrification:
Market Assessment Survey in Bangladesh
by

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Prokaushali Sangsad Ltd. Dhaka, Bangladesh
(Energy Research Center)

Village Power '98, Washington DC

1. BACKGROUND AND CONTEXT:

Of the 12.7 million rural households in rural Bangladesh, only about 2 million (approximately 15%) currently enjoy electrification from the national power grid. The task of providing electricity to the remaining 10 million rural households is a large one. The task is made more challenging by constraints such as the lack of an extensive transmission network throughout the country, the limited generating capacity to serve additional rural markets, and the scarcity of capital for investments in generation, transmission, and distribution. Economic extension of rural electrification is further constrained by the generally small loads and greater dispersion of rural customers, making it difficult to justify the costs of distribution networks. Three individual government owned enterprises, Rural Electrification Board (REB), Bangladesh Power Development Board (BPDB), and Dhaka Electric Supply Authority (DESA) are presently engaged in providing electricity service to the rural population. More than 70% of the rural connections are served through Palli Biddut Samities (PBS)s operating under the regulatory guidance of the REB. Currently there are 54 PBSs in commercial operation, which are user owned co-operatives, offering electrification services to households, small commercial enterprises, rural industries and irrigation needs in diverse parts of the country.

Bangladesh has joined its Asian neighbors as well as other countries throughout the world in considering a broader array of options for providing the benefits of electrification to rural populations. Alternative options to the conventional grid based electrification, such as low cost isolated grid systems, solar, wind and micro hydro are under consideration for serving remote villages and other clusters of customers. Another strong contender, particularly for disbursed consumers and clusters with combined loads too small to justify grid systems is the use of solar photovoltaic (PV) panels for electrification of individual homes or buildings. These are commonly called solar home systems (SHS). Thus, grid supported conventional methods of power generation may be complemented by utilizing SHS for providing electrification services to these sparsely distributed unelectrified rural households. Such systems can offer basic electricity services of lighting and operation of small appliances such as TV, radio, or fans. The convenience, safety and high quality service provided by SHSs make them generally more desirable than traditional rural energy usages such as kerosene and externally charged automotive batteries. However, a typical SHS is not economically viable for household appliances consuming large quantities of electricity, that is generally available from the grid.

Information on solar home systems is not yet widespread in rural Bangladesh. However, in a recent effort of REB, 700 households within an island of 29 square km, have already been electrified by SHSs in an ongoing pilot program with support from the French government. Narsingdi PBS is in charge of operation and maintenance of this project. Suitability of SHSs for rural electrification in the socio-economic context of this region has already been demonstrated in this project. Survey [1] of 166 users show that 52.4 percent of the total users are either satisfied or very satisfied with the use of SHSs. The remaining 47.6 percent of the users are not particularly satisfied or totally dissatisfied with the services. More than 30% percent of the users of battery systems with external charging using a central PV station have expressed their dissatisfaction, which originates from transport of batteries, and insufficient daily charging for desired usage. This pilot project provides a platform for bench marking the solar PV service requirements in rural Bangladesh through the existing rural electrification service delivery mode of the PBSs.

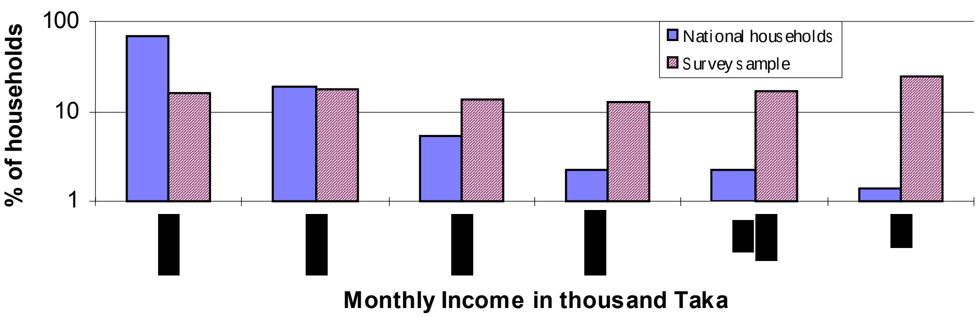
2. SURVEY OBJECTIVE AND METHODOLOGY:

The survey performed is an initial investigation[2] towards determining the potential market for SHSs in Bangladesh in view of the growing demand for rural electrification. The survey was limited to 701 samples covering three Thanas (administrative areas) within PBS territories, and one Thana outside the operating area of any PBS. Objective of the survey was to determine the potential for SHSs to serve rural households of Bangladesh which may not be accessible to grid electrification in the near future. The survey focussed on obtaining following information relevant to this determination:

a. Current energy usage and expenditure for lighting and battery charging
b. Desired service level for electrification
c. Attitude of the households towards solar PV electrification
d. Preferred mode of service delivery

The survey focussed on middle to high income households. The relationship of the survey categories in relation to the national income distribution of unelectrified rural households are shown in Fig 1. As seen in the figure the survey population is nearly uniformly distributed at above 10% for

Figure 1 Household Income - National Vs Survey sample



[1] Survey of Solar PV Applications in Rural Electrification: Narshingdi Solar PV Project, World Bank Survey by PSL, June 1998

[2] Market Assessment Survey of Solar PV Application in Bangladesh, World Bank Survey by PSL, July 1998

all income groups above 2000 Taka per month. Small commercial enterprises, who could also be part of a potential market for solar PV were also included in the survey. The information gathered on the above characteristics from the survey was combined with that from the Household Expenditure Survey (HES)[3] to characterize the households that are likely to adopt SHSs and to predict the potential market for each administrative division in the country. Additionally, this information will be useful in selecting PBSs that will be targeted for the initial marketing of SHSs.

Three different payment schemes for solar home systems was offered in the survey:
(A) Cash purchase through a single payment
(B) Cash purchase through payment in monthly installments
© Monthly payment with a down payment for electrification services to Energy Service Company (ESCO)[4]

Customer's monthly payments to the ESCO cover amortized capital costs, installation, operation, maintenance, component replacement costs, and other service fees. This monthly fee is dependent upon the financial assumptions used, including the on-lending terms of long term loans typically obtainable for rural electrification in Bangladesh. Description of SHS's capacity, and service levels as used for the survey are indicated in Table 1a.

Table 1a. Estimated SHS Capacity, Costs, and Service Levels

	Module Capacity	Battery Capacity	Service Level for Solar PV
Small Solar Home System **(SHSS)**	35 W_p	70 Ah	35Wp system operating 3 lights of 10W each
Large Solar Home System **(SHSL)**	75 W_p	100 Ah	75Wp system operating 5 lights of 10W each OR operating 3 lights of 10W with 1 B/W Television

[3] HES:Household Expenditure Survey 1995-96 , Bangladesh Bureau of Statistics, Govt.of Bangladesh
[4](ESCO):Energy Service Company Best Practices in Solar PV Applications, 1996, ASTAE, World Bank Report

Three different payment options for Solar PV electrification used in the survey are given in Table 1b.

Table 1b Payment Options for Solar PV Electrification Service

Scheme A. Cash Purchase of SHS:

SHS- Small	22,600 Taka
SHS- Large	40,700 Taka
Solar Lantern	2,500 Taka

Scheme B. Purchase of SHS with Credit:

System Type	Option I		Option II	
	Deposit	Monthly Payment	Deposit	Monthly Payment
SHS- Small	10,000	325	4,000	500
SHS- Large	10,000	850	4,000	1,000

Scheme C. Payment for Service with SHS Only:

System Type		Option I	Option II	Less than Offered
	Connection	Monthly fee	Monthly fee	Values suitable to the respondent.
SHS- Small	**1,000**	200	**160**	
SHS- Large	**4,000**	350	**300**	
Battery Charging	700	150	110	

1$ = 46.5 Taka

3. RESULTS

3.1 The Potential Solar Home System Market in Bangladesh

The survey indicates that a significant market for SHSs exist in Bangladesh. The report provides market estimates based on administrative districts and household income categories. According to the data obtained from HES, rural households typically do not have sufficient income for direct cash purchase of a solar home system. However, use of credit or other forms of extended payment can expand the potential market significantly. The lowest monthly costs are obtained when the SHSs are owned by an ESCO and the customer only pays for the service from the system.

Ability to pay for solar home systems has been estimated by two different methods, which yield market predictions as follows:

- In most developing countries, households typically spend no more than 5% of their income on lighting and use of small appliances. By this measure, about 4.8 million rural Bangladeshi households could pay for a solar home system as shown in the *"Potential SHS Market"* of Tables 2 and 3. This accounts for nearly 45% of all *unelectrified rural* households.

- A more conservative market estimate *"Existing SHS market"* was obtained through the survey conducted for this study, based upon the current expenditure level of the households. Ability to pay for the services is measured by the current expenditure for lighting and battery charging, most of which is to be replaced by a SHS. This market, which is approximately 470,000 households, is shown on Tables 2 and 3 according to division and income category differentiation respectively. Figure 2 shows the relative distribution of the projected existing market within the administrative divisions.

Table 2. Projection of Solar PV Market in Bangladesh by Administrative District

Division	Rural Households in Bangladesh	Total unelectrified Households	Potential **SHS Market** (Liberal Market)		Existing **SHS Market** (Conservative Market)	
			SHSS (1)	SHSL (2)	SHSS (3)	SHSL (4)
Barisal	888,240	778,072	361,803	52,131	29,469	10,768
Chittagong	2,416,469	1,848,455	1,059,165	177,452	92,134	31,708
Dhaka	3,802,678	3,274,445	1,293,406	121,154	99,045	34,942
Khulna	1,348,908	1,096,733	470,498	44,966	35,268	12,512
Rajshahi	3,436,323	3,018,767	821,105	81,507	64,208	25,300
Sylhet	861,797	717,057	261,009	63,101	24,926	8,081
Total	12,754,415	10,733,529	**4,266,986**	**540,311**	**345,050**	**123,311**

Table 3. Projection of Solar PV Market in Bangladesh by Income Group

Division	Rural Households in Bangladesh	Total unelectrified Households	Potential **SHS Market** (Liberal Market)		Existing **SHS Market** (Conservative Market)	
			SHSS (1)	SHSL (2)	SHSS (3)	SHSL (4)
below 2000	6,606,787	5,926,232				
2000-3999	3,992,132	3,364,026	3,364,026		217,034	108,517
4000-5999	1,237,178	902,960	902,960		50,633	-
6000-7999	408,141	251,133		251,133	27,563	3,063
8000-9999	178,562	105,513		105,513	9,848	-
10000-14999	204,071	114,225		114,225	20,561	3,427
15000-19999	38,263	30,915		30,915	7,134	2,378
20000 & More	89,281	38,525		38,525	12,277	5,927
Total	12,754,415	10,733,529	**4,266,986**	**540,311**	**345,050**	**123,311**

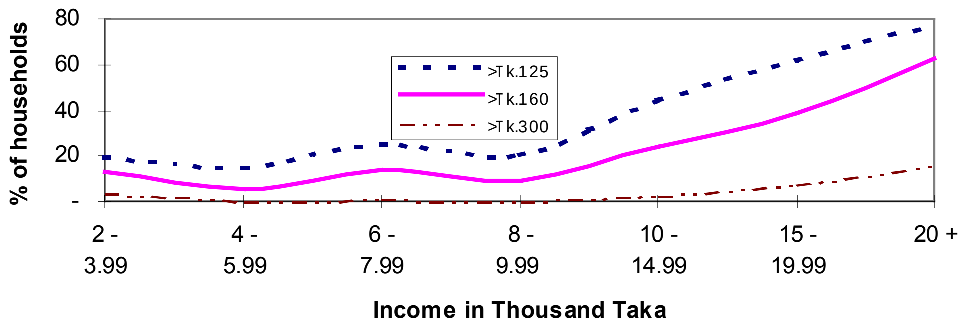
1) monthly income Tk.2,000-5,999
2) monthly income above Tk.6,000
3) currently spending Tk.160-300 for kerosene and battery charging
4) currently spending more than Tk.300 for kerosene and battery charging

3.2 Current Energy Usage Pattern:

The survey results show that 98% of the households use kerosene lanterns or "huricane" lanterns for children's studying, and 69% use them for an average of 5 hours per night. More than 90% of the respondents feel the most valuable impact of solar PV electrification will be in providing better lighting for studying. Usage of batteries for watching television is also widespread among the high income rural households. These households will benefit from SHSs by having an improved quality of environment and removal of inconvenience caused by transportation of the batteries to the charging stations.

In the survey households, current spending for lighting and battery charging indicate that 39.34%, 18.67%, 4.17% of the respondents spend above 125, 160 and 300 Taka per month respectively. Percentage of households spending more than 160 or 300 Taka per month, increases monotonically with income above 8000 Taka, as shown in Figure 3.

Figure 3. Current Expenditure on Kerosene for Lighting and Battery Charging

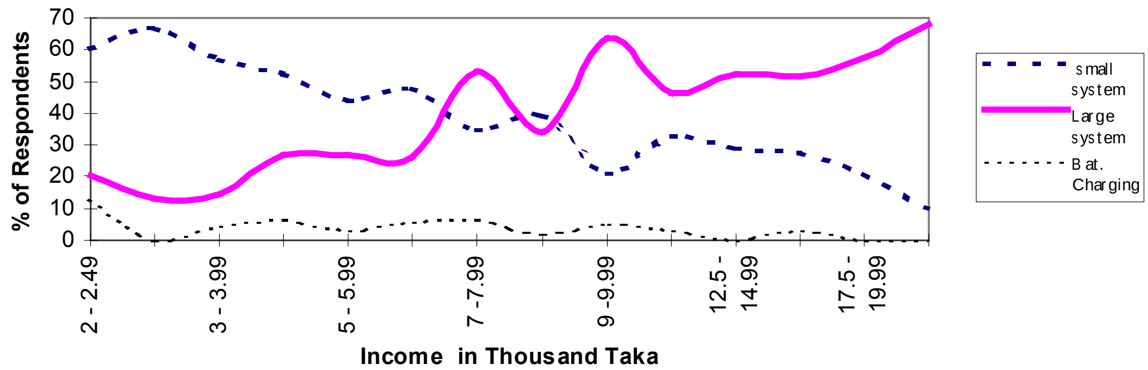


3.3 Willingness to Pay for Type of SHS

The survey covered 606 households and 95 commercial enterprises in three different districts (Natore, Gopalgonj and Kishoregonj). 80.5% of the surveyed holdings have shown an interest in obtaining any

SHSs. In general, the higher income groups show willingness to pay for the large solar home system (SHSL) while lower income groups are willing to pay for small solar home system (SHSS) as shown

Figure 4. Income Vs. Willingness to Pay for Solar PV



in Figure 4. The survey did not reveal wide regional variations in the preference for SHS. One striking exception, however, was the survey in the riverain island of Kishoregonj district. Here, 100% of the respondents expressed willingness to obtain service from SHSs through monthly billing. The agricultural and fishing industry in this area has created a somewhat higher level of wealth than in the average Bangladeshi village. However, the annual floods all but preclude extension of grid service. The high willingness and ability to pay for electricity services, and the lack of a competitive alternative combine to create an excellent market for SHSs. Similar areas throughout the country may offer the best near-term market for solar home systems.

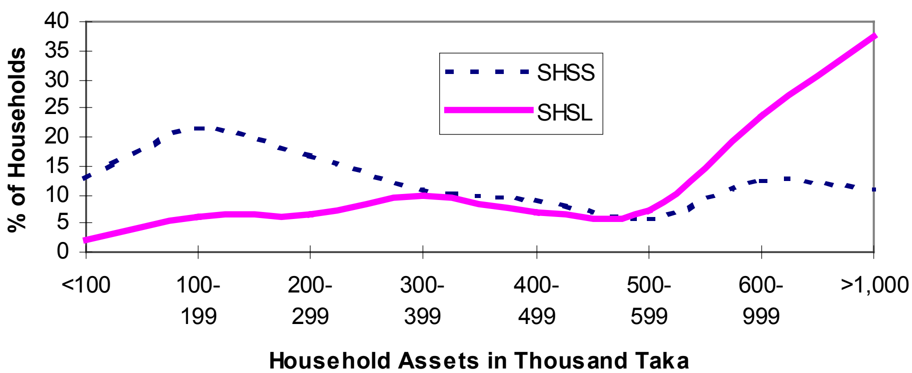
Willingness expressed in the survey towards battery usage with central PV battery charging is low. Only 3.3% of the survey respondents are interested in receiving their electrification services through a solar PV battery charging station, although 15% of the households surveyed are currently watching television through battery charging. This signifies the difficulties people face with remote charging.

In addition to monthly income, interest in SHS is found to be a strong function of the assets owned by the households. Figure 5 shows direct correlation between willingness of the respondents to pay for SHS and their household assets. Considering the results obtained on willingness to pay for electrification, and the variation of income and asset among the potential users, it is recommended that the SHS be sized according to the desire of the users, ie options for service levels such as SHSS and SHSL should be made available.

3.4 Preferred Mode of Payment

The surveyed households and commercial units showed a strong preference for obtaining SHSs based on monthly payment as opposed to direct purchase either outright or on a credit payment plan. Nearly 68% of the respondents showed preference for service with monthly billing (similar to ESCO method) at rates shown in Table 1, while 12% opted to pay in cash or credit. In an ESCO system the PV installation remains the property of the ESCO, and the lighting services inclusive of replacement of major components are provided for a monthly fee. Service for wiring and procurement of

Figure 5. Household Assest vs. Willingness to Pay for SHS



consumable items like the lamps are typically purchased by the user directly.

3.5 Preferred Mode of Service Delivery:

With respect to choice of service providers, 61% prefer to receive service from the existing PBSs in the area operating as an ESCO. The next preferred service delivery organization (18% of respondents) is local co-operatives.

If the ESCO service is to be provided by a private dealer or enterprise using financing arrangements available commercially (including charges for dealer financing), a higher rate of monthly payments beyond the purchasing capacity of the households would be required. Purchase of SHSs through cash or credit is *not a preferred mechanism* of electrification to nearly 88% of the households.

3.6 Preference Within the Buffer Zone:

The zone within a range of 1 km from an existing distribution line is identified as the "buffer" zone. The households within this zone are close enough to distribution networks but are unable to obtain a service due to the high cost or delayed request of securing a connection. The survey shows that a favorable interest exists for SHSs in such buffer zones. 67% of the 274 respondents in the buffer zone expressed willing to obtain SHSs as shown in Table 4. Nearly 30% of these households are currently spending more than 160 Taka per month on lighting and battery charging for watching television. On the other hand, 85% of the 374 households outside the buffer zone have shown interest in SHSs. 44% of these respondents are currently spending more than 160 Taka per month, and more than 32% is using batteries for watching television.

Table 4 Willingness And Ability to Pay for SHS: Households in Buffer vs. Non-buffer Zone

	Willingness to Pay	Ability to Pay			
Type of Zone	Households Willing to Pay for SHS	Current Monthly Spending More than			Using TV
		125 Taka	160 Taka	300 Taka	
Buffer Zone (274)	67%	48%	29.5%	6%	26%
Non Buffer Zone (332)	85%	75%	44%	8%	32%

3.7 Preference of Commercial Enterprises:

Owners of shops in rural markets have significant interest in using small solar systems (SHSS) for lighting, in order to facilitate their business operations. Outside the buffer zone, 90% of the commercial respondents are willing to obtain SHSS while only 8% are willing to pay for the large solar system. Within buffer zones, 60% of the commercial respondents are willing to obtain SHSS while 13% are willing to pay for SHSL. 10% of the commercial respondents within the buffer zone are currently spending more than 300 Taka per month on lighting, which is equivalent to the monthly payment of the SHSL. However, the SHSS is the optimum size for the rural shops of Bangladesh. It is interesting to note that 20% of the owners of commercial enterprises outside the buffer zone, are using batteries for watching television in their homes.

3.8 Socio Economic Background of the Survey Respondents:

This survey has focused on the middle and higher income groups of the rural population in the selected areas. This was done to ensure that the survey adequately characterized these income groups, which will comprise the near-term market for SHS[5]. In comparison to the national average monthly income of 3,658 Taka per month[2], the survey households earn 13,062. The main occupation of 65% of the survey population is agriculture and 45% of the total respondents are owners of large farms. Preference for SHSL have been expressed by 55% and 45% of the owners of large and medium size

[5] The survey scope, limited by budget constraints to 700 households, would not have adequately characterized these groups if a completely random household sample had been used because the absolute number of each of these income groups is relatively small.

farms respectively. The SHSS is preferred by 50% of the small and marginal size farm owners . The roof material of 96% of the households is tin or tile, reflecting semi permanent structures. It is noteworthy that 58% of the surveyed households have a single earner in the family, 44% of whom showed preference for the SHSS. 50% of the households with more than two earning members are willing to pay for the SHSL. National average for the number of family members per household is 5.26, while the average number of earners is 1.48 according to the HES[2].

4. CONCLUSIONS:

- The present study on market assessment provides information on the rural consumers and their requirements in the context of solar electrification. A market size of approximately 0.5 million households is envisioned for solar electrification, which has the potential of extending to 4 million in the future. National and regional plan for implementation of large scale program for SHS in rural electrification should now be developed using predetermined criteria for qualification of solar PV programs. This plan should be consulted in association with the conventional master plan in place with REB for expansion of rural electrification, considering 61% of the respondents have opted for service from the existing PBSs.

- The survey shows that solar battery charging stations are not a suitable option for electrification in Bangladesh and should therefore be avoided in future implementation of solar PV programs.

- Appropriate measures should be taken for local certification and quality control of hardware. Use of trained distributors and maintenance contractors are recommended for sustainablity of the systems.

- Large scale demonstration of SHS in different geographic regions should be initiate to create awareness for SHS.

- Considering the results obtained on willingness to pay for different levels of service, and the variation of income and assets of the potential users, it is recommended that the SHS be sized according to the desire of the users, ie, options for service levels should be made available.

- Quality of service must be ensured from the beginning of any future SHS program through standardized systems and effective implementation of regulatory rules.