FULL REPORT

ALASKA'S RENEWABLE ENERGY FUTURE:

New Jobs, Affordable Energy

Developed for Regenerative Economies Working Group – Alaska Climate Alliance

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KEY TAKEAWAYS:

- Alaska has a vast endowment of renewable energy resources
- Renewable energy technology costs continue to decline, while local and global fossil fuel costs continue to escalate
- Renewable energy technologies are on track to affordably replace legacy fossil fuel energy systems in the 2030-to-2050 time horizon
- The development of Alaska's vast renewable energy potential has the potential to generate more than 103,554 jobs across Alaska – more than replacing the jobs lost as fossil fuels become obsolete
- With continued federal support, renewable hydrogen-based fuels have the potential to replace fossil fuels in the marine and aviation sectors and form the basis of a new export economy

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Developed for: Alaska Climate Alliance – Regenerative Economies Working Group

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Land Acknowledgement:

The authors and contributors (and readers, we hope!) of this report humbly and respectfully acknowledge that the land and resources we are describing and analyzing are the ancestral and unceded territory of the Indigenous Peoples of Alaska. We write this with deep gratitude to the Indigenous Peoples of Alaska for their continued care and stewardship of the land on which we live, work and play. We acknowledge this not only in thanks to the Indigenous communities who have held relationship with this land for generations but also in recognition of the historical and ongoing legacy of colonialism. Additionally, we acknowledge this as a point of reflection for us all as we work towards dismantling colonial practices.

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Executive Summary

Alaska has a vast endowment of renewable energy resources that can be tapped in its transition to a renewable energy future. Benefits of accelerating the energy transition in Alaska include more jobs, lower energy prices, higher energy security and the potential for renewable resources to support zero carbon hydrogen-based fuels for the aviation and maritime industries.

The state has already begun to develop its renewable energy resources and continues to support renewable technology development for Alaska's challenging environment. The scale of Alaska's vast undeveloped renewable energy resource endowment *remains more than 14 times the total U.S. energy consumption.*[1]

Alaska's historically high and volatile fossil fuel-based energy costs have been moderated by the successful development of renewable energy resources across the state, including:

- Bradley Lake & Battle Creek Diversion, Solomon Gulch, Terror Lake, Swan Lake, Tyee Lake, and other recent hydro projects in both the Southeast and Southwest
- Fire Island, Eva Creek, Kotzebue, Kodiak & AVEC Wind
- GVEA & HEA Battery Energy Storage Systems
- GVEA Solar PV, MEA Solar PV by Independent Power Producers; with discussions underway for a 20MW solar PV project in HEA territory
- Village scale solar PV projects in remote rural communities, e.g., Eagle, Hughes, Kaltag
- Juneau, Tok, Coffman Cove, Craig, Gulkana, Elim, Thorne Bay, Haines, and Tanana Biomass
- Chena Hot Springs Geothermal Heat and Electricity

Renewable energy technologies, including wind, solar, geothermal, and ocean and river hydrokinetic, along with complementary energy storage technologies, are continuing to exhibit declining costs which make them increasingly attractive as a primary energy source to substitute for fossil fuels in the electric sector and to support the electrification of buildings and the transformation of the transportation sector to electrification and renewable hydrogen-based fuels.

As local fossil fuel costs escalate across Alaska, from 2.5X higher in the Railbelt to as much as 4X higher in Rural Alaska (as compared to the U.S. average), renewable energy technologies are increasingly attractive investments and are poised to affordably replace legacy fossil fuel energy systems in the 2030-to-2050 time horizon while providing greater energy security, increased energy resiliency especially in rural Alaska, and broad environmental, economic and health benefits.[2]

Independent studies have confirmed that the development of Alaska's renewable energy potential will generate thousands of jobs – at least comparable in magnitude to the fossil fuel jobs that may be displaced by the transition to a clean renewable energy sector.[3]

Based on adjusting a sample of independent studies for Alaska cost differentials for renewable resource, energy storage and zero carbon hydrogen/clean fuels infrastructure, **we estimate that by 2050, the transition to a 100% clean renewable energy future for Alaska would generate a net increase of 67,216 jobs** (103,554 additional renewable jobs minus 36,338 fossil fuel energy related jobs lost).[4]

In addition to developing renewable energy resources on the supply side, the electric sector has opportunities to rebuild flagging electricity sales through building electrification and transformation of the transportation sector to electric and green hydrogen-based fuels. The acceleration of the transformation of the building heating and transportation sectors to clean renewable energy will require a sustained federal, public, and private investment in science, technology, including systems integrations.

Renewable hydrogen-based fuels have the potential to replace fossil fuels in the marine and aviation sectors as renewable energy, renewable hydrogen production, storage, and hydrogen fuel cell technologies continue to develop [see Potential Pathways for Renewables to Replace Fossil Fuels, subsection Green Hydrogen-Based Fuels below].

Collaborative consultations with key stakeholders, including local communities, Tribes, residential energy consumers, public and private sector energy consumers and producers (including Alaska Native Corporations), and local utilities will be essential to ensuring long term support for successful development of local renewable energy resources.

Key strategies for the state of Alaska to accelerate the transition to a clean, renewable energy future include:

- Undertake a comprehensive statewide strategic policy and planning effort, including an explicit goal of transitioning to 100% clean renewable energy by 2050, to help focus emerging integrated planning efforts. One potential planning mechanism is an Integrated Resource Plan required by recent legislation establishing an Electric Reliability Organization in the Alaskan Railbelt.
- Enact legislation to require electric utilities to achieve 100% clean renewable energy by 2050 and to regularly measure and report progress toward that goal, including adoption of reasonable Renewable Portfolio Standards, e.g., 80% by 2040.[5]
- Develop plans that ensure equity and affordability in clean energy, making energy transition costs affordable for people across income scales, with programs like community solar and on-bill financing.
- Provide a vital round of seed funding and financing commensurate with the need to accelerate the transition to 100% clean renewable energy by 2050.[6]
    - Extend the Alaska Renewable Energy Fund beyond its current sunset of 2023 and fund it with a fresh round of $3.2 billion in “clean renewable energy” seed capital.[7]
- Encourage and support private and public sector entities that seek to develop and disclose their environmental impacts under a credible, independent global environmental disclosure system, e.g. CDP, formerly known as “Climate Disclosure Project.”
- Seek Alaska Permanent Fund support for publication of environmental disclosures of its investments to ensure portfolio investments are assessing and addressing climate risks.[8]

- Raise the net metering cap so utilities can enable electric customers who produce their own electricity to receive a credit for the excess energy they transfer back to the utility and/or change the net metering regulation so that credits generated during peak months can be utilized in off-peak months, shifting to annual accounting of credits instead of monthly.
- Require Regional Integrated Resource Plans include:
    - Substantive opportunities for local collaboration/consultation;
    - Consideration of future cost escalation associated with fossil fuel resources from both direct and indirect costs, e.g. CO_2 equivalent emissions costs and other environmental externalities;[9]
    - Explicitly require regional energy plans to include the overarching policy goal of reaching 100% clean renewable energy for all energy needs by 2050 and include a pathway to achieve it within their options for consideration.
- Workforce Development:
    - Incentivize industry-led training curriculum for the construction and operations of renewable energy technologies.
    - Incorporate renewable energy training curriculum into a state-certified apprenticeship program.
    - Encourage engagement of K-12 and University students in renewable energy technology education.

To understand the history, current state, and future potential of a transition to a 100% clean, renewable, and equitable energy future in Alaska by 2050, the authors and supporting organizations engaged the Cadmus Group for a literature review and quantitative analysis of existing resources and data to supplement the research and analysis developed by the working group and its collaborators.

This report illustrates a vision for a clean renewable energy future in Alaska and the potential benefits this increasingly urgent transition to an equitable new energy system could provide.

Introduction

This study looks at the potential for 100% clean renewable energy to replace fossil fuel energy in Alaska by 2050 and its attendant benefits including more jobs, lower energy prices, higher energy security and the potential for renewable resources to support the equitable transition to hydrogen-based fuels for the aviation and maritime industries.

Benefits of Accelerating the Transition to a Renewable Energy Future in Alaska by 2050

The benefits of transitioning to 100% clean renewables for all energy purposes (including electric, building heating and transportation fuels) by 2050 include:[10]

1. Creation of 67,500 more long-term, full time jobs in Alaska than lost
2. Eliminates 43 million tonnes CO_{2equiv} per year in 2050 in Alaska
3. Reduces 2050 all-purpose, end-use energy requirements by roughly half
4. Reduces total annual energy, health and climate costs by 25%; from $23.2 billion to $17.3 billion per year
5. The substantial up-front investment costs, on the order of $128 billion over 30 years, can be mitigated by federal and state co-investment.
    a. Aggregate public co-investment on the order of 25% should be sufficient to more than buy down the net price of energy to be less than the superficial cash price of the business as usual fossil fuel projection
    b. The 25% public co-investment, which could be split between state and federal consistent with the historic approach to federal highway funds, 1:9, would amount to $3.2 billion for the State of Alaska
6. The net increase in annual investment and expenditure costs in a 100% clean renewable energy transition by 2050 may be on the order of 0.91% of Alaska's GDP in 2050.[11]
7. Requires 0.14% of Alaska's land for the renewable resource development
    a. Including wind farms, solar arrays, geothermal power plants, electric and heat storage infrastructure, transmission lines and substations
    b. Amounts to roughly 600,000 acres which is roughly equal to the current total area of wind farms in TX and OK[12]

This report seeks to raise public awareness of positive clean renewable energy potential and its many associated benefits so Alaskans can work together to accelerate the development of robust renewable energy capacity, energy storage, and transmission systems that will build the foundation for a reliable renewable energy grid system which can support:

- Reliable electric service for local microgrid and grid interconnected communities,
- Electrification of the building and transportation sectors, and
- Development of clean renewable hydrogen-based transportation fuels to help sustain and grow critical Alaska industries, including:
    - Fisheries fleet and processing activities,

- Marine transportation, including refueling and transshipment, and
- Anchorage International Airport World Class Cargo Hub.

The Regenerative Economies Working Group of the Alaska Climate Alliance is working with a broad coalition of entities and individuals with the goal of articulating and advancing an economic vision for a prosperous, clean energy future for Alaska. The Alaska Climate Alliance is a group of 50+ organizations and more than 120 participants united by our desire to align Alaska's climate action community with Just Transition principles, addressing the climate crisis head-on at all levels of society and shifting our state towards a joyful, interdependent and Indigenous-led future.

This report, *Alaska's Renewable Energy Future: New Jobs, Affordable Energy*, showcases specific renewable energy technologies that are ripe for development as well as the potential scale of the renewable energy sector jobs, and recommends strategies to support Alaska's transition to a clean energy future.

The report is structured into the following sections:

Alaska's Energy Context: This section details Alaska's historic energy context, including insights into how much energy the state consumes, how that energy has been generated, and the jobs the energy industry has supported in the past.

Alaska's Vast Renewable Energy Resource Endowment: Due to its unique geography, Alaska has a vast endowment of diverse natural resources that can support a vibrant renewable energy sector capable of scaling up to meet the state's energy demand. The renewable energy resources covered in this report are onshore and offshore wind, solar, ocean and river hydrokinetic, geothermal, hydropower, biomass, and green hydrogen-based fuels.

Renewable Energy Technology Trends: This section highlights the history and outlook for declining costs of renewable energy and energy storage technologies that will enable an affordable transition to a renewable energy future.

Rising Cost of Fossil Fuels: This section highlights the history and outlook for the rising cost of fossil fuels that can be avoided by accelerating the transition to a renewable energy future.

Potential Path for Renewables to Replace Fossil Fuels: This section highlights recent research into potential pathways to 100% clean, renewable power across Alaska by 2050 and the benefits that can be achieved by accelerating the development of renewable energy resources to replace fossil fuels.

Strategies to Accelerate the Renewable Energy Transition: This section describes policy, planning, funding and financing, and workforce development initiatives aimed at accelerating the transition to a renewable energy future.

Conclusion: This section describes the key takeaways and calls for action from the report.

Alaska's Energy Context

Introduction

Alaska's unique geography of widely dispersed remote communities and variable local energy resources have contributed to a long history of high energy costs across the state, exemplified by rural electricity residential rates as high as 7X the U.S. average in remote rural locations.[13]

Over the decades, a wide variety of efforts to help mitigate the high cost of energy have been undertaken across the state.

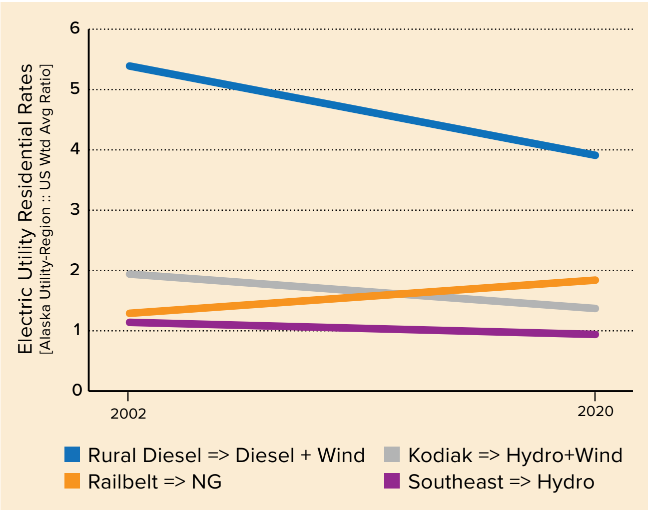
Beginning in the 1950s, the federal Alaska Power Administration built and operated hydroelectric projects in Alaska in part to mitigate the high cost of energy in Alaska. These assets were divested to local utilities over 1989-1991.[14]

In the 1980s, the State of Alaska began to invest in hydro resource development, including Bradley Lake (Railbelt) and the Four Dam Pool (Tyee Lake, Swam Lake, Solomon Gulch, Terror Lake).

In the 2008 oil price spike era, the State of Alaska enacted and funded a renewable energy fund administered by the Alaska Energy Authority to help mitigate the high cost of fossil fuels.[15] More than 95 operating projects have been built, collectively saving more than 30 million gallons of diesel each year.

The net results of those investments have helped reduce residential electric rates across Alaska over the past 20 years – especially across rural and Southeast communities [see Electric Utility Residential Rates Figure 1].

FIGURE 1 Electric Utility Residential Rates (Ratio of selected Alaska Regions to US Weighted Average), 2002-2020



Source: EIA Electric sales, revenue and average price, October 7, 2021, 2020, data tables, Table 6, with previous editions available in pdf at: https://www.eia.gov/electricity/sales_revenue_price

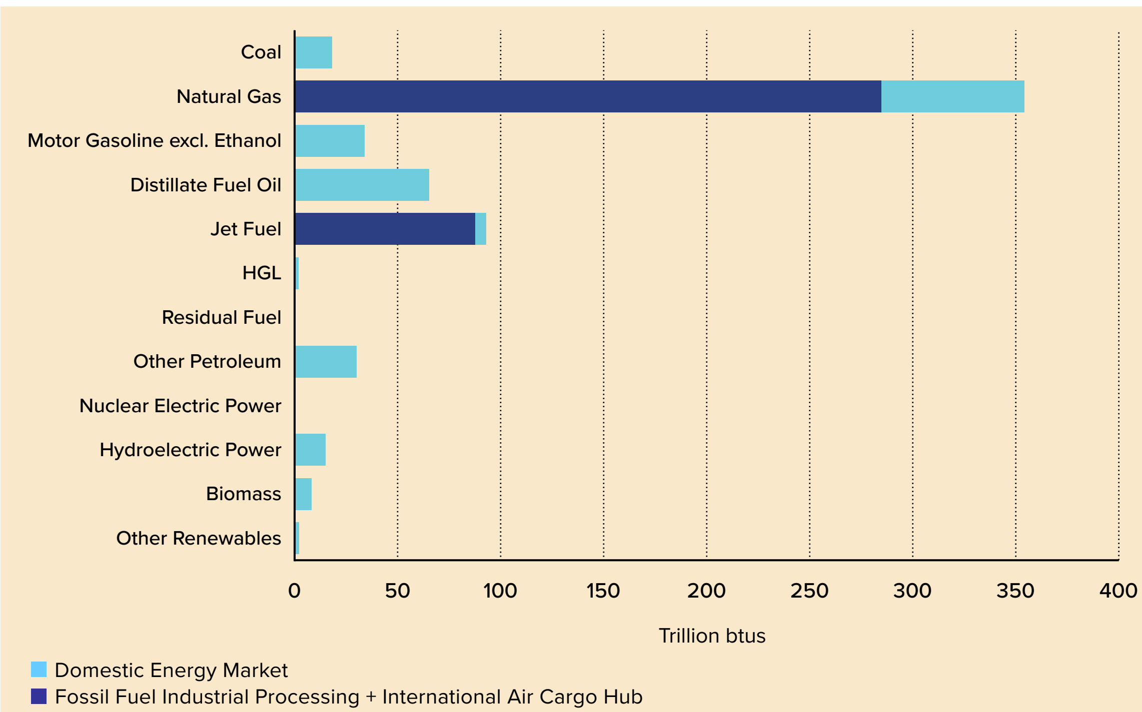
However, residential electric rates across most of Alaska remain extremely expensive compared to the U.S. and the upward trend in residential electric rates in the Railbelt continues to present a challenge to household budgets. The renewable investments in the Railbelt, e.g., Bradley Lake Hydro, Fire Island & Eva Creek Wind, and State of Alaska direct subsidized support of natural gas exploration and development in the Cook Inlet have not been enough to mitigate the rise in residential electric rates driven by the increase in natural gas supply prices in the Cook Inlet [see Electric Utility Residential Rates Figure 1].

The balance of this section on Alaska's Energy Context provides an overview of:

- Consumption
- Production - Oil & Gas
    - Oil Production Employment
- Fossil Fuel Price Outlook
    - Electric Power Sector
- Alaska's Unique Dispersed Geography & Associated Energy Infrastructure Adaptations
    - Energy Infrastructure Employment
- Renewable history & outlook
    - 1980s
    - 2008 Oil Price Surge
    - Federal Infrastructure Act Opportunities
- Utility Renewables Goals & Activities

Alaska's Energy Consumption

FIGURE 2 Alaska Energy Consumption Estimates by Energy Source (EIA, 2019)



Source: EIA State Energy Data System, Alaska Energy Consumption, 2019

In 2019, Alaska consumed an estimated 616 trillion btus of energy. Roughly 57% of that total consumption was supplied by natural gas. Renewable energy resources generated an estimated 24 trillion btus or 4% of the total state energy supply.

Alaska North Slope and Cook Inlet Oil & Gas exploration, development and processing use almost 80% of the natural gas consumed in Alaska for those industrial processes.

In a 100% clean, renewable energy future, oil & gas exploration and development is expected to essentially fade away, leaving behind a very modest residual for non-energy end-use, e.g., asphalt, and be replaced by a robust mix of renewable energy resources with a markedly diminished energy footprint for their exploration, development, processing and production of end-use energy for electricity, heating/cooling and green hydrogen-based fuels.[16]

Thus, before taking into consideration population growth and other changes in the energy mix and production processes between now and 2050, we expect Alaska Energy Consumption to be roughly 280 trillion btus lower in a 100% clean renewable energy future.

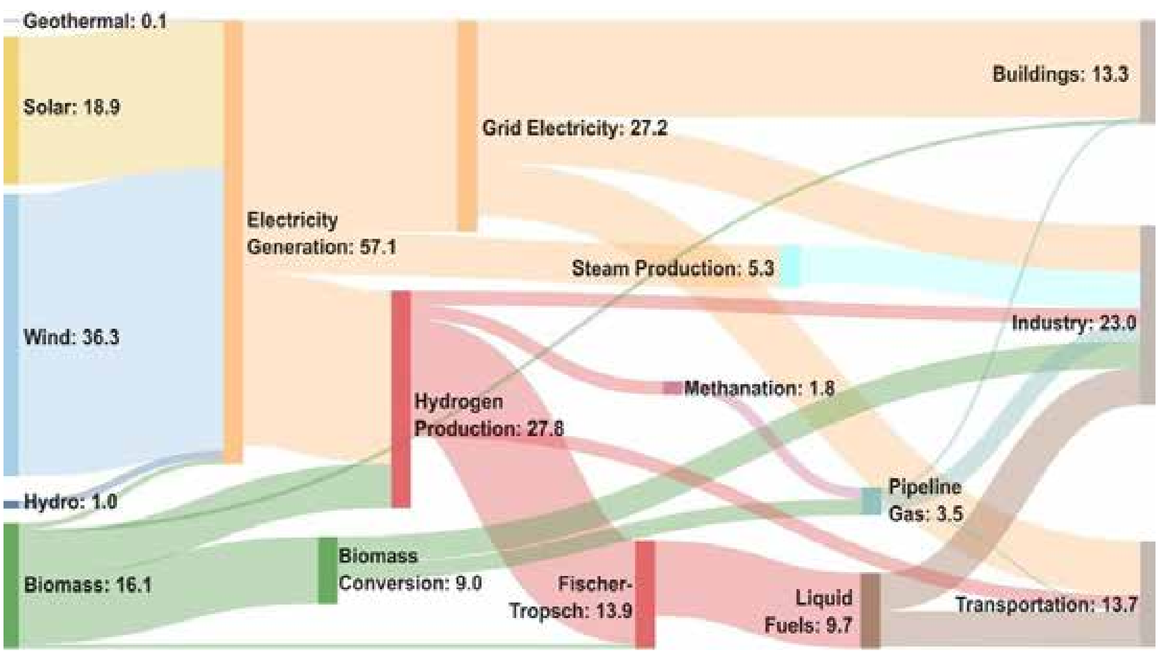
The next largest energy resource consumed in Alaska after natural gas is jet fuel.

The Anchorage International Airport moved from the sixth to the fourth largest air cargo hub in the world in 2021. In 2019 (most recent EIA State Data), jet fuel consumption at the Anchorage International Airport was on the order of 17.5 million barrels of jet fuel in 2019. Jet fuel at the Anchorage International Airport is a substantial fossil fuel energy demand center in Alaska that merits special attention given its prominence in the Alaska energy picture; 90 trillion btus are associated with the international passenger and air cargo flights.[17]

Distillate fuel oil, the third largest energy resource consumed in Alaska, is widely used in truck, rail, and marine transport, and rural Alaska electric generation.

In the synthesis of the reports describing costs and benefits from 100% clean renewables in 2050, MAFA included the estimated cost of transitioning to 100% renewables and renewable hydrogen production and further downstream processing into liquid fuels for the transport sector, including aviation jet fuels, marine fuels. For an illustrative example of the energy flows under a 100% renewable scenario, please see the figure below from the Williams (2020), supplemental materials.

FIGURE 3 2050 100% Renewable Energy Sankey Diagram (Exajoules)



Source: J.H. Williams et al, Carbon-Neutral Pathways for the United States, AGU Advances Research Article, 10.1029/2020AV000284, Supplemental Materials, Figure S4. Sankey diagram by scenario, p. 12

Renewables in Electricity Supply

Alaska's historically high and volatile fossil fuel-based energy costs have been moderated by utility and independent power producer investments in renewable energy resources across the state. Renewables have grown to supply 30% of the total electrical demand in Alaska. Renewable energy projects include:

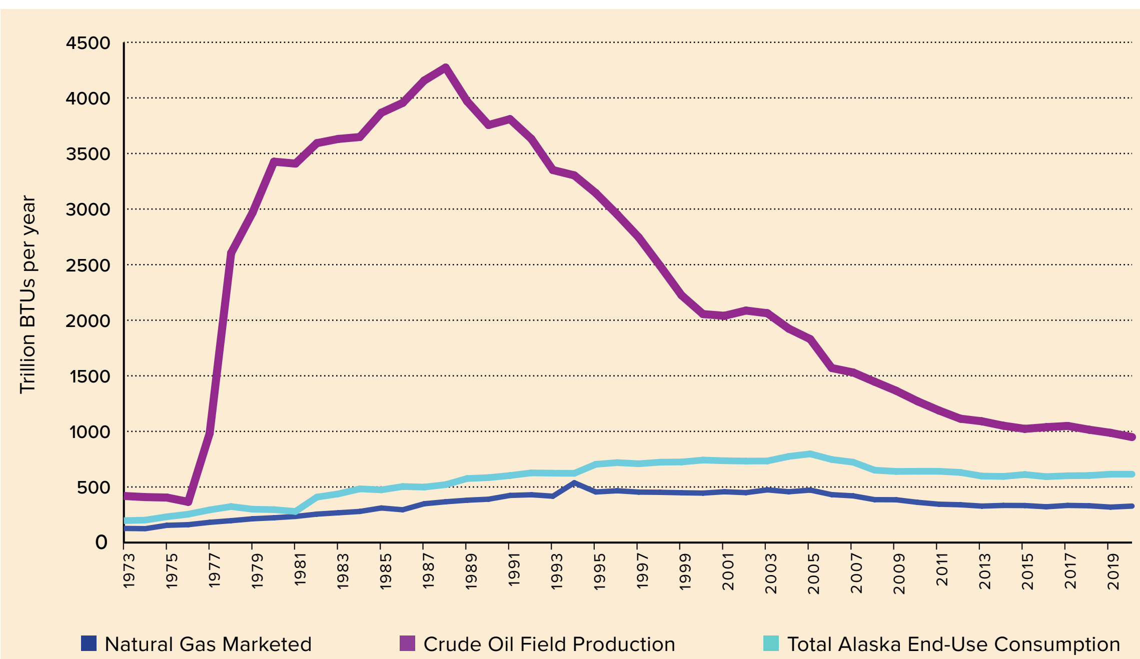
- Bradley Lake & Brattle Creek, Four Dam Pool & other Southeast Hydro
- Fire Island, Eva Creek, Kotzebue, Kodiak & Alaska Village Electric Cooperative (AVEC) Wind
- GVEA Battery Energy Storage System (BESS)
- MEA Solar PV
- Juneau, Tok, Coffman Cove, Craig, Gulkana, Elim, Thorne Bay, Haines & Tanana Biomass
- Chena Hot Springs Geothermal
- Hydrokinetic power in Igiugig

Historic Context and Emerging Trends

To understand emerging trends and opportunities in the context of a thirty-year outlook, it may be useful to look back at the history that brought us to this point, including a quick look back to the 1970s, before the construction and completion of the Trans Alaska Pipeline System (TAPS), to see the impact of that development on the energy sector across Alaska and discern the long-term decline of the oil and gas sector.

DECLINING OIL INDUSTRY

FIGURE 4 Alaska Energy Production & Alaska's End-Use Energy Consumption Comparisons, 1973-2020



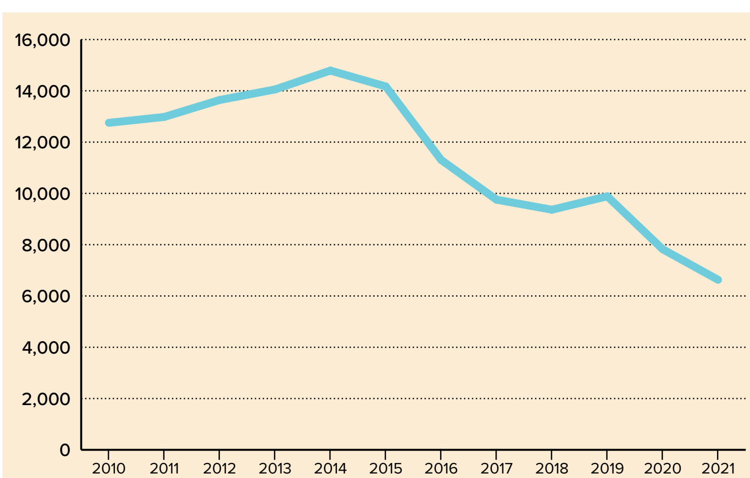
Source: EIA Crude Oil Production, Natural Gas Marketed Production, Alaska, 1973-2020

Alaska's energy production history took a quantum leap in 1977 with the completion and operation of the Trans-Alaska Pipeline Systems (TAPS) which enabled Alaska North Slope crude oil production.

After peaking at slightly over 4200 trillion btus per year (2 million barrels of oil per day), crude oil production has declined rapidly through 2010 (5.4% per year), with the decline rate moderating to 2.6% per year since 2010.

Natural gas marketed production (approx. 80% of which supplies energy for the oil & gas industry exploration, development and production activities), has been declining at 2.4% per year.

FIGURE 5 Alaska Oil & Gas Sector Average Monthly Employment (2014-2021)



Source: Alaska Department of Labor Workforce Development, Research Analysis Section, Alaska Employment & Wages, 2010-2021

More recently, while the rate of decline of oil & gas production has moderated, oil & gas sector employment has been falling rapidly – the average annual employment decline has been 11% per year since 2014. This includes all those who receive compensation as employees, which typically include oil & gas companies as well as the oil & gas industry contractors who employee people. It does not include sole-proprietors.[18]

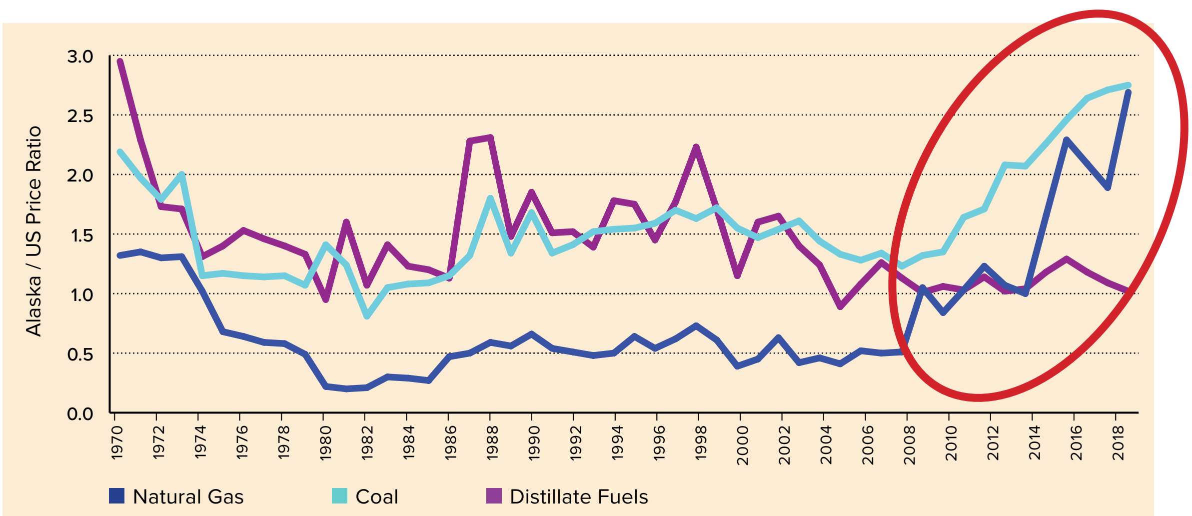
TURNAROUND IN FOSSIL FUEL PRICE OUTLOOK IN ALASKA (2008)

The available Energy Information Administration (EIA) State Energy Data (1970-2019) allow us to view the big changes in fossil fuel price regimes in Alaska and consider the potential for real continuing escalation in the price of fossil fuels in the future. This report highlights observations from the electric power, residential, and transportation sectors especially as they pertain to the trends and outlook for fossil fuel prices in Alaska after 2008 and how those trends inform the energy outlook to 2050.

Electric Power Sector

Following the OPEC oil embargo in 1973 and concurrent with the preparation for and construction of the Trans-Alaska Pipeline System (1974-1977), the price of fossil fuels (coal, natural gas, distillate fuels) dropped from historic patterns with energy as high as 2 to 3 times national norms into a new price regime marked by low natural gas prices from the Cook Inlet (around 50% of U.S. norms) and coal and distillate fuels in the range of 20% to 50% above U.S. norms – with volatility in between – for the 34-year period from 1974 to 2008. See Figure 6. EIA State Energy Data: Electric Power Sector Fossil Fuel Prices (Alaska/U.S. Price Ratio, 1970-2019) below.

FIGURE 6 EIA Electric Power Sector Fossil Fuel Prices (Alaska/U.S. Price Ratio, 1970-2019)



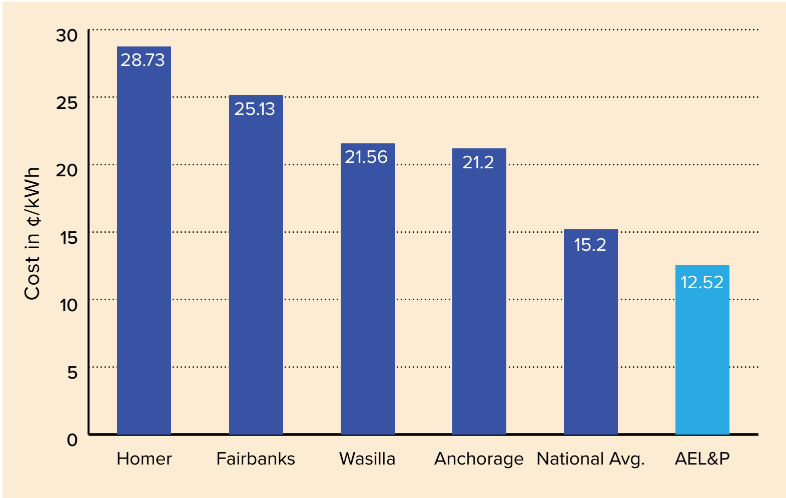
Source: EIA State Energy Data

In the period of fossil fuel price escalation in 2002-2008, natural gas price ratios stayed flat while coal and distillate fuels moved toward parity with the U.S., i.e., Alaska prices rose slower than U.S.

Following the oil price spike in 2008, a new price regime emerged where coal and natural gas prices rose in Alaska while declining in the U.S. The Alaska Electric Power Sector was paying over 2.6X as much for coal and natural gas compared to the U.S. in 2019.

In a June 2021 presentation to the City and Borough of Juneau Assembly, Alaska Electric Light & Power, whose baseload is served 100% by hydroelectric power, highlighted the benefits of its long-standing strategic investments in hydroelectric power compared to the natural gas dependent Railbelt utilities. AEL&P residential rates were 12.5c/kWh while Homer Electric Association rates were 28.7c/kWh – a stark reflection of the rapid price escalation in natural gas prices for the Railbelt electric utilities.[19]

FIGURE 7 Alaska Electric Light & Power Residential Electric Rate Comparison – selected Alaska Utilities (2020)



Note: AEL&P's rates remain the lowest among the large, regulated utilities in Alaska. Our rates are also comparable to the national average, which is due in large part to our ability to sell surplus energy to interruptible customers.

Source: AEL&P compilation from Table 5.3 of Electric Power Monthly with Data for December 2020 published by the U.S. Energy Inforamtion Administration in February 2021

ALASKA'S UNIQUE ENERGY INFRASTRUCTURE

FIGURE 8 Alaska Energy Regions Map

Source: Alaska Energy Authority

It is also useful to note Alaska's unique energy supply infrastructure which has evolved around the state's vast and diverse geography. The Railbelt, which is interconnected by transmission facilities, stretches from the Interior down to the Kenai Peninsula and represents roughly 79% of the state's electric utility generation.

Alaska also has over 150 individual microgrids,[20] an estimated 12% of the planet's microgrid infrastructure. Found primarily in remote, rural Alaskan communities, microgrids can be more cost-effective and often more efficient in integrating multiple power sources compared to traditional large-scale energy grids.[21]

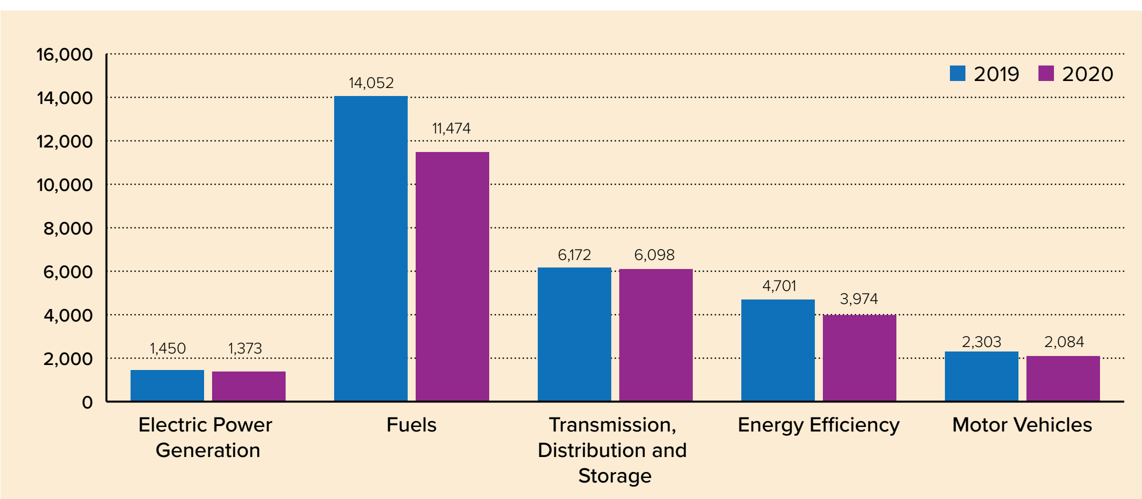
Interestingly, key regional hub communities, including Kotzebue in the Northwest Arctic, Kodiak, as well as several communities across Southeast Alaska have been leaders in developing their local renewable resources. Many smaller rural community microgrids are powered by diesel generators, which often create challenges in transporting diesel and contribute to high electricity costs for remote communities.[22] Alaska's microgrid infrastructure poses both an opportunity and a challenge for the transition to renewable energy and remains a key consideration in the development and implementation of the strategies and approaches detailed in this report.

EMPLOYMENT BY MAJOR ENERGY TECHNOLOGY APPLICATION

Alaska has a high concentration of workers employed in the energy sector, with 21,673 traditional energy workers statewide as of 2019, equating to 6.4% of total state employment.[23] The number of traditional energy workers statewide fell to 18,945 in 2020, led by a sharp downturn in the fuels sector. However, given reductions in total employment in 2020, traditional energy workers in Alaska still made up a higher proportion of the total state employment in 2020, at 8.3%.[24]

Jobs figures for both 2019 and 2020 are presented in this section. The 2020 jobs numbers provide the most up-to-date information, while 2019 jobs numbers are provided because that was the year for which the most updated energy consumption and supply data were available. In addition, 2020 figures may have been impacted by the COVID-19 pandemic. Examining both years allows for presentation of a more complete picture. A breakdown of energy employment in the state is shown in Figure 9.

FIGURE 9 Alaska's Employment by Major Energy Technology Application (2019 - 2020)



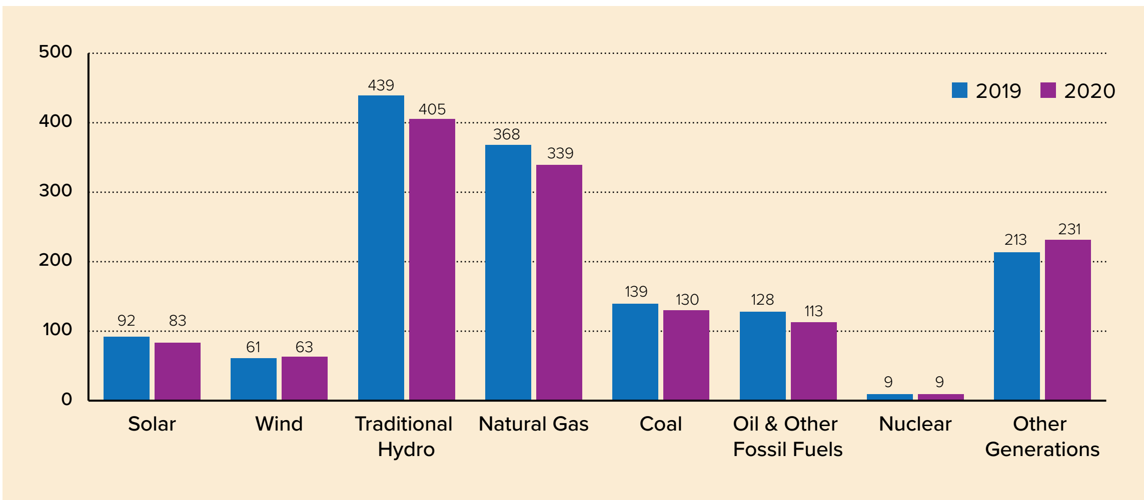
Source: U.S. Department of Energy. 2020. "Alaska Energy and Employment – 2020.", Source: U.S. Department of Energy. 2021. *Energy Employment by State: 2021.*

As of the *2021 Energy and Employment Report*, the fuels industry employs the largest proportion of energy workers in Alaska, with petroleum (7,036), natural gas (3,682), and other fossil fuels (498) making up the largest segments of employment. Of these jobs, 8,058 were related to mining and extraction of these fossil fuel resources.

EMPLOYMENT IN ELECTRIC POWER SECTOR

Of the 1,373 Alaskan workers employed by the electric power generation industry in 2020, traditional fossil fuel generation makes up the largest segment of employment, with 582 jobs, followed by traditional hydroelectric generation at 405 jobs,[25] as shown in Figure 10.

FIGURE 10 Alaska's Electric Power Generation Employment (2019 – 2020)



Source: U.S. Department of Energy. 2020. "Alaska Energy and Employment – 2020." Source: U.S. Department of Energy. 2021. *Energy Employment by State: 2021.*

Alaska's Shift Toward a Renewable Energy Future

Though Alaska's energy sector has historically been dominated by fossil fuels, the state has been transitioning toward a renewable energy future.

The most recent escalation in fossil fuel prices (2008-2019) combined with increased appreciation for the need for a transition to a clean renewable energy future has sparked renewed efforts among Alaska electric utilities.

State and federal legislation has been passed and funding allocated to advance Alaska's renewable energy sector.

STATE RENEWABLE ENERGY FUND

In 2008, the Alaska State Legislature established the Renewable Energy Fund, a grant program administered by the Alaska Energy Authority (AEA).[26] Between 2008 and 2015, this program was responsible for Alaska's largest public investment into renewable energy and efficiency projects, with wind and hydroelectric receiving majority of the funding. It is estimated that the program saved $74 million in diesel costs across the state.[27] As of December 2020, the program has $6.5 million left and is scheduled to sunset in 2023.[28] In 2010, Alaska set a nonbinding goal of generating 50% of the state's electricity from renewable and alternative energy sources by 2025.[29]

FEDERAL $1.2 TRILLION INFRASTRUCTURE INVESTMENT AND JOBS ACT

At the federal level, a recently enacted $1.2 trillion Infrastructure Investment and Jobs Act has the potential to benefit a variety of sectors in Alaska, including, but not limited to, grid reliability and resiliency upgrades, smart grid matching grants, renewable energy demonstration projects, energy efficiency and weatherization, energy storage, hydrogen, hydroelectric production incentives, hydropower, electric vehicle (EV) charging stations, and electric and hybrid school buses.[30,31,32]

These funds have renewed interest in renewable energy projects across the state and sparked an interest in leveraging the new federal resources to continue a shift toward renewable sources.

UTILITY GOALS

Many utilities in Alaska have also set their own goals related to generating electricity from renewable sources and carbon reduction. Key examples from the Railbelt include the following:

- In January 2021, Homer Electric Association (HEA) set a goal of sourcing 50% of its energy demand from renewable sources by 2025.[33] Since declaring that goal, HEA created a Strategic Services division to lead renewable energy projects, environmental compliance, and regulatory affairs.[34]
- Golden Valley Electric Association (GVEA) adopted a goal to reduce its carbon output by 26% by 2030, and renewable energy was identified as one way for GVEA to achieve this goal. In 2013, renewable energy was already supplying 20% of GVEA's system peak load through energy conservation, hydroelectric, customer small-scale renewable energy projects, and the Eva Creek Wind Farm.[35] The GVEA Board of Directors faces a mandated decision by December 2022 whether to decommission or refurbish the Healy 1 coal plant

that must be implemented by 2024. Fairbanks has some of the worst air pollution in the nation, high emission rates of carbon dioxide and other greenhouse gasses, and lack of integration of affordable, clean energy.

- Chugach Electric Association released a request for proposals in October 2021 to source renewable energy projects that will contribute to its goal of adding 100,000 megawatt hours (MWh) per year of renewable energy by 2025.[36]
- In response to member support, in April 2021 Matanuska Electric Association (MEA) adopted a carbon reduction goal of 28% from 2012 levels by 2030. To achieve this goal, MEA has prioritized sourcing energy from renewable sources, such as hydropower and member-generated solar, among other initiatives to reduce its carbon footprint.[37]

MAJOR RAILBELT UTILITY INITIATIVES IN SUPPORT OF RENEWABLE DEVELOPMENT

In 2021, HEA installed a large 46.5 MW (up to 93 MWh) Battery Energy Storage System (BESS) in preparation for developing alternatives to the high and escalating cost of natural gas, enabling the integration of non-firm energy sources, e.g., 20MW solar project. The battery project is expected to cost $40 million.[38]

UTILITY RENEWABLE / ENERGY EFFICIENCY / BUILDING ELECTRIFICATION INITIATIVES

A few utilities in Alaska have initiatives in place to incentivize electrification of building heating and vehicles.

AEL&P in Juneau, which is served primarily by hydropower, has two options which allow customers to charge their EV during off-peak hours at a reduced rate and offer charging equipment for rent.[39]

AP&T, whose service territory includes Prince of Wales Island in Southeast Alaska, which is served primarily by hydropower, has incentive programs to encourage the installation of heat pumps for building heat and the purchase of electric vehicles.[40]

Kodiak Electric Association, which is served primarily by wind and hydro with two flywheels and a battery energy storage system, has an incentive program to encourage customers to switch to electric heating for both space heating and hot water heaters.[41]

Vast Alaska Renewable Energy Resource Opportunity

SEVERAL STUDIES OVER THE PAST DECADE HAVE DOCUMENTED ALASKA'S VAST RENEWABLE ENERGY RESOURCE POTENTIAL.

Renewable Energy in Alaska, WH Pacific, Inc, National Renewable Energy Lab (NREL), March 2013, found:

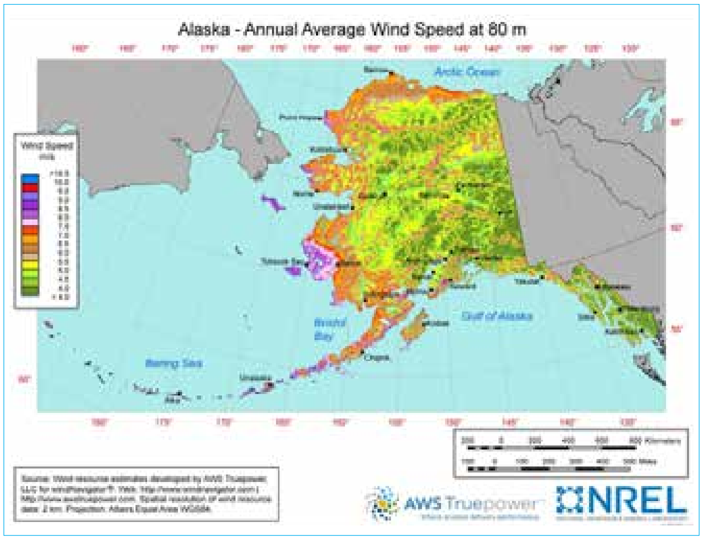
- Alaska is uniquely endowed with a full range of renewable energy opportunities, including extensive and diverse biomass, hydropower that ranges from run-of-river and low-impact high-head to traditional massive dams; wind energy that ranges from micro, wind-hybrid turbines in small coastal villages to large wind farms [coastal + mountain range funnels]; world class tides; and huge geothermal potential on the northern edge of the Pacific Rim of Fire.
- The Levelized Cost of Electricity (LCOE)[42] from many renewable energy projects in Alaska, including energy efficiency initiatives, were competitive with local diesel fuel alternatives in the short term (2010-2020) and looked increasingly competitive with other fossil fuel alternatives (coal and natural gas) in the longer term (2020-2030) as natural gas prices were forecast to increase from below the U.S. market average to well above and increased regulation of coal was expected to add both capital and operating costs.

More recent studies have continued to document a large renewable energy resource base in Alaska:

- Onshore Wind = 37,753 TWh/yr (2.48 times Texas) and 6726 GW potential nameplate capacity, 2.4 times Texas, the next largest onshore wind potential state[43]
- Offshore Wind = 12,087 TWh/year, more than 2000 times the statewide energy consumption in Alaska and more than 3 times the total U.S. energy consumption, a net offshore wind energy potential that is 68% higher than all other states combined[44]
- Onshore + Offshore Wind Potential = 49,840TWh/yr; more than 14 X the total U.S. energy consumption (EIA US Energy Consumption, 2020)
- Hydroelectric = 46.36 GW undeveloped potential of which 4.723 GW is feasible potential[45]
- Geothermal = 2.4 GW potential[46]
- Solar PV = the solar PV resource is comparable to Germany, which has a cumulative installed solar PV capacity of >55 GW[47]
- Tidal Power = Technical Power Potential of U.S. Marine Resources in Alaska = 1,100 TWh/year, 27% of the total U.S. electricity generation[48], of which Cook Inlet East-West Foreland Transect = 46MW, 400 GWh/year[49]

FIGURE 11 Alaska Renewable Energy Resource Map Compilation (2021)

Wind Speed



Wind Speed

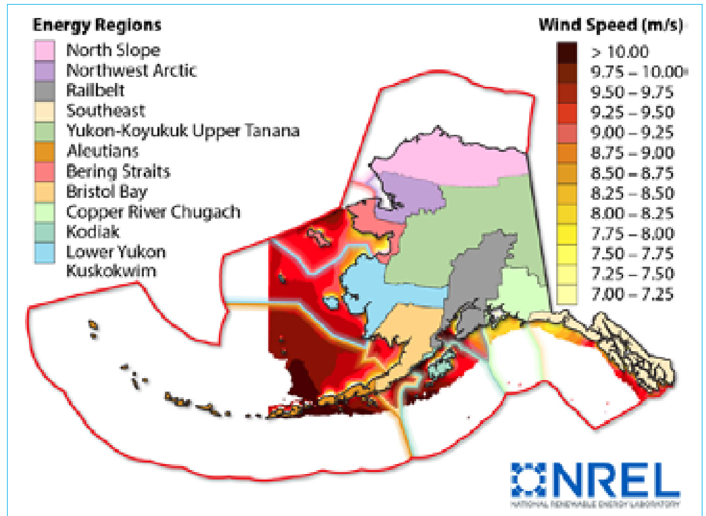
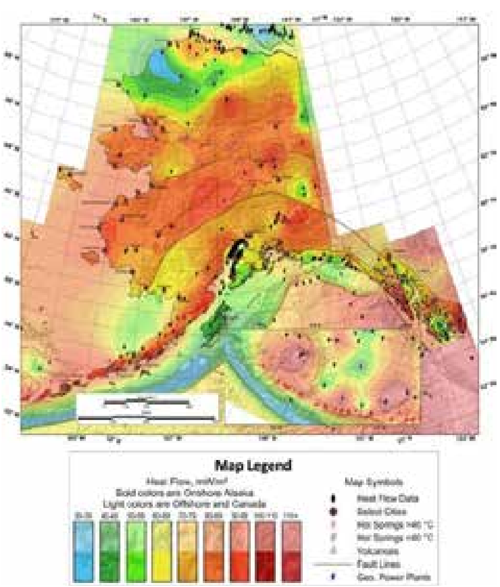


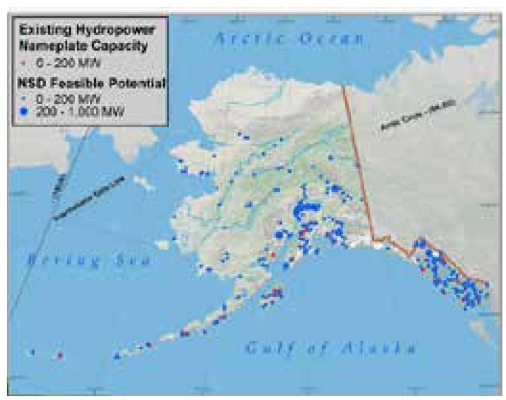
Figure ES-1. Wind speed (m s^{-1}) 100 m above ground temporally averaged over the entire simulation period for grid cells within the technical offshore wind resource area. Note that the data extent is limited due to the model simulation domain, which did not include part of the Aleutians Arc, as will be discussed in the report.

Geothermal Potential

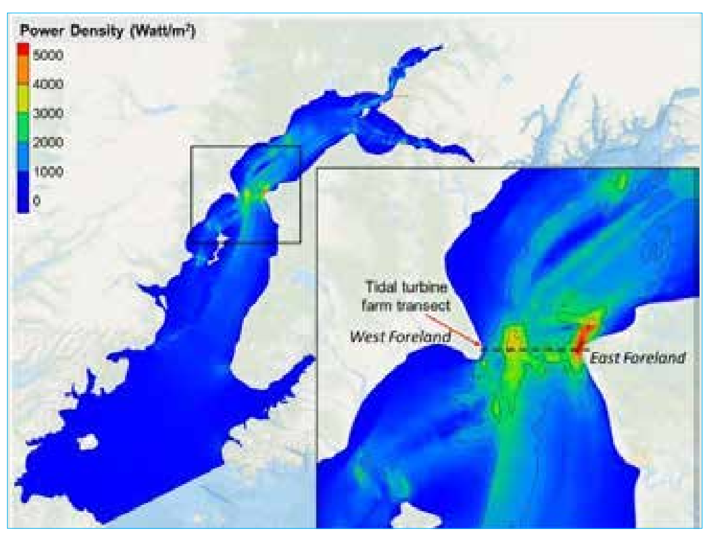


Joe Batir, David D. Blackwell, Geothermal Lab, Southern Methodist University, TX, Alaska Figure 5: **Geothermal Potential**, Heat Flow and temperature-depth curves throughout Alaska: finding regions for future geothermal exploration, June 2016

Alaska Hydropower Existing and Feasible NSD Sites

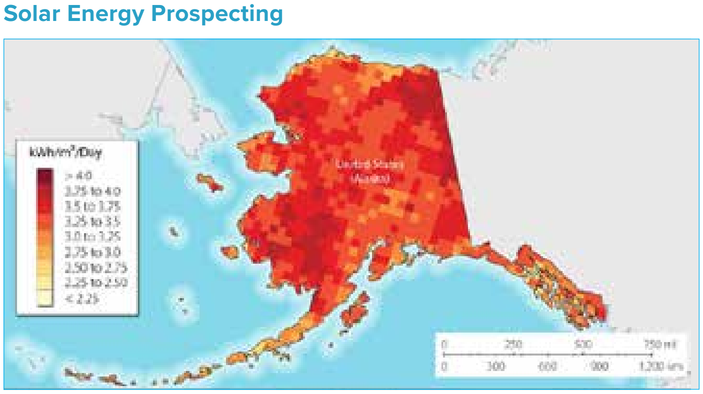


Tidal Hydrodynamic Model for Cook Inlet



Taiping Wang, Zhaoqing Yang, A Tidal Hydrodynamic Model for Cook Inlet, Alaska, to Support Tidal Resource Characterization, Pacific Northwest National Laboratory, 4 April 2020, Journal of Marine Science and Engineering, 2020, 8(4), 254, Figure 12 Tidal Power Distribution near the Foreland Region

Solar Energy Prospecting



Billy J. Roberts, NREL, Solar Resource Comparison of Alaska and Germany, Figure 1, **Solar Energy Prospecting in Remote Alaska**, Paul Schwabe, NREL, February 2016

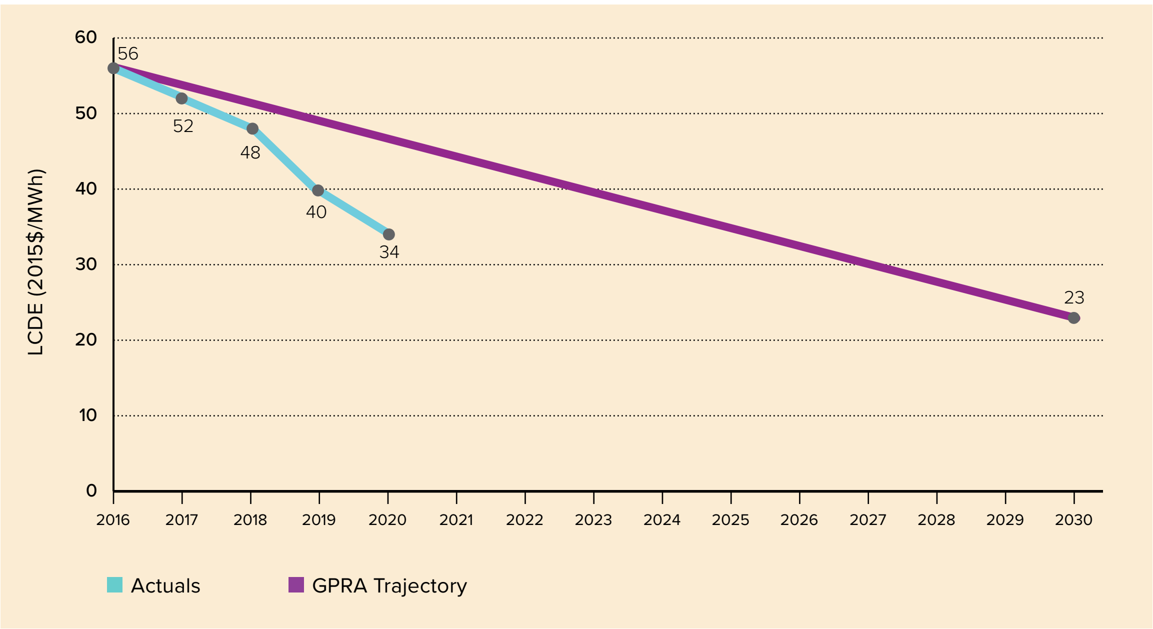
Renewable Energy Technology Trends

History – Rapid Reduction in Costs

ONSHORE WIND COST TRENDS

As illustrated in NREL's 2019 Cost of Wind Energy Review (December 2020), Figure 12: Land-based wind GPRA cost trajectories for LCOE (in 2015 USD), the actual onshore wind levelized cost of energy (LCOE) from 2016 to 2020 has declined from $56/MWh to $34/MWh in real $ terms (-39%) which is considerably faster than the previously projected cost decline trajectory.

FIGURE 12 Land Based Wind Cost Trajectories (NREL, 2020)



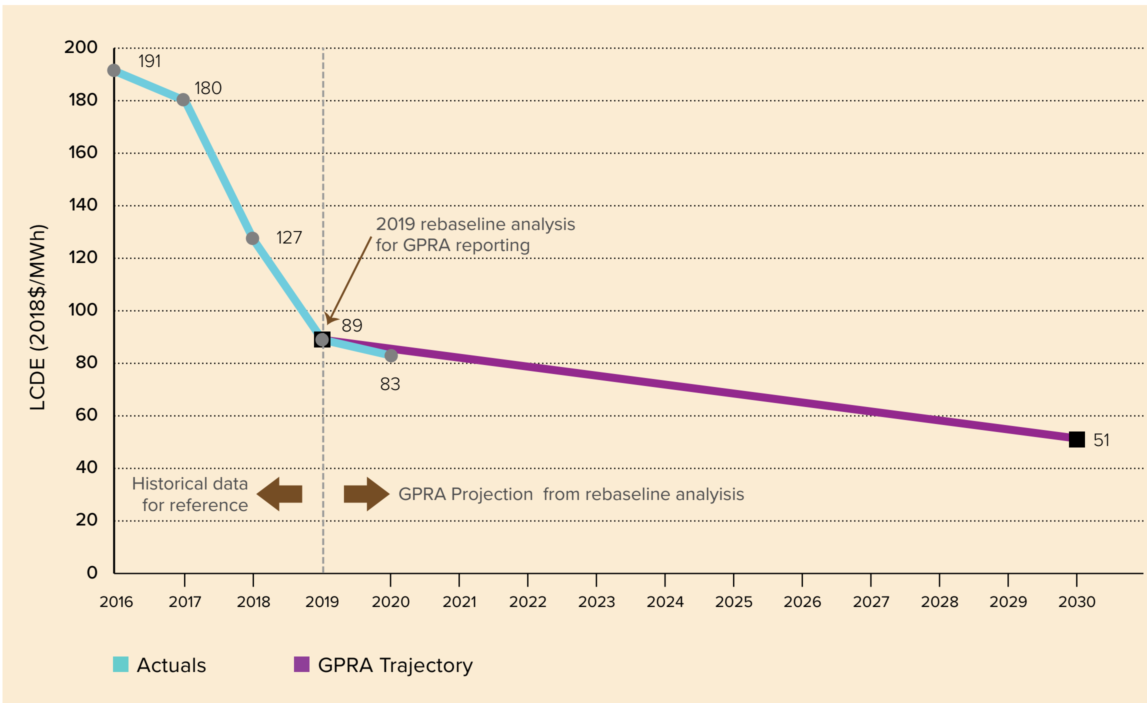
Source: NREL 2019 Cost of Wind Energy Review (December 2020)

Note: The drop in LCOE between 2019 and 2020 is largely because of updates made to the financing assumptions. Prior to the "2018 Cost of Wind Energy Review," WETO reported land-based financing using a constant and conservative FCR. The land-based FCR is updated in 2020 to maintain reporting consistency between land-based wind and offshore wind technologies. Land-based-wind cost of capital data collected by Lawrence Berkeley National Laboratory (Wiser and Bolinger 2020) gives a basis for WACC assumptions for the representative wind project in 2019 and results in a nominal WACC of 6.32%. A sensitivity analysis using the finance assumptions in last year's cost report is captured in Appendix A.

OFFSHORE WIND COST TRENDS

As illustrated in NREL's 2019 Cost of Wind Energy Review (December 2020), Figure 13: Fixed-bottom wind GPRA cost trajectories for LCOE, the actual offshore wind levelized cost of energy (LCOE) declined from $191/MWh to $83/MWh (2016-2020) in real $ terms (-56%). And the cost is projected to continue to decline toward $51/MWh (2018$).

FIGURE 13 Fixed Bottom Offshore Wind Cost Trajectories (NREL, 2020)



Source: Extract from NREL 2019 Cost of Wind Energy Review (December 2020)

BATTERY STORAGE COST TRENDS

Electric power markets in the United States are undergoing significant structural change that are projected to result in the installation of the ability of large-scale battery storage to contribute 10,000 megawatts to the grid between 2021 and 2023 – 10 times the capacity in 2019.[50]

Average battery energy storage costs declined from $2012/kWh to $589/kWh from 2015-2019, an average rate of decline of 27% per year.[51] The EIA Update on Market Trends also reported that, "Although Alaska and Hawaii represent a significant share of current U.S. battery storage capacity, their utilization patterns are unique in that batteries need to provide a wider range of additional services and engineering support than is commonly used in the Lower 48 states."[52]

NREL's most recent comprehensive cost projections for utility-scale battery storage (2020) anticipate 4-hour battery costs will continue to fall, reaching $208/kWh by 2030 and $156/kWh by 2050.[53]

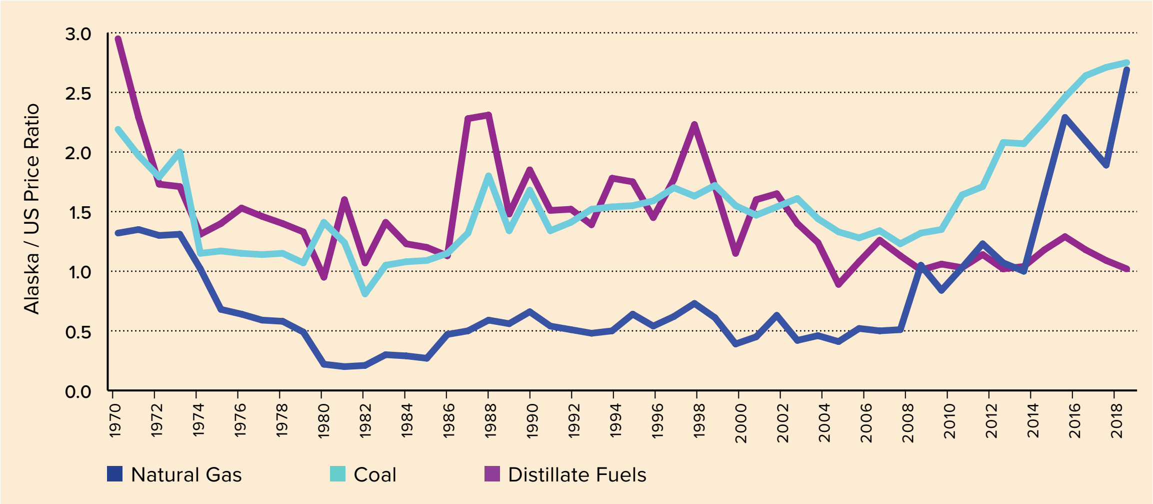
Section summary

Renewable energy costs, including battery storage and the integration of intermittent renewables into an electric grid, continue to decline. GVEA and HEA leadership in investing in battery storage resources is to be commended. Additional investments in battery storage should enable the development of additional intermittent renewable energy resources as well as support additional variability in demand from the electrification of building and transportation sectors. Centralized and distributed storage are critical components needed to cost effectively integrate variable renewable energy resources – around the world, in the U.S. and in Alaska.

Rising Cost of Fossil Fuels

Against the backdrop of the rapid decline in the cost of renewables and projected future cost reductions, the electric power sector in Alaska has been experiencing an unusually rapid increase in the cost of fossil fuels since 2008.

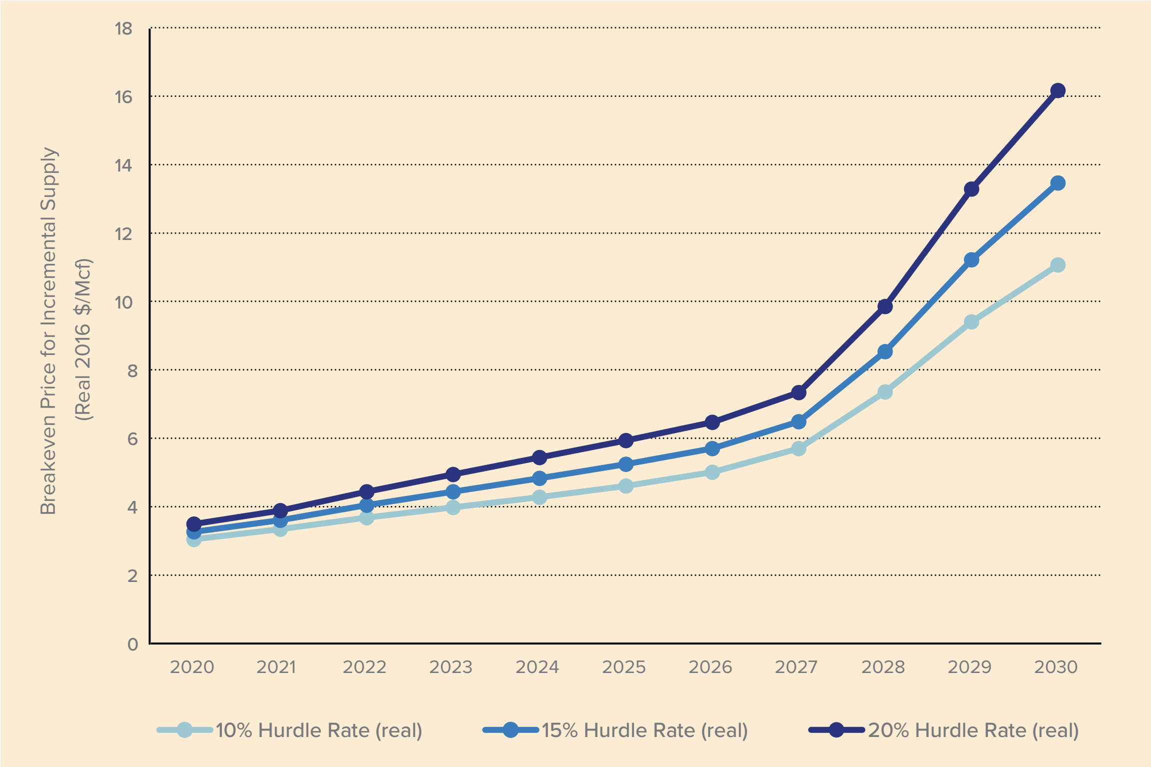
FIGURE 14 Electric Power Sector Fossil Fuel Prices, Alaska to U.S. Price Ratio, 1970-2019



Source: EIA State Energy Data

Alaska electric sector price premium for coal and natural gas has been escalating at an unusually high rate since 2008. A State of Alaska Division of Oil and Gas Cook Inlet Natural Gas Availability study in 2018 projected the costs for Cook Inlet natural gas supply are poised to continue escalating rapidly.

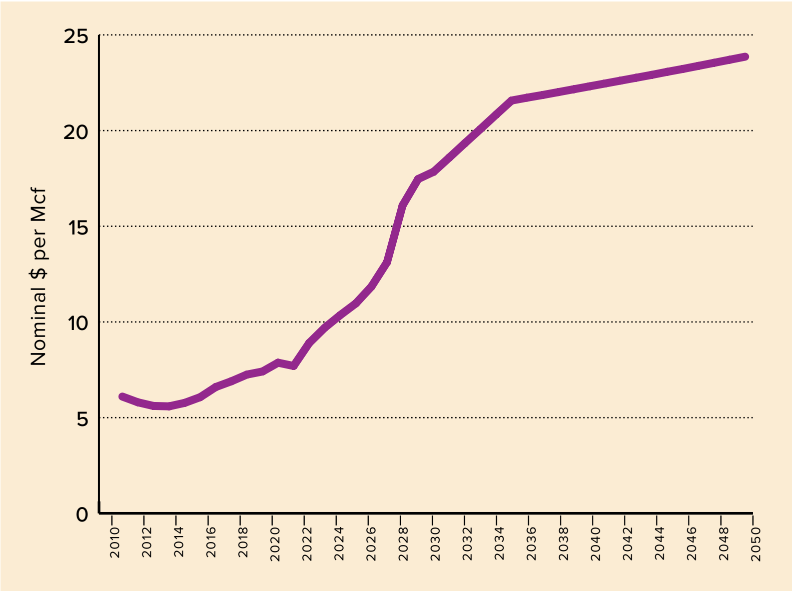
FIGURE 15 Cook Inlet Natural Gas Breakeven Costs for Incremental Supply



Source: State of Alaska Division of Oil and Gas Cook Inlet Natural Gas Availability study (2018)

Extending the State's analysis, natural gas price escalation appears likely to continue until LNG imports become competitive.

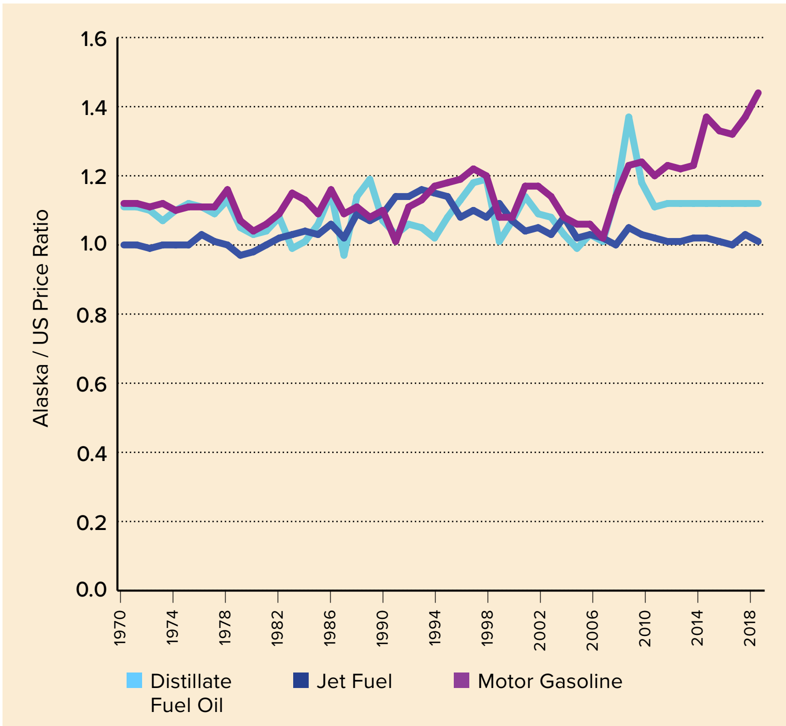
FIGURE 16 Alaska Cook Inlet Natural Gas Prevailing Price of Utility Purchases: History + Outlook with LNG Import Competition in 2031 & beyond



As Cook Inlet natural gas prices rise from $8/Mcf toward a projected $19/Mcf over the next decade, the levelized cost of electricity from natural gas is slated to increase toward $136/MWh, rising well above the cost of *competitive renewable* alternatives.[54]

Transportation Sector

FIGURE 17 Transportation Sector Fossil Fuels: Alaska to U.S. Price Ratio, 1970-2019



Source: EIA State Energy Data

From 1970-2008, the price premium for Alaska "retail" transportation fuels (diesel, motor gasoline) hovered around 5 to 15%.

From 2008-2019, the price premium for Alaska motor gasoline rose to over 40% above the U.S., the price premium for diesel fuel rose to 12% above the U.S.

Compared to the continental U.S. (aka Lower 48), Alaska motor gasoline prices have taken off since 2008 and appear poised to continue to escalate due to increasingly limited competitive alternatives.

Section Summary

Fossil fuel prices are escalating rapidly across the electric, residential, and transportation sectors. Policy makers can help reduce the exposure to fossil fuel price escalation by providing financial and policy support for electric vehicle purchases, discounted rates for charging at off-peak times and extending the electric vehicle charging infrastructure.

And to stay ahead of the growth in the electric demand from electric vehicles, policy makers can encourage co-investment and a supportive policy environment to accelerate the deployment of renewable energy resources and the transition to a 100% clean renewable energy future.

Potential Paths for Renewables to Replace Fossil Fuels

Former Saudi Oil Minister Sheikh Ahmed Zaki Yamani famously observed (Daily Telegraph, June 25, 2000):

- "The Stone Age came to an end, not because we had a lack of stones, and the oil age will come to an end not because we have a lack of oil."
- "Oil will remain underground with no buyers in 30 years [2030]."

Indeed, 20 years later as the cost of clean renewable energy continues to decline while the costs of fossil fuel energy continue to escalate, recent international and national studies highlight the potential for renewable energy to replace fossil fuels as the primary, if not exclusive, source of energy by 2050.

Below are highlights of the findings from three studies that were used in the MAFA analysis of the potential costs and benefits of a transition to 100% clean renewables for Alaska by 2050.

McKinsey & Company, The net-zero transition (January 2022)

- The Network for Greening the Financial System Net Zero 2050 global scenario would entail around $275 trillion in cumulative investments over 30 years - around $25 trillion more than the Current Policies scenario - an increase of 0.3% of the global GDP[55]
- In the Network for Greening the Financial System Net Zero 2050 global scenario, about 200 million direct and indirect jobs would be gained and 185 million lost by 2050 for a net gain of 15 million jobs[56]
- None of the boroughs in Alaska show up on the list of US counties at high employment risk in a net zero transition[57]

M.Z. Jacobson, Zero Air Pollution and Zero Carbon From All Energy Without Blackouts at Low Cost in Alaska (December 7, 2021)[58]

- Transitioning Alaska to 100% wind-water-solar (WWS) would create more jobs than lost
- Save lives from reduced air pollution
- Eliminate >43 million tonnes-CO2 equivalent per year in 2050
- Reduces 2050 all-purpose, end-use energy requirements by half
- Reduces Alaska's 2050 annual energy costs
- Reduces annual energy, health plus climate costs

J.H.Williams, et al, Carbon Neutral Pathways for the United States, (12 November 2020)[59]

- The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C points to the need for carbon neutrality by mid-century
- Multiple carbon neutral pathways, including 100% Renewables, met all forecast U.S. energy needs at a net cost of 0.2–1.2% of GDP in 2050, using only commercial or near-commercial technologies, and requiring no early retirement of existing infrastructure
- All pathways employed four basic strategies: energy efficiency, decarbonized electricity, electrification, and carbon capture

- Least-cost pathways were based on >80% wind and solar electricity plus thermal generation for reliability[60]
- We found multiple feasible options for supplying low-carbon fuels for non-electrifiable end uses in industry, freight, and aviation, which were not required in bulk until after 2035.
- In the next decade, the actions required in all pathways were similar: expand renewable capacity 3.5 fold, retire coal, maintain existing gas generating capacity, and increase electric vehicle and heat pump sales to >50% of market share.[61]

Key observations from MAFA's analysis of the transition to 100% renewable energy by 2050 in Alaska include:

- The high cost of fossil fuels in Alaska, including the rapid and continued projected increase in natural gas prices, accelerate the window in which renewable energy becomes attractive across the electric and heating sectors in Alaska.
    - The relatively higher cost of fossil fuels in the total cost of electricity across Alaska tend to outweigh the relatively higher capital and operating costs across Alaska [relative to CONUS cost assumptions used in McKinsey, Jacobson, Williams].
- The relatively small scale of industrial fuel production plants (H2, Fischer-Tropsch, Liquid "Synthetic" Fuels) that might be modeled for the domestic Alaska market, not unlike Alaska in-state petroleum products refineries, tend to driver higher unit costs and, all other things being equal, increase the cost of 100% renewable fuels by 2050 [relative to potential large scale plants in Alaska that serve both domestic and transit traffic/international markets or imports from larger scale plants in Canada or CONUS].

Emerging Opportunities for Decarbonization of Building and Transportation Sectors

BUILDING ELECTRIFICATION

Building electrification has been incentivized by Alaska utilities with substantial hydroelectric resources, including AEL&P in Juneau, Kodiak Island Electric Association, AP&T on Prince of Wales Island, and Sitka.

The Northwest Arctic Borough engaged Analysis North to develop an Alaskan Heat Pump Calculator to help assess whether a heat pump may be an economic choice for a homeowner and to compile the results of the application of that model to a wide range of communities and home energy configurations around the state.[62]

The Mini-Split Heat Pumps in Alaska Report concluded:

- Heat pumps appear competitive in many cases in communities served by home heating oil or propane.
- At the then current residential prices for natural gas in the Cook Inlet and Railbelt electric rates, heat pumps did not appear economically competitive.

When utility prevailing natural gas prices rise into the $15/Mcf range (and residential retail rates rise toward $1.90/ccf) and electric utilities have migrated to a mix of renewables with residential electric rates around 20c/kWh, which appears to be a plausible scenario in the 2030-time frame, building heat pump technology will be competitive with natural gas and poised to quickly capture market share and grow electric demand.[63]

TRANSPORTATION ELECTRIFICATION

Electrifying transportation provides an opportunity to power vehicles and other modes of transportation with clean energy rather than fossil fuels, thereby reducing carbon emissions. Electric vehicles (EVs) are a key component of a renewable energy transition. In addition to emissions reductions, EVs offer health benefits and the future potential to support resilience via power to the grid.[64]

In a recent study of the total cost of ownership of electric vehicles for Consumer Reports from October 2020, the report concluded: [65]

- Both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEV) are saving 50% on their repair and maintenance costs, when averaged over a typical vehicle lifetime compared to internal combustion engine (ICE) vehicles.
- Based on average driving habits, BEVs were estimated to save consumers about 60% on fuel costs compared to the average ICE vehicles.
- For all EVs analyzed, the lifetime ownership costs were many thousands of dollars lower than all comparable ICE vehicles' costs, with most EVs offering savings of between $6,000 and $10,000.
- Overall, these results show that the latest generation of mainstream EVs typically cost less to own than similar gas-powered vehicles, a new development in the automotive industry with serious potential consumer benefits.

With the growing interest for EVs in Alaska, the Alaska Center for Energy and Power conducted a literature review to understand how these vehicles perform in colder weather. The results showed that EVs generally perform similar to or better than an internal combustion engine in the cold.[66] As of June 2021, Alaska had nearly 1,000 EVs on the road.[67] Currently, there are 62 public level 2 charging plugs and five public direct current fast charging (DCFC) plugs throughout the state.[68] To grow this number, recent funding efforts have been announced. In 2021, the AEA, with support from the Volkswagen Mitigation Trust Fund and the U.S. Department of Energy's State Energy Program, awarded nearly $1 million in grants to add EV charging stations at nine sites along the state's backbone highway system.[69]

Alaska's ferry system also presents another opportunity to advance electrification of the transportation sector. The Infrastructure Investment and Jobs Act will fund at least one program in Alaska to pilot electric ferries.[70]

Electric vehicle purchases and charging have been incentivized and supported by Alaska utilities with substantial hydroelectric resources including AEL&P and AP&T.

GREEN HYDROGEN-BASED FUELS

Hydrogen gas is anticipated to play a vital role in decarbonization, potentially addressing 30% of GHG emissions.[71]

When the electricity used to electrolyze water and create hydrogen is generated from renewable energy sources, it is termed "green hydrogen."[72]

A recent comprehensive study from the Columbia Center on Global Energy Policy, *Green Hydrogen in a Circular Economy: Opportunities and Limits*, Fan et al., August 2021 has a particularly insightful set of findings and analysis:

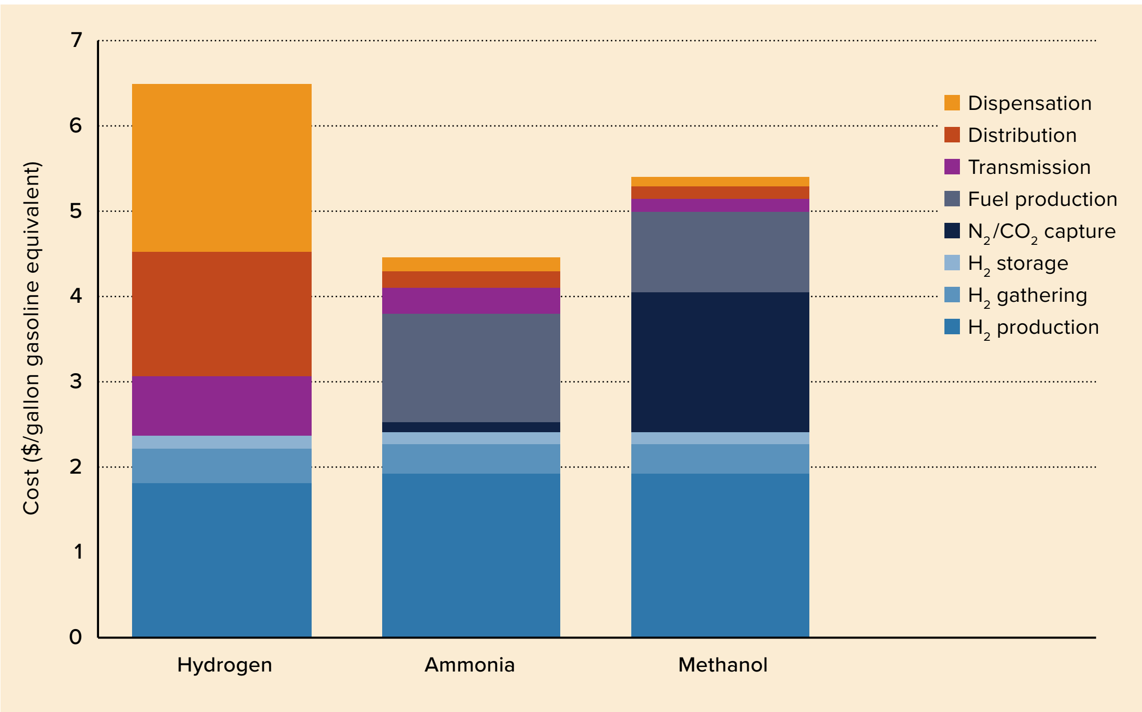
- Green hydrogen and fuels derived from it, e.g., ammonia, methanol, aviation fuels, can replace higher carbon fuels in some areas of the transportation sector, industrial sector, and power sector. They can provide low-carbon heat, serve as low-carbon feedstock, reduce gas for chemical processes, and act as an anchor for recycling CO2 [executive summary findings].
- The cost of green hydrogen is high today, between $6-14/kg on average in most markets [executive summary findings].
    - Dramatic technical improvements in key technologies, e.g., fuel cells and hydrogen tanks, have stimulated many recent analyses (IEA World Energy Outlook 2021) to see hydrogen as an essential component of the energy transition, provided its upstream production and use emit very few greenhouse gases and pollutants [background, page 16]
    - Mean 2030 levelized cost of hydrogen forecasts in the U.S. cluster around $4/kg [Figure 18].
        - With low-cost renewable energy with high capacity factors, the levelized cost of hydrogen forecasts are as low as $2.30/kg in 2030. These high-quality sites will likely provide early opportunities to grow green hydrogen and help develop infrastructure and commercial frameworks [Figure 10 notes].
        - See Figure 19 "geographies with resources of high capacity and low cost" below [opportunities (production), p. 49].

- Green hydrogen commercialization is limited by existing infrastructure [executive summary findings].
- The governments of Japan, Canada, Australia, Germany, and the EU have published formal road maps for hydrogen production, use and growth. These plans include subsidies for manufacturing electrolyzer and fuel cells, port infrastructure, and market aligning policies. [executive summary findings].
- Use of green hydrogen and green hydrogen fuels could provide substantial additional benefits to local economies and environments, including reduction of particulate and sulfur pollution, maintenance or growth of high-wage jobs, and new export opportunities (fuels, commodities, and technologies) [executive summary findings].
- Transportation Market Opportunities for Green Hydrogen
    - Medium- and Heavy-Duty Trucks (p. 38)
        - Both hydrogen fuel cells and lithium batteries are potential options for decarbonizing pathways for heavy-duty vehicles. However, batteries are not practical for many heavy applications for several reasons:
            - Batteries have limited range. Hydrogen fuel cells can significantly extend trucks' zero emissions range capability to on par with conventional vehicles.
            - A typical regional truck haul for trucks of 350 miles requires 16,000 pounds of batteries; the same distance requires 120 pounds of hydrogen and a 4,000-pound hydrogen storage tank.
            - Batteries have long charging times, which for long-haul vehicles could be hours; by contrast refueling time for hydrogen fuel cell trucks is only 10 to 20 minutes, significantly reducing downtime in a fleet's daily operations.
        - A relatively small number of hydrogen fueling stations at key truck freight hubs could serve large hydrogen fuel cell powered truck fleets.
    - Ships (p. 38-39)
        - The global shipping industry currently exclusively uses heavy oil or marine diesel as fuel. Shipping fuel has a high concentration of sulfur that produces air polluting chemicals and particulates that are harmful to human health. These pollutants are concentrated near coastlines where densely populated communities reside. Changing to cleaner shipping fuels will not only reduce GHG emissions but also yield significant health benefits, especially to communities living near ports.
        - Similar to medium- and heavy-duty trucks, batteries are impractical for maritime applications due to their relatively heavy weight and limited range. Hydrogen can provide a range of different marine fuel options, including liquid hydrogen or gaseous compressed hydrogen, or methanol or ammonia, which are both made from hydrogen. Of these, ammonia is seen by many as most suitable for transition to a sustainable shipping industry, as liquid hydrogen cannot be blended into conventional marine fuels and must be kept at high pressures or extremely cold temperatures. Ammonia has a higher energy density than liquid hydrogen and lower overall fuel related costs (*see figure 18 below*) because it can be easily stored as a liquid in inexpensive tanks at very low pressures. Additionally, ammonia can be used in internal combustion engines or fuel cells, and many ship engines can be retrofitted to adapt to use of ammonia fuel, making ammonia not just a low-carbon alternative but also available today and viable for rapid scaling. Methanol has also demonstrated many of these benefits; however, ammonia contains no carbon and releases no carbon

dioxide in use, making it both a lower carbon and lower full-cost alternative.

- During the oil price spike in 2008, AP&T and other Southeast diesel fuel consumer stakeholders conducted a desktop feasibility study in collaboration with fuel suppliers in an exploration of ammonia fuel as a potential substitute for diesel and concluded that it could become a viable competitive alternative under the right combination of high diesel fuel prices, diesel emissions regulations and a competitively priced source of ammonia [MAFA personal communication, 2008].

FIGURE 18 Overall Fuel-related Cost Components of Hydrogen, Ammonia and Methanol

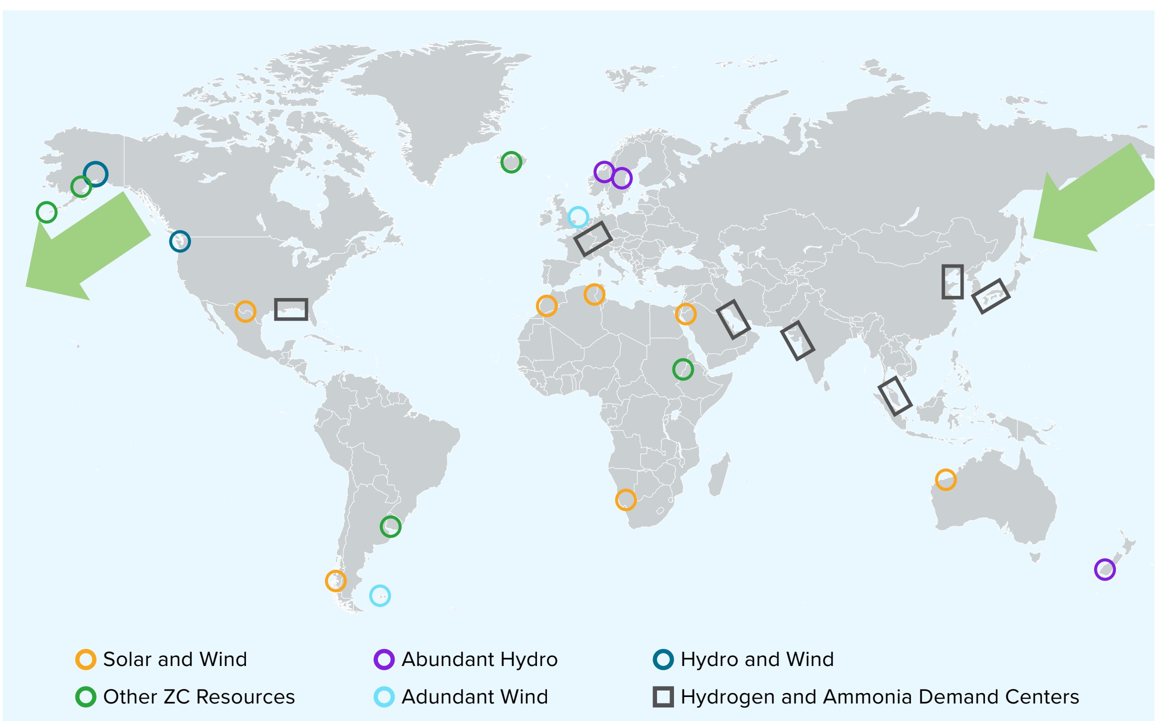


Source: Data courtesy of Yun Zhao, originally reported in Zhao et al., "An Efficient Direct Ammonia Fuel Cell for Affordable Carbon-Neutral Transportation," Joule 3, no. 10 (2019): 2472–2484, https://doi.org/10.1016/j.joule.2019.07.005.

Other countries have also been exploring the potential for green hydrogen. A recent feasibility study determined that Australia was ideal for green hydrogen development because of available infrastructure, land, and renewable resources.[73]

The Alaska Air Group is exploring green hydrogen to meet its goal of net-zero emissions by 2040. In partnership with ZeroAvia, a zero-emission aviation company, the two companies aim to develop a fleet of hydrogen fuel cell electric planes powered by green hydrogen.[74] If the technology is successful, it could serve as a model for future green hydrogen production and use at key airport hubs and beyond. In addition, with infrastructure improvements that could be sited in the Nikiski area, Alaska has the potential to manufacture green hydrogen to serve the international air cargo hub in Anchorage as well as export green hydrogen to Pacific Rim demand centers. See Alaska opportunities in *Figure 19: Geographies with combined zero-carbon resources of high capacity and low cost* [Fan, et al, p. 49, October 2021].

FIGURE 19 Geographies with Combined Zero-carbon Resources of High Capacity and Low Cost

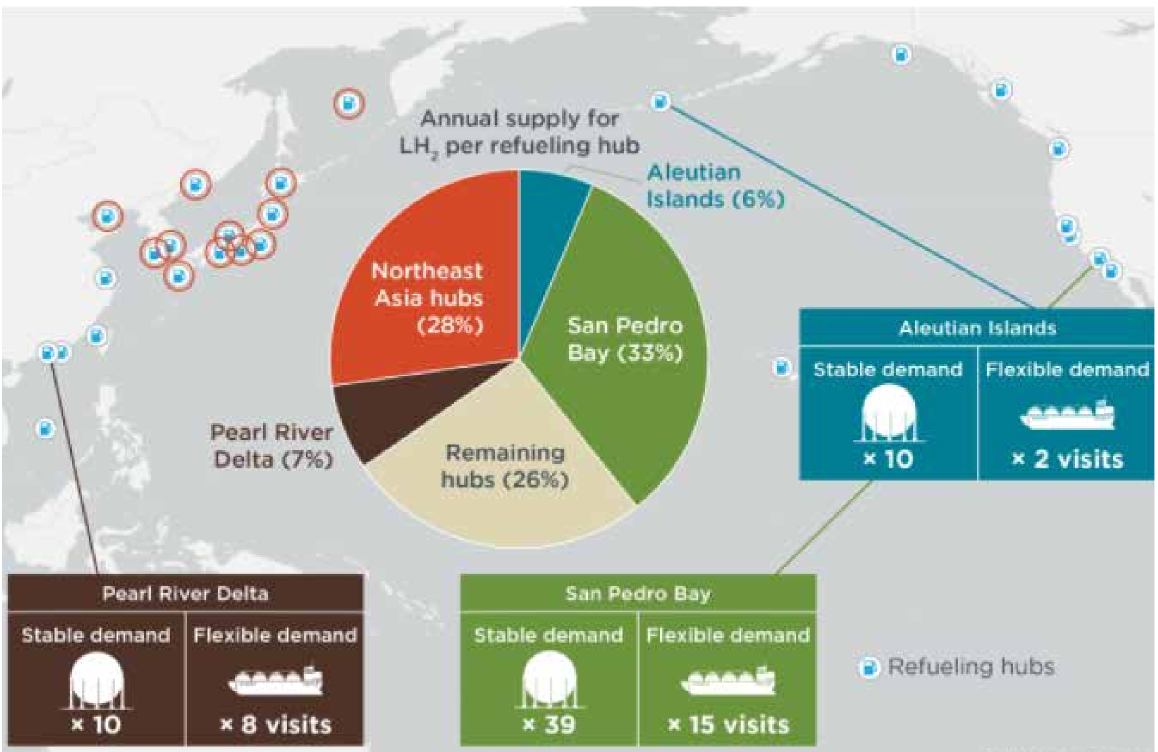


Source: Columbia Center on Global Energy Policy, *Green Hydrogen in a Circular Economy: Opportunities and Limits*, Fan et al., August 2021.

In addition, we note that the International Council on Clean Transportation has two recent working papers which highlight the potential for zero emission fuels in the Pacific and the potential for an Aleutians port to serve as a critical refueling hub:

- REFUELING ASSESSMENT OF A ZERO-EMISSION CONTAINER CORRIDOR BETWEEN CHINA AND THE UNITED STATES: COULD HYDROGEN REPLACE FOSSIL FUELS?, By: Xiaoli Mao, Dan Rutherford, Liudmila Osipova, Bryan Comer, March 3, 2020.
- LIQUID HYDROGEN REFUELING INFRASTRUCTURE TO SUPPORT A ZERO-EMISSION U.S.–CHINA CONTAINER SHIPPING CORRIDOR, By: Elise Georgeff, Xiaoli Mao, Dan Rutherford, Ph.D., Liudmila Osipova, Ph.D., October 14, 2020, see Figure 20 below highlighting the potential for an Aleutian Island refueling hub.

FIGURE 20 Hydrogen Demand and Refueling Infrastructure Needed for Transpacific Container Ships Under the Full Deployment Scenario



Source: International Council on Clean Transportation: LIQUID HYDROGEN REFUELING INFRASTRUCTURE TO SUPPORT A ZERO-EMISSION U.S.–CHINA CONTAINER SHIPPING CORRIDOR, By: Elise Georgeff, Xiaoli Mao, Dan Rutherford, Ph.D., Liudmila Osipova, Ph.D., October 14, 2020

Strategies to Accelerate the Transition to Clean Renewable Energy

This section outlines some of the approaches in policy, planning, funding and financing, and workforce development that could help accelerate Alaska's transition to clean renewable energy.

Though few explicit barriers hinder renewable energy development in Alaska, the state currently lacks the regulatory framework and supporting legislation needed to attract additional investment in the industry at scale. Attracting private investment to facilitate further development in renewable energy remains a critical hurdle, as the market stability and predictability investors require is difficult to achieve if the state remains relatively silent in regulating the sector. Aligning Alaska's renewable energy goals with supporting legislation will provide the public, private, and nonprofit sectors of Alaska, some of which may have limited technical or financial ability to procure renewables, greater access to clean energy.

Additional federal and state investments are necessary if Alaska is to realize significant and achievable clean energy benefits (and get out from under the heavy burden of fossil fuels) by 2050.

ACTIONS THAT COULD HELP ACCELERATE ALASKA'S TRANSITION TO CLEAN RENEWABLE ENERGY ARE OUTLINED BELOW.

Transparent accounting – Encourage transparent accounting for the $1.2 trillion Infrastructure Investment and Jobs federal support. More transparent and accessible information will benefit private entrepreneurial, utility and community efforts to access and effectively deploy available funds. HB 177 would prevent a Governor, without legislative approval, from unilaterally spending large sums of federal money should it flow into the state when the legislature is not in session, thus ensuring an opportunity for public input. This bill is needed to correct a statutory blind spot as Alaska prepares to receive an influx of new federal infrastructure funds.

State Comprehensive Plan – Undertake a comprehensive statewide, strategic policy and planning effort, including an explicit goal of transitioning to 100% clean renewable energy by 2050, to help focus emerging integrated planning efforts, including the Railbelt Integrated Resource Plan required by recent 2020 legislation establishing an Electric Reliability Organization.

Legislation to set goal – Enact legislation requiring utilities to achieve 100% clean renewable energy by 2050, and to measure progress toward that goal. Legislation could encourage a supportive and transparent regulatory environment aimed at accelerating the transition to renewables by providing clear guidance and promoting creative solutions like power purchase agreements (PPAs) and community solar.

Investments – Provide funding and financing commensurate with the need to accelerate the transition to 100% clean renewable energy by 2050.[75]

FUNDING MECHANISMS COULD INCLUDE:

Alaska Renewable Energy Fund – Extend the Alaska Renewable Energy Fund beyond its current sunset of 2023 and fund it with a fresh round of seed capital in the range of $3.2 billion to help leverage federal and private co-investment.

The REF, a grant program established by the Alaska State Legislature in 2008, helps utilities, independent power producers, and local and tribal governments develop renewable energy projects.[76] The REF is managed by AEA in coordination with a nine-member Renewable Energy Fund Advisory Committee. The program provides grant funding for the development of qualifying and competitively selected renewable energy projects; as of February 2021, 287 REF grants have been awarded to projects totaling $268 million.[77] Over 90 operating projects have been built with REF contributions, collectively saving more than 30 million gallons of diesel each year. As of January 2018, operational REF projects have an overall benefit-cost ratio of 2.5 based on total known project cost, of which state funding is only a portion.[78]

Energy Efficiency Programs – Increase support for Building Energy Efficiency, including Building Envelope Improvements (AHFC/Cold Climate Housing), and Lighting and Energy Appliance upgrades (local electric utility programs).

Clean Energy Infrastructure – Invest in key renewable energy infrastructure including electric vehicle charging station infrastructure, upgrades and additions to electric transmission lines and energy storage capacity for renewable generated power.

> ***Energy Storage Capacity for Renewable Energy*** – Homer Electric Association's (HEA) investment in a new battery system for storing energy provides a great example for other utilities in Alaska. The new battery system will allow HEA to diversify its energy matrix and will meet reliability requirements without burning additional fuel. Incorporating the battery storage facility into HEA's grid structure will ultimately lower greenhouse gas production by allowing HEA to utilize non-dispatchable renewable energy instead of remaining over dependent on natural gas.[79]
>
> ***Electric Vehicle Charging Station Expansion*** – As demand for Electric Vehicles (EVs) grows in Alaska, the need to expand EV charging infrastructure also grows. Recent investment in an EV fast-charging corridor from Healy to the Kenai Peninsula in the railbelt by Alaska Energy Authority (AEA),[80] via the Volkswagen Settlement funds, provides an example of the type of infrastructure needed in Alaska to support a transition to renewable energy.
>
> ***Upgrade and Extend Railbelt/Rural Transmission Lines*** – The lowest potential cost energy resources, potentially including wind, geothermal, solar, and low-impact hydro may not be located adjacent to load centers and electric system substations. In CONUS markets, the cost of transmission system upgrades has become a significant hurdle for the integration of low-cost new renewable generation.[81] In the AEA's Railbelt Integrated Resource Plan (2009), the cost of transmission system upgrades to support renewable resource development was considered a system wide benefit and not charged to individual projects. Advocate for the upgrade and extension of transmission infrastructure (Railbelt, Rural, Southeast) where the total system wide benefits of access to low cost renewables (displacing the total cost of fossil fuels – direct, health and climate costs over the study time horizon) exceed the cost.

Alaska Permanent Fund (APF) investment policies – Seek Alaska Permanent Fund support for publication of environmental disclosures of its investments to ensure portfolio investments are accessing and addressing climate risks, analogous to the CALPERS initiative to require improved environmental disclosures among its investments of the nation's largest public pension fund.

Federal support of the transition to 100% clean renewable energy – Advocate for the revival of the national mandate to electrify America under the Rural Electrification Administration (now know as Rural Utility Service) under a new "clean energy for America" banner with funding support modeled on the federal highway funding program which grew out of the National Interstate and Defense Highways Act of 1956 with a state:federal funding ratio of 1:9.

IN ADDITION TO FUNDING RENEWABLE INVESTMENTS, OTHER ACTION ITEMS INCLUDE:

Disclosure - Encourage and support private and public sector entities that seek to develop and disclose their environmental impacts under the CDP (formerly known as "Climate Disclosure Project"), a leading global environmental disclosure system. See https://www.cdp.net/en

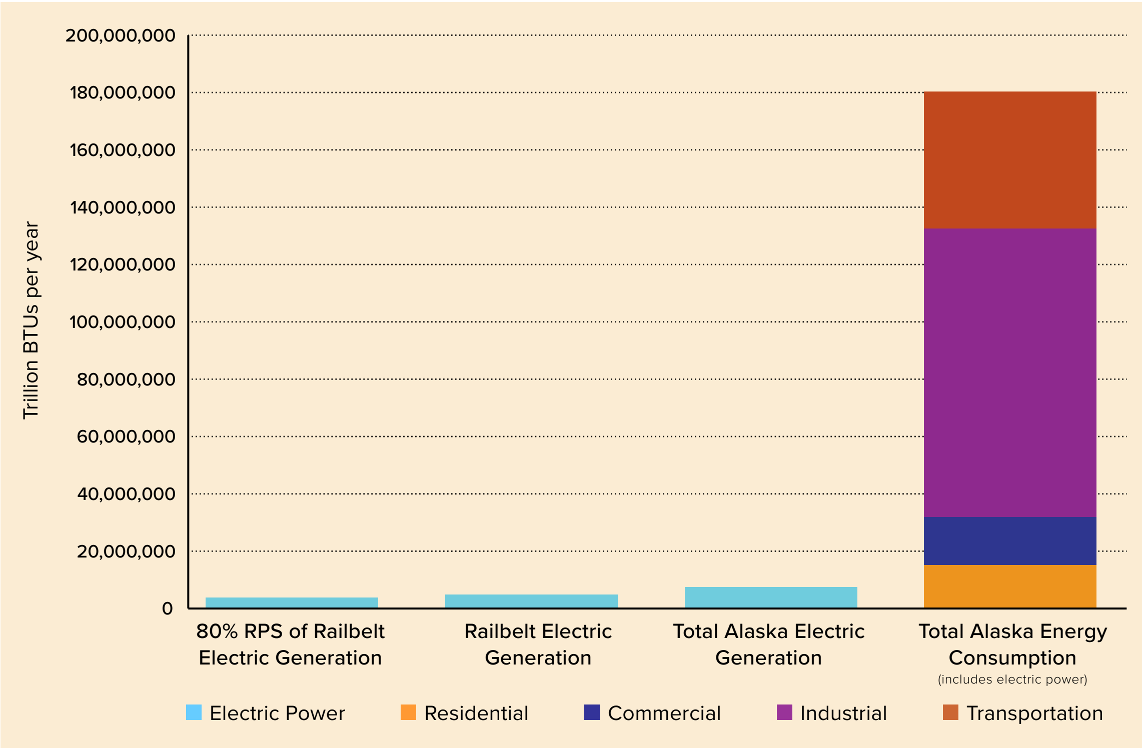
Regional Integrated Resource Plans – Advocate for Regional Integrated Resource Plans that include:

- Substantive opportunities for local collaboration/consultation
- Consideration of future cost escalation associated with fossil fuel resources from both direct and indirect costs, e.g. $CO_{2\ equiv}$ emissions costs[82]
- Explicitly require regional plans to include the overarching policy goal of reaching 100% clean renewable energy for all energy needs by 2050 and include a pathway to achieve it within their options for consideration

Renewable Portfolio Standard – Enact Renewable Portfolio Standard. Alaska Gov. Mike Dunleavy recently introduced SB 179 and HB 301 to establish a Renewable Portfolio Standard (RPS) for the Railbelt region of Alaska. The proposed bills would require the five electric utilities on the Railbelt to generate a specified percentage of their electricity from renewable resources according to the following timeline: 20% by 2025, 30% by 2030, 55% by 2035 and 80% by 2040.

Under current end-use energy consumption patterns, the 80% renewable portfolio standard applied to the Railbelt Electric Utilities amounts to roughly 3% of the total energy consumption in Alaska. See chart below.

FIGURE 21 80% Renewable Portfolio Standard (RPS) for Alaska Railbelt Electric Utilities compared to Total Alaska Energy Consumption by Market Segment (2019 data)



Source: Energy Information Administration, State Energy Data System, 2019 data

An 80% renewable portfolio standard for the Railbelt electric utilities, expressly limited to clean renewable energy, would be a welcome first step toward 100% clean renewable energy by 2050.

However, recognizing that more than 90% of Alaska end-use energy is not electrified, an 80% renewable portfolio standard for the current railbelt electric utilities, would fall far short of the need to transform our collective energy use to clean renewable energy by 2050.

Regulatory Commission of Alaska – Enact regulatory reforms to encourage renewable energy development, improve transparency and support community involvement. The Regulatory Commission of Alaska (RCA) regulates public utilities by certifying qualified providers of public utility services and ensuring that they provide safe and adequate services and facilities at just and reasonable rates, terms, and conditions.

Raise the Net Metering Cap – Raise the net metering cap so utilities can enable electric customers who produce their own electricity to receive a credit for the excess energy they transfer back to the utility. Caps are set on most net metering policies to limit the utility's risk of lost revenue. The most common cap type is set at a percentage of the utility's or state's peak demand, capacity, or load in a given year. Most states have a peak demand cap between 0.2% and 9%. Credit amounts, eligible technologies, and caps vary by state and locality.[83] Net metering policies not only incentivize customers to invest in renewable energy technologies, they also can help utilities meet their requirements to achieve 100% clean renewables by 2050.

Alaska's net metering policies apply to renewable energy systems that are 25 kW or less and set a cap of 1.5% of the utility's average load. Customers who export excess energy to the utility receive a credit equal to the utility's savings on fuel and operations necessary to generate that electricity. With an increase in solar projects,[84] there is a need for raising the net metering cap for all utilities in Alaska under the current regulatory framework. As of 2021, with the approval from the Regulatory Commission of Alaska, GVEA raised its net metering cap from 1.5% to 3%. Homer Electric Association, which had already previously raised its cap, did so again, from 3% to 7%. At the end of 2020, the installed net metered capacity across the Railbelt rose 52% from 2019 and involved 1,638 net metered customers. Solar PV was responsible for 97% of the total energy fed to the Railbelt grid.[85]

Good Governance Regulations – Enact regulations that improve transparency and support community involvement in the transition to lowest reasonable cost renewable energy. For example, ensuring that fuel and operation costs for utilities are transparent and accessible to the public and/or utility cooperative members would allow for better planning and understanding of a renewable energy transition and true energy costs, as would enforcing timelines for cost- and energy-saving programs like tight power pools. Eliminating any "pancaking" or stacking of rates through the Electric Reliability Organization's reliability standards would lower the cost of adding renewable energy to the grid and increase trust with ratepayers. Providing member lists to community members seeking to serve on utility boards and ensuring that utility board and member meetings and minutes are accessible via the internet, as well as scheduling public comment and public portions of meetings before executive sessions, would allow for more efficient engagement between electric co-ops and members. And, developing guidelines on on-bill financing programs as well as moving from promises to action on building community solar programs would allow for a better interface between community advocates and utilities.

Increase expertise – Increase funding to both the Regulatory Commission of Alaska and outside advocacy groups (ie, ratepayer groups) to increase staffing and expertise to better balance the energy industry, private and member-owned electric utilities, and ratepayer needs and help ensure the capacity needed to foster an accelerated transition to renewable energy.

Private Sector Initiatives – Encourage and support public and private sector entities to disclose their Scope 1, 2 and 3 climate emissions.[86]

WORKFORCE DEVELOPMENT

Incentivize industry-led training curriculum for the construction and operations of renewable energy technologies to provide current industry workers with renewable energy skills and alignment with existing jobs. Building the skills of workers in existing construction and operations fields, such as fossil fuels, HVAC, and electrical, will be essential to a renewable energy transition. Most of these occupations already require continuous learning and skill development.[87] The state can partner with these industries and fund development of training curriculums that can be incorporated into existing training, rather than develop training specifically for renewable energy technologies. In addition, industries can drive curriculum development according to the skills needed for available jobs.

Alaska has several training programs funded by the Alaska Workforce Investment Board (AWIB). These programs include the Alaska Construction Academies (ACA) trainings offered by the Alaska Works Partnership, Alaska Technical Vocational Education Program (TVEP), State Training and Employment Program (STEP), and youth training program. Through these programs, organizations, and state entities can receive support to train and prepare workers for jobs that align with AWIB's industry priorities.[88] According to the State Integrated Workforce Plan, there is still heavy emphasis on training for the oil and gas industry. However, the plan notes that Alaskans should grow their skillsets as demand for renewable energy workers grows.[89] As the industry expands in Alaska, AWIB could identify renewable energy as a priority and fund entities to develop training curriculum through the existing training programs.

Incorporate training curriculum into a state-certified apprenticeship program that offers a paid opportunity for individuals entering a workforce to gain skills, knowledge, and mentorship without obtaining an advanced degree. These programs also connect employers with qualified workers.[90] Incorporating renewable energy training curriculum into a state-registered apprenticeship program can help standardize the level of renewable energy knowledge and skills needed to enter the workforce. An example of a statewide training initiative is the California Advanced Lighting Controls Training, which was developed to teach employed electricians how to install and maintain advanced lighting systems and energy efficiency technologies. The curriculum was also integrated into the apprenticeship program to build a pipeline of qualified workers.[91]

Since 2015, there has been an emphasis placed on expanding apprenticeship programs in Alaska, with a primary focus on new industries and occupations.[92] With a majority of apprentices in construction, there is a significant opportunity to incorporate established renewable energy training programs into the existing construction apprenticeships as the demand for these jobs grows.

The Alaska IBEW/NECA apprenticeship program for electricians has adopted a standardized curriculum for the installation of electric vehicle charging equipment. It's called the Electric Vehicle Infrastructure Training Program (EVITP) and the curriculum has been adopted by several other apprenticeship programs around the country.

Encourage engagement of students in renewable energy technology education to give them early exposure to career possibilities and create a network of educated individuals who could later contribute to a renewable energy transition. With a focus on clean energy and job creation, the Colorado Energy Office, U.S. Department of Energy, and Tri-State Generation and Transmission funded the Colorado State University Extension to develop a clean energy curriculum for middle and high school students. The curriculum includes hands-on activities and locally relevant examples that can be tailored by teachers for any grade level.[93]

Currently, the Renewable Energy Alaska Project (REAP) is working to connect energy education to Alaskans. Through its initiative, Alaska Network for Energy Education and Employment, REAP compiles and categorizes energy curricula so they can be easily accessed by Alaskans.[94] This institutional knowledge presents an opportunity to understand gaps in existing curricula and inform development of a state-funded renewable energy technology education curriculum.

OTHER FUNDING MECHANISMS

Green Bank – A Green Bank is a capital management program that leverages limited public dollars to attract greater private investment in clean energy. Its goal is to accelerate growth in the clean energy market while making energy cheaper and cleaner for consumers, driving job creation, and preserving taxpayer dollars. A Green Bank is intended to deploy public capital efficiently through financing to help maximize private investment and lower the costs of clean energy to spark consumer demand. A Green Bank also facilitates market development by working with originators and lenders and offering the information consumers and businesses need to confidently purchase clean energy.[95]

Pending legislation, SB 123 in the Senate and HB 170 in the House of Representatives, known as the Alaska Energy Independence Fund, would support the creation of a Green Bank in Alaska.[96,97] The Alaska Energy Independence Fund would be under the jurisdiction of the Alaska Industrial

Development and Export Authority (AIDEA) and would support public-private partnerships oriented toward renewable energy.[98] The proposed Green Bank would require starting capital; pending legislation recommends $10 million in unrestricted general funds, which could be augmented by $130 million in expected federal funds. After that initial capital, the Green Bank would use payments from its borrowers to pay for future loans.[99]

Commercial Property Assessed Clean Energy (C-PACE) Loans – Broader investment in marketing and implementing C-PACE programs in municipalities around Alaska could benefit the transition to renewable energy. C-PACE is a financing tool for improving commercial buildings with energy efficiency measures or renewable energy systems. Unlike conventional construction loans, C-PACE is designed to work specifically with the unique needs and barriers of financing building improvements, including longer loan terms, off-book debt, and repayment that transfers with the sale of property just as does the savings generated by the building improvements. Debt associated with doing the improvements is repaid via a line item on local tax assessments. Authorizing legislation was adopted into Alaska law in 2017 (AS 29.55.100) that allows local governments to create and manage C-PACE programs.[100]

On-bill Financing and On-bill Repayment – Further investment in marketing and expanding the program could benefit utility ratepayers and the transition to clean energy. On-bill financing allows the utility to incur the cost of the clean energy upgrade, which is then repaid on the utility bill. On-bill repayment options require the customer to repay the investment through a charge on their monthly utility bill as well, but with this option, the upfront capital is provided by a third party, not the utility. Additionally, on-bill repayment allows for a streamlined process as utilities already have a billing relationship with their customers, as well as access to information about their energy usage patterns and payment history. In some on-bill repayment programs, the loan is transferable to the next owner of the home or building.[101] Authorizing legislation (HB374[102]) was passed in 2018.

Utility Incentive Programs – There are numerous examples of successful incentive programs in Alaska that could be expanded to support a transition to renewable energy and reduce costs for consumers. Alaska Power and Telephone Company (AP&T) in Southeast Alaska has an incentivized installation of ground or air-source heat pumps with a $500 rebate matched by Sealaska Corporation for shareholders.[103] AP&T also offers a $1000 cash incentive for customers in their service area who purchase Electric Vehicles (EVs), and offers a $1000 cash incentive to local or tribal governments that install EV charging stations.[104] Utilities may also offer lower rates for charging EVs during off-peak hours as Alaska Electric Light & Power does for its service area.[105]

Conclusion

Alaska has the potential to create many thousands of jobs and make the high cost of energy more affordable for Alaskans by accelerating its transition to a clean energy future. Worsening climate impacts throughout Alaska and globally make this transition urgent, and ultimately inevitable, as the world moves away from fossil fuels.

Global leaders agree that atmospheric temperature rise must be held to 1.5 degrees C or well below 2 degrees C above pre-industrial levels to avoid catastrophic impacts on people and the planet. The international movement away from climate-damaging fossil fuels is driving transformative energy changes that present new opportunities for Alaska's economy.

Alaska is well positioned to be part of the new energy economy with its vast endowment of renewable energy resources. Renewable energy technology costs continue to decline, while local and global fossil fuel costs continue to escalate. The resulting confluence of factors makes it possible that renewable energy technologies will affordably replace Alaska's legacy fossil fuel energy systems in the 2030-to-2050 time horizon.

The development of Alaska's vast renewable energy potential will generate thousands of jobs across Alaska – with the potential to more than replace the jobs lost as fossil fuels become obsolete. Renewable hydrogen-based fuels have the potential to replace fossil fuels in the marine and aviation sectors and form the basis of a new export economy.

Substantial funding and effort on the part of many will be required to achieve the aspirational goal of achieving 100% renewable energy use and production across all sectors of Alaska's economy by 2050.

Clean and affordable energy is good for Alaskans, our economy, our pocketbooks, our health and the planet, and one of the best ways to achieve those benefits is to accelerate Alaska's transition to renewable energy. Alaska can benefit by increasing investment now in the clean energy revolution, creating thousands of jobs, reducing the cost of energy, improving health, slowing the Arctic melt, and building climate stability for future generations.

Endnotes

1 The combination of Onshore and Offshore Wind Energy potential alone, in and around Alaska, has been estimated to be on the order of 37,753 TWh/yr (onshore) + 10,043 TWh/yr (offshore) for a total of 47,796 TWh/year which is 14 times the total U.S. energy consumption of 3,397 TWh/yr (EIA, U.S. Energy Consumption, 2020, 11.59 Quads). Onshore wind energy potential estimate from *Onshore wind energy atlas for the United States accounting for land use restrictions and wind speed thresholds,* von Krauland, et al, Smart Energy, 3 (2021), 100046. Offshore wind energy potential estimate from *Offshore Wind Energy Resource Assessment for Alaska*, Doubrawa, et al, Golden, CO: NREL, December 2017.

2 The net zero emissions by 2050 target derives from The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C which points to the need for carbon neutrality by mid- century (2050).

3 We asked local Alaska energy sector consultant Mark Foster (MAFA), to review multiple recent studies on the local Alaska employment potential of transitioning the Alaska energy sector to 100% clean renewables. He reviewed four studies (JH Williams et al, *Carbon Neutral Pathways for the United States*, AGU Advances, Research Article 10.1029/2020AV000284, 12 Nov 2020; Cadmus, Alaska's Renewable Energy Future: New Jobs, Affordable Energy, December 2021; MZ Jacobson et al, *Zero Air Pollution and Zero Carbon from All Energy Without Blackouts at Low Cost in Alaska,* December 7, 2021; McKinsey, *The Net-Zero Transition: What it would cost, what it could bring*, January 2022) for their investment, benefits, jobs and economic impact estimates and adjusted their estimated costs and benefits to reflect local Alaska capital, operating, fuel costs and energy systems performance and extended those results through the NREL Jobs and Economic Impact (JEDI) models to derive estimates of the jobs potential of a transition to 100% clean renewables.

4 For an illustrative example of the basis for the job estimates, MAFA adjusted the Jacobson job estimates Table 14. Changes in Employment, Zero Air Pollution and Zero Carbon From All Energy Without Blackouts at Low Cost in Alaska, Professor Mark Z. Jacobson, Stanford University, December 7, 2021. https://web.stanford.edu/group/efmh/jacobson/Articles/I/21-USStates-PDFs/21-WWS-Alaska.pdf

The MAFA job estimates were developed based on Alaska capital and operating costs [which ran from 25% to 225% above the continental United States (hereinafter CONUS) basis used by Jacobson] and rerun the resulting cost estimates through the JEDI models for each respective renewable energy technology. The result is an increase in local Alaska jobs from 82,843 to 103,554 which are offset by the Jacobson identified anticipated loss of 36,338, for a net gain on the order of 67,216 jobs. MAFA notes that this may be a conservative figure in light of the estimated magnitude of the capital investment associated with the construction of the infrastructure to support a transition to 100% clean renewable energy of roughly $128 billion (2020$) over 30 years. This is roughly comparable to building the equivalent of the TransAlaska Pipeline System ($32 billion in 2020$) every 8 years.

5 See HB 301 and SB179, "Legislation setting Renewable Energy Standard benchmarks to prepare the Railbelt for energy independence", introduced by Governor Dunleavy on February 4, 2022.

6 MAFA has reviewed the detailed renewable energy and energy storage capacity requirements and associated capital cost estimates of Jacobson (2021) and Williams (2020) and adjusted each of the studies to reflect Alaska renewable energy resource development costs *across Alaska* [Railbelt + Rural]. The net result is a 100% clean renewable energy investment portfolio estimate on the order of $128 billion over 30 years.

7 The magnitude of the challenge to transition the energy system from fossil fuels to 100% clean renewables, on the order of 0.9% of Alaska GDP by 2050 [MAFA adjusted estimate from J.H. Williams, et al (2020)], suggests substantive federal support is in order. As Alaska (and Midwest to Western States) well know, the Rural Electrification Administration and its successor the Rural Utility Service of the Federal Government have been essential in enabling rural America to construct electric, telecommunications and water/sewer infrastructure and transform rural America. Similarly, Eisenhower's Interstate Highway System launched by the Interstate Defense Highway Act of 1956, has been an essential source of support for the development of Alaska as well as the Midwest and Western states. Using the Interstate Highway System funding model, we might anticipate a state federal funding ratio of 1:9 for the roughly 25% public co-investment estimated to bring the total cost of energy in Alaska to be comparable to the long run projections for fossil fuels [Williams (2020) Reference Case, EIA AEO 2021 Outlook, Jacobson (2021), McKinley (2022)] adjusted to reflect Alaska price outlook compared to CONUS, e.g., Cook Inlet natural gas prices have been high and trending upward compared to CONUS and rural Alaska diesel and gasoline prices remain high. Starting with an estimated total capital investment of $128 billion [roughly 4X TAPS in 2020$], 25% public funding = $32 billion of which the State of Alaska:Federal match of 1:9 would yield a State of Alaska co-investment of $3.2 billion.

8 See for example the collaboration between CDP and CALPERS to ensure that CALPERS investments were assessing their environmental footprints and associated risks.

9 For a comprehensive guide to utility IRPs, see the Renewable Assistance Project / Institute for Market Transformation, "Participating in Power: How to Read and Respond to Integrated Resource Plans", Duncan, et al, October 13, 2021. In addition, a panel of practitioners in the field provided an instructive update of recommendations for processes that consider all available resources, align the plan process with policy objectives and sort options to emphasize "least-regrets" outcomes in "Building a Next-Generation Mix of Energy Resources: Practical Perspectives", Baak, et al, December 2, 2021, available at: https://www.raponline.org/event/building-a-next-generation-mix-of-energy-resources-practical-perspectives/ .

The integrated resource plans should not only include consideration of future fossil fuel price escalation, but also include explicit consideration for fossil fuel *price volatility* and its attendant stress on household budgets compared for example to the long term stability in the price of renewable energy resources exemplified by residential electric rates in Public Utilities District No. 1 of Douglas County, Washington where the EIA 2020 Utility Bundles Sales to Ultimate Consumers - Residential indicates an average price of 3.08 cents per kWh, a slow steady increase in nominal rates of 2.3% per year since 1994 (EIA earliest data currently available on their web site, page 74 EIA/Electric Sales and Revenue, 1994), within 18 basis points of the consumer price index-urban for the U.S. over the same time period *without any substantive volatility.* In stark contrast, the price of diesel / home heating fuel rapidly rose from 2000-2008 and bounced around, dropped from 2013 through 2016, then has been rapidly escalating again in 2021/2022. Meanwhile the prevailing price of natural gas in the Cook Inlet has been steadily trending upward for the past ten years while CONUS prices through 2019 were falling. While CONUS natural gas prices have increased due in part to international LNG market developments, the NYMEX natural gas futures outlook remains downtrending following short term shortage and uncertainties. In contrast, the State's most recent study of Cook Inlet Natural

Gas Availability (2018) indicates there is a substantive risk of continued escalation in Cook Inlet natural gas prices due to increasingly costly local supply options, with rising price risk exacerbated by increasingly limited competition (MAFA Analysis of Cook Inlet Natural Gas Supplier Market Shares over the prior decade).

In addition, the integrated resource plans should include consideration of the social cost of life cycle emissions, including, but not limited to CO_2, CH_4, N_2O, Hg and $PM_{2.5}$.

10 Synthesis of findings from the four reports reviewed by MAFA (see footnote 2), benchmarked to Alaska construction, operating and fuel costs, project development scale and productivity, and extended through the NREL Jobs and Economic Impact (JEDI) models for each respective renewable technology. Independent estimates of storage, transmission and distribution system costs, including both renewable energy resource and demand side resource integrations into a more complex and robust grid were developed from local project cost estimates and local/outside spending patterns and comparable JEDI model multipliers.

11 MAFA synthesis of Williams (2020), Jacobson (2021) and McKinsey (2022) estimates, adjusted to reflect Alaska costs, scale and productivity.

12 Total area of wind farms in TX and OK is estimated to be 599,308 acres based on: [33,133 MW installed capacity + 4,418 MW under construction = 37,551 MW [U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, WINDExchange: Wind Energy in TX, https://windexchange.energy.gov/states/tx] plus total area of wind farms in OK based on: 9,048 MW installed capacity + 1,928 MW = 10,976 MW [U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, WINDExchange: Wind Energy in OK, https://windexchange.energy.gov/states/ok] multiplied by (0.05 km^2 per MW * 247 acres/$km^{2)}$ [Enevoldsen, et al, Data investigation of installed and output power densities of onshore and offshore wind turbines worldwide, Energy For Sustainable Development, 28 Nov 2020, https://web.stanford.edu/group/efmh/jacobson/Articles/I/WindSpacing.pdf]

13 EIA Electric Utility Sales to Ultimate Customers - Residential (EIA-861), 2002, Alaska utility residential rates [oldest excel data set currently available on-line]

14 GAO Federal Electric Power: Views on the Sale of Alaska Power Administration Hydropower Assets (February 1990), GAO / RCED-90-93.

15 The Renewable Energy Fund was established in 2008 and in 2012 was extended 10 years to 2023. Since its inception, 244 grants have been awarded to projects totalling $275 million. https://www.akenergyauthority.org/What-We-Do/Grants-Loans/Renewable-Energy-Fund

16 See the Jacobson Alaska Report [April 2021], *NREL life cycle greenhouse gas emissions from Electricity Generation: Update,* Gavin Health, September 2021, and this report's subsection on **Green Hydrogen-Based Fuels** for additional detail.

17 Anchorage International Airport Statistics, 2019

18 The State of Alaska Department of Labor and Workforce Development "live labor stats" exclude self-employed workers, fishers, domestics and unpaid family workers.

19 The rapid increase in retail electric rates in the Railbelt, including HEA, have been mitigated by the relatively steady and low cost of Bradley Lake and the Battle Creek enhancement. In the most recent HEA cost of power adjustment filing (TA441-32, December 21, 2021) Bradley Lake with Battle Crrek hydropower cost $236,000 a month for an average of 8,108,059 kWh per month (Aug, Sept, Oct) (2.91 c/kWh) while natural gas power cost an average of $2.63 million for 34.5 million kWh (7.63 c/kWh); natural gas power production costs were 2.62 X more expensive than hydro. And the outlook is for hydro to decline while natural gas is expected to continue to increase.

20 Renewable Energy Alaska Project. *Renewable Energy Atlas of Alaska.* Alaska Energy Authority, 15 Apr. 2019. https://alaskarenewableenergy.org/library/renewable-energy-atlas/.

21 Center for Economic Development. *Emerging Sector Series: Renewable Energy, Growth and Obstacles in the Renewable Energy Sector in Alaska.* The University of Alaska, Apr. 2018. https://greenenergy.report/Resources/Whitepapers/a7a03441-ad76-482b-9881-5fbc5c293521_Emerging-Sector-Series-Renewable-Energy.pdf.

22 Doubrawa, Paula, et al. *Offshore Wind Energy Resource Assessment for Alaska.* National Renewable Energy Laboratory, Dec. 2017. https://www.nrel.gov/docs/fy18osti/70553.pdf.

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25 U.S. Department of Energy. 2021. *Energy Employment by State: 2021.* https://www.energy.gov/sites/default/files/2021-07/USEER%202021%20State%20Reports.pdf.

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33 Homer Electric Association, Inc. Board of Director's Regular Board Meeting. January 2021. https://www.homerelectric.com/wp-content/uploads/2021-HEA-Board-Minutes.pdf.

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Photo Acknowledgements

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Pg 34: Joseph Umnak via Openverse. *Moon Setting Anchorage Airport*. https://wordpress.org/openverse/image/1f672a84-cf20-453a-ae7e-08d4f2b194f1/

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Pg 40: Photo provided by Fran Mauer and Solarize Fairbanks

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