Alaska Renewable Energy Fund:

Impact and Evaluation Report

2023

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EXECUTIVE SUMMARY

Introduction

Report Overview

The Alaska Energy Authority (AEA) commissioned BW Research Partnership to conduct research into the economic, community, and environmental impacts of the state's Renewable Energy Fund (REF). Alaska's legislature established the REF and the associated Renewable Energy Grant Recommendation Program in 2008 via Chapter 31 SLA 2008. The bill included a new statute, AS 42.45.045, which outlined the program and assigned AEA responsibility for administering the program. AEA also adopted regulations under 3 AAC 107.600 – 695 for the purpose of implementing the program.[1] In May 2023, with the signing into law of House Bill 62, the REF was renewed in perpetuity.

REF Background

According to the United States Energy Information Administration (EIA), the oil and gas industries are a key part of Alaska's economy, and the state ranks third in the nation in terms of energy consumption per dollar of gross domestic product. Alaska's North Slope contains six of the 100 largest oil fields in the U.S. and one of the 100 largest natural gas fields. In addition, Alaska's recoverable coal reserves rank 13th among the states, and its rivers offer significant hydroelectric power potential. Large sections of the state's coastline have significant wind energy potential, and its volcanic areas offer geothermal energy potential.

Owing to Alaska's climate, economic structure, and population size, Alaska's per-capita total energy consumption is the second highest in the nation. Natural gas fueled 42 percent of Alaska's total electricity net generation in 2022, and hydroelectric power fueled 29 percent. In total, renewable energy accounted for approximately 33 percent of Alaska's total electricity generation in 2022.[2] However, a non-binding goal, set in 2010, aims to increase this percentage to 50 percent by 2025.[3]

Alaska's REF has been crucial in helping the state transition to a clean economy. The fund is designed to produce affordable renewable power to meet Alaskans' energy needs.[4] The REF has been an important tool in catalyzing renewable energy growth in Alaska and will help the state to meet its clean energy goals. In addition, the REF has helped local communities stabilize energy prices by reducing their dependence on diesel fuel for power generation and heating needs.

[1] https://www.akleg.gov/basis/aac.asp#3.107%20article4
[2] https://www.eia.gov/state/analysis.php?sid=AK
[3] http://www.launchalaska.com/blog/2023/1/18/alaskas-renewable-energy-fund-a-critical-catalyst-in-our-energy-transition
[4] https://alaskarenewableenergy.org/ppf/the-renewable-energy-grant-fund/

The REF provides grants for development of renewable projects across the state.[5] So far, the fund has financed over 100 renewable projects, which are primarily wind and hydroelectric, with 60 more currently in development. Since its inception, the REF program has secured over $317 million in state funds, leveraging over $300 million in federal and local funds.

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Project Requirements

Per Alaska's regulatory statutes, to qualify for REF funding, eligible projects must be a new project not in operation in 2008, and must:

- Operate as a hydroelectric facility
- Directly use renewable energy resources
- Generate electricity from fuel cells that use hydrogen from renewable energy sources or natural gas (subject to conditions)
- Generate electricity using renewable energy

Natural gas applications must also benefit communities that have a population of 10,000 or less and do not have economically viable renewable energy resources that can be developed.

[5] https://alaskarenewableenergy.org/ppf/the-renewable-energy-grant-fund/

Project Evaluation Process

In selecting projects for program funding, AEA assigns the greatest weight to "projects that serve any area in which the average cost of energy to each resident of the area exceeds the average cost to the resident of other areas of the state." In addition, significant weight is assigned to the availability of matching funds available to a particular project.[6]

AEA initially assesses applicant eligibility, including formal authorization and ownership, site control, and operation; project eligibility; and application completeness. Subsequently, AEA's team and the Alaska Department of Natural Resources assess technical feasibility, including but not limited to the sustainability of current and future availability of renewable resources, site availability and suitability, technical and environmental risks, and the reasonableness of the proposed energy system; and economic feasibility, including project cost-benefit ratio, financing plans, and other public benefits attributable to the project. The evaluation of economic feasibility and related cost-benefit analyses are performed by third-party, competitively procured economists and reviewed by AEA. Based on these internal and external evaluations, AEA rejects applications that are determined to lack technical and/or economic feasibility, or which are deemed not to provide sufficient public benefit to justify support through the REF.

Eligible projects are then preliminarily ranked by AEA, taking into consideration the following factors: cost of energy, applicant matching funds, project feasibility, project readiness, public benefits, sustainability, local support, regional balance, and compliance.

In the final ranking stage, AEA's team assesses the cost of energy burden associated with each project to determine target funding allocations by region. Funding limits may apply depending on the requested phase of the application and the technology type. AEA solicits advice from the Renewable Energy Fund Advisory Committee (REFAC) relating to recommendations in changes to funding levels, ranking, and/or the total amount of funding and number of projects funded by the REF program. AEA, in conjunction with the REFAC, forwards a final list of prioritized projects to Alaska's legislature for funding consideration and approval.

Once funding is approved, reimbursement is provided to grantees on a cost-reimbursable basis based upon a predetermined schedule outlined in the respective final grant agreements. While AEA may authorize a percentage of grant funds as advance payment, grantees are still obligated to document all expenditures of grant and matching funds, including advance payment, in subsequent requests for reimbursement. AEA also withholds a percentage of the total grant subject to project completion and submission of final documentation required by the program.

Current Program Status

In May 2023, Alaska Governor Michael Dunleavy signed into law House Bill 62 extending the REF in perpetuity. According to Governor Dunleavy, "The Renewable Energy Fund has a successful track record of increasing energy security for Alaskans."[7] The fund had initially been authorized for just five years but was extended in 2012 until June

[6] Information regarding the project evaluation process summarized in this section was obtained from the "Round 15 (FY 2024) Renewable Energy Fund (REF) Status Report" prepared by AEA for the Alaska State Legislature in April 2023 at: https://www.akenergyauthority.org/Portals/0/Renewable%20Energy%20Fund/2023.04.07%20AEA%20REF%20Round%2015%20Status%20Report%20(Final).pdf?ver=mW0S1n0vZfCcCf_g89AluQ%3d%3d.

[7] https://gov.alaska.gov/governor-dunleavy-signs-bill-to-continue-renewable-energy-grant-fund/

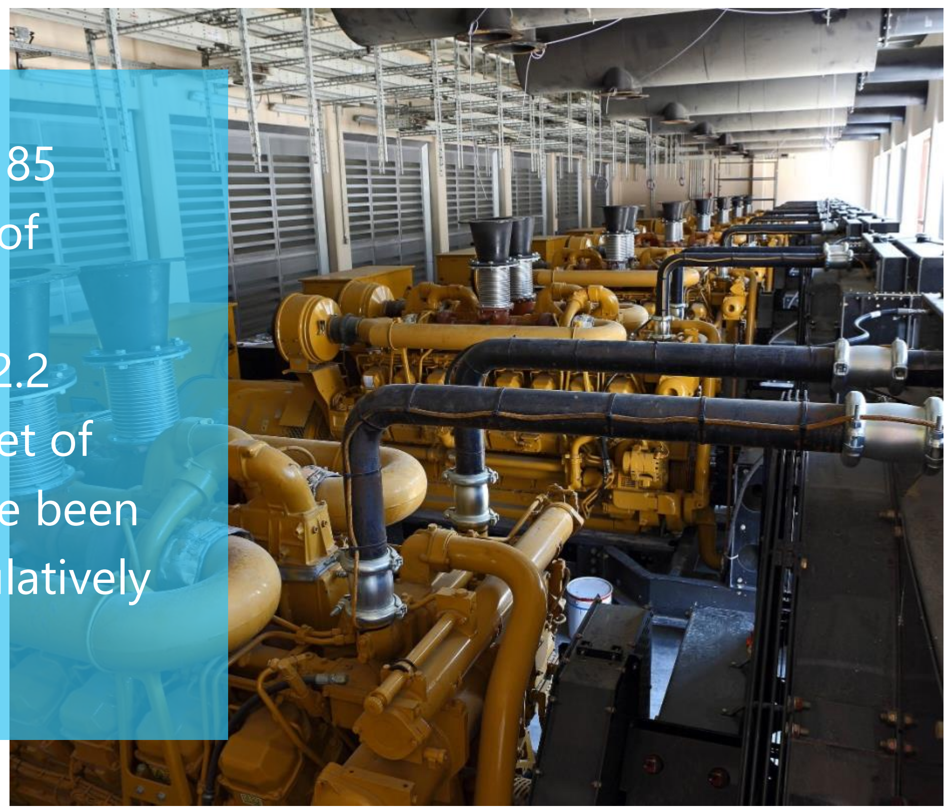
2023.[8] This recent extension has repealed any sunset dates for the program, cementing it as a permanent component of Alaska's energy infrastructure-development toolkit. In June 2023, the Alaska Legislature approved an appropriation of $17 million of general funds to the REF, to fund 18 AEA-recommended REF grant projects for the 2024 fiscal year.[9] This $17 million capitalization for fiscal year 2024 was the largest capital injection into the REF since the prior fiscal year 2023, which had been the largest appropriation since fiscal year 2014.

Key Findings

Impact Models

The REF program has significantly reduced greenhouse gas (GHG) emissions and $PM_{2.5}$ pollutants[10] in Alaska. The evaluation assessed the magnitude of switching from fossil fuels to renewable fuels and calculated the associated GHG emissions and $PM_{2.5}$ pollutant reductions.

> Approximately, 85 million gallons of diesel and approximately 2.2 million cubic feet of natural gas have been displaced cumulatively through 2022.



[8] http://www.launchalaska.com/blog/2023/1/18/alaskas-renewable-energy-fund-a-critical-catalyst-in-our-energy-transition

[9] The Alaska Legislature created the Power Cost Equalization (PCE) Endowment Fund under AS 42.45.070 as a separate fund of the Alaska Energy Authority. The purpose of the PCE Endowment Fund is "to provide for a long-term, stable financing source for power cost equalization which provides affordable levels of electric utility costs in otherwise high-cost service areas of the state." More information about the PCE Endowment Fund is available at: https://treasury.dor.alaska.gov/home/investments/power-cost-equalization-endowment-fund#:~:text=The%20Alaska%20Legislature%20created%20the,of%20the%20State%20of%20Alaska.

[10] PM is defined as particulate matter and can come in many sizes and shapes. PM can be made up of hundreds of different chemicals. PM contains microscopic solid or liquid droplets that are so small that they can be inhaled and cause serious health problems. Of these, $PM_{2.5}$, or fine inhalable particles with diameters that are generally 2.5 micrometers and smaller, pose the greatest risk to human health. For more information, see https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

Approximately 85 million gallons of diesel and approximately 2.2 million cubic feet of natural gas have been displaced cumulatively through 2022.
This amount of diesel fuel is equivalent to roughly five percent of all petroleum consumed in Alaska in 2021.[11] Hydro projects account for the largest share of diesel displaced of all technology types, as well as the largest share of natural gas displaced through the program. (Figure 1 through Figure 4)

Approximately 1,110,424 gross metric tons of CO_2 and approximately 1,063,548 net metric tons of CO_2 were mitigated cumulatively through 2022.
This is equivalent to three percent of Alaska's total energy-related CO_2 emissions in 2016.[12] Diesel accounted for all CO_2 mitigated for off-grid projects. For on-grid projects, natural gas accounted for the majority of CO_2 mitigated, followed by diesel. (Figure 5) The associated net avoided social cost of carbon (SCC) is estimated at $54 million.[13] (Figure 6)

The avoided cost of $PM_{2.5}$ pollutant reduction through 2022 is estimated to range from $29 million to $43 million.
These avoided costs include additional costs associated with healthcare, declines in productivity due to illness, and other factors.

Cumulative gross energy cost savings from 2008 through 2022 reached $357 million, while cumulative net energy cost savings reached $53 million.
These figures demonstrate the REF program has generated significant energy savings over the course of the program, even after accounting for the costs of additional electrical infrastructure and other renewable energy infrastructure. (Figure 7)

[11] https://www.eia.gov/state/data.php?sid=AK
[12] "Energy-Related Carbon Dioxide Emissions by State, 2005-2016". U.S. Energy Information Administration. https://www.eia.gov/environment/emissions/state/analysis/
[13] The social cost of carbon (SCC) is an estimate of the cost, in dollars, of the damage done by each additional ton of carbon emissions. It is also an estimate of the benefit of any action taken to reduce a ton of carbon emissions. Estimates of the SCC vary. The Biden administration currently values the SCC at $51 per ton globally, but in November 2022, the U.S. Environmental Protection Agency proposed a nearly fourfold increase, to $190. For more information, see: https://www.brookings.edu/2023/03/14/what-is-the-social-cost-of-carbon/

The REF program has made a significant contribution to Alaska's economy.

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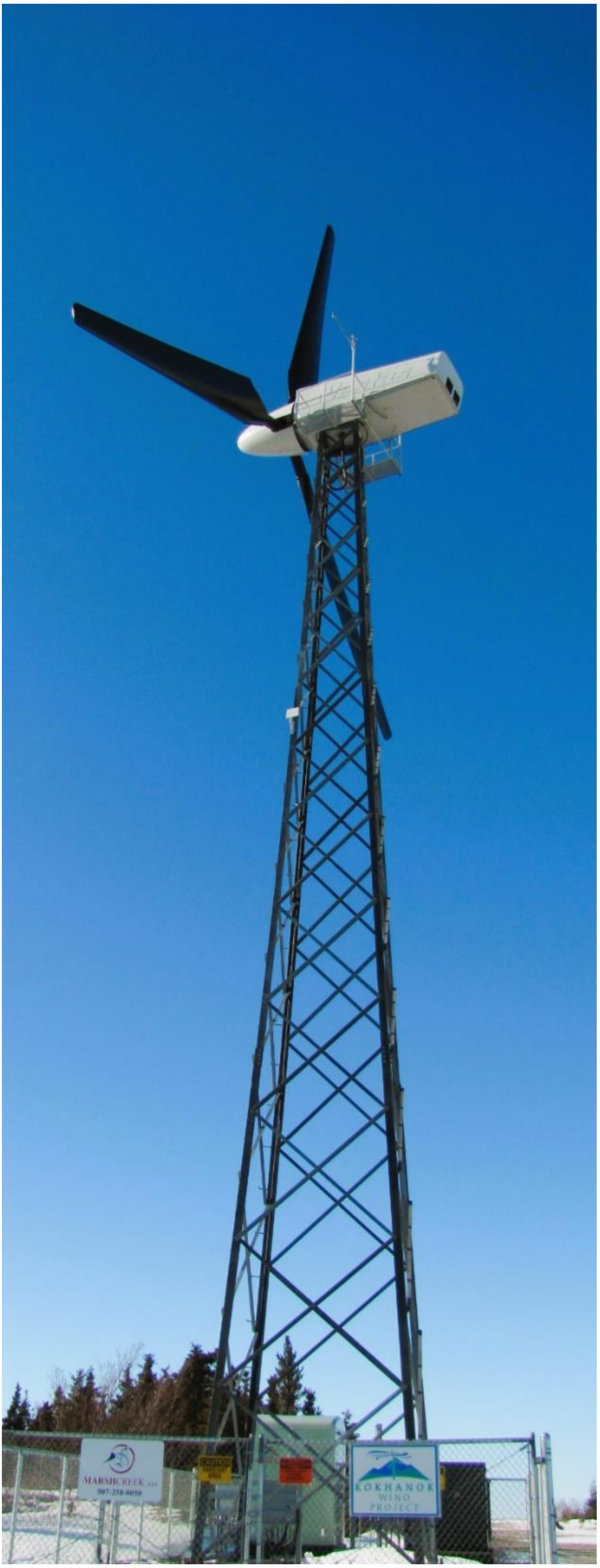
Through 2022, the REF program spent roughly $245 million in funds directly, which helped catalyze $558 million in project portfolio development. The cumulative wide range of benefits — including the SCC, the avoided costs of energy, and the value added through additional economic activity — amounted to nearly $507 million in total net benefits.[14] This suggests that this program is tremendously successful in providing a return on investment to Alaska residents.

The REF program has created 2,931 new jobs, $237 million in labor income, and $399 million in value added.

The largest share of new jobs created were in the Construction sector (1,540), followed by Professional & Business Services (211), Utilities (201), Healthcare (175), Retail Trade (172), and Manufacturing (151). (Table 1 and Figure 8)

[14] This net benefit calculation incorporates the additional costs of renewable energy infrastructure and other input capital, but it does not include the potential benefits of a counterfactual scenario or alternative use of REF funds.



Grant Funding Profile

The REF is a catalyst for project development.
Most grant funding has been used for project development: 60 percent of funded grants were primarily used to support the creation of a new project, 24 percent was used to assess feasibility of a project that was ultimately never built, and 11 percent was used to renovate or retrofit an existing facility or infrastructure. (Figure 15) These findings highlight the vital role that REF funding played in the development of these projects.

Grantees indicated that the most common primary goal for grants received was to reduce fossil fuel use. The second most-common goal was to provide reliable sources of energy for communities in need.
Approximately 90 percent of grants were primarily used for fuel displacement purposes, with approximately 94 percent of grants reportedly having achieved this goal. In addition to fossil fuel reduction, other goals or objectives of REF grant funding cited by grantees were: to provide reliable sources of energy for communities in need (27 percent), to reduce GHG emissions in Alaska (16 percent), to provide economic and employment opportunities for communities in need (15 percent), and to determine if a project or investment would be feasible (13 percent). (Figure 16)

Wind energy projects topped the list of grants received.
Wind energy projects accounted for 47 percent of projects funded for surveyed grant recipients. Biomass, landfill, and wood processing projects; hydropower projects; and heat recovery system projects each accounted for at least 10 percent of the grants received. Solar energy projects, heat pump projects, and other geothermal projects each accounted for less than five percent of the grants received (Figure 14).

Grantee Experience & Perceptions

The REF has made a valuable contribution to the economy of many communities.

Approximately 95 percent of grantees surveyed felt that the grants they received supported small and rural communities in need. Approximately 72 percent also felt that the REF grants supported economic and employment opportunities in underserved communities. (Figure 18)

The REF has generated significant environmental benefits.

Approximately 77 percent of grantees surveyed felt that REF grants supported the growth of valuable clean technologies in Alaska, 76 percent believed that REF grants reduced the amount of GHG emissions, and 71 percent believed that REF grants reduced local pollution. (Figure 18)

Proper funding is critical to success.

When asked about key lessons learned from working with the REF program, the most common response (24 percent) was that securing adequate funding is critical to project success. Other lessons learned include lack of feasibility of a proposed project, the critical role of the community and local workforce to project success, and the viability of renewable energy as a means to bringing more affordable energy to Alaskans.

There are some challenges to the grant application process.

Approximately 38 percent of respondents cited the length of the application and award process as a challenge, 33 percent cited difficulty in obtaining technical support, 33 percent cited information requirements, and 29 percent cited the complexity of the application process as challenges. Only 10 percent of respondents reported that they experienced no challenges in applying for REF funding. (Figure 20)

While the selection process for funding has become more competitive in recent years, the process is considered fairly transparent and often easier to access than other grants.

Some program recipients worked on obtaining grants from the state of Alaska prior to the REF's inception and remember it as a less onerous process. However, others applaud the transparency of the program regarding the type of projects they are looking to invest in and the REF program's responsiveness to inquiries.

The REF program is critical to displacing diesel generation in rural communities of Alaska.

Several program recipients noted that there were not as many grant opportunities targeted at creating renewable alternatives to diesel before the REF. This means more rural communities are seeing lower energy prices and greater access to energy due to REF investments.

REF funds are catalytic and attract other investors to projects in rural Alaska.

Numerous grant recipients noted that securing REF funds was crucial in signaling credibility to other investors and bridging gaps in funding that otherwise may have stalled a project or forced it to be abandoned. AEA has also allowed for cost-sharing with other grants, which gives utilities and cooperatives more opportunities to develop rural energy infrastructure. Approximately 52 percent of grantees surveyed indicated that REF grants allowed them to obtain additional funding from federal sources. (Figure 18)

Some rural communities incur significant costs when applying for grants, including costs associated with hiring consultants and grant writers to compete successfully against larger utilities with experience obtaining grants from AEA.

While experienced program recipients indicated that the grant application process was relatively easy, other recipients emphasized that some small cooperatives are understaffed and do not have the necessary experience applying for grants, which can lead to difficulties competing for REF funding.

Conclusions

Based on the results of the analyses, the REF program has played a key role in supporting the development of Alaska's renewable energy sector. The evaluation concluded that the REF program led to the displacement of approximately 85 million gallons of diesel and approximately 2.2 million cubic feet of natural gas through 2022. The program has also led to the avoidance of approximately 1.1 metric tons of GHG emissions between 2008 and 2022. GHG emissions and $PM_{2.5}$ pollutants are associated with numerous negative human health and social impacts. Reducing $PM_{2.5}$ pollutants and GHG emissions results in healthier communities and lower public health costs.

Based on an investment of approximately $245 million[15] in grant funding, the REF program has resulted in the following avoided costs/monetary benefits through 2022:

Over $357 million in cumulative gross energy cost savings, and over $53 million in cumulative net energy cost savings due to fuel switching

Approximately $54 million in net avoided Social Cost of Carbon (SCC)

Up to $43 million in avoided costs associated with $PM_{2.5}$ pollutant reduction

Approximately $237 million in labor income and $399 million in value added from 2,931 new jobs created, and the associated boost in spending for local communities generated from those new jobs

The REF program has also helped local communities stabilize energy prices by reducing their dependence on diesel fuel for power generation and space heating, and has supported AEA's drive to diversify Alaska's energy portfolio increasing resiliency, reliability, and redundancy through the sustainable deployment of viable renewable energy sources.

Stakeholder interviews indicated that program participants believed that REF grants were successful in reducing fossil fuel use and in attracting other investors to projects in rural Alaska, where communities face limited access to private capital due to the small scale renewable energy projects and the perceived risks associated with private lending. According to stakeholders, the ability to leverage REF funding has effectively lowered barriers to project financing for grant recipients, allowing them to invest in new renewable energy projects that might not have otherwise been feasible to pursue.

[15] According to the project database, $273 million has been budgeted toward the REF, but only $245 million has been spent to date as of July 2023.

OBJECTIVES AND METHODOLOGY

Research Objectives

The primary research objectives of this study included:

1. To quantify the overall impact of the REF on local communities in Alaska, including job growth, GHG emissions and $PM_{2.5}$ pollutant reductions, fuel displacement, and cost savings.
2. To profile the types of projects and investments primarily funded by the REF by technology type, investment use, primary goals, and benefits.
3. To understand grantee experiences and perceptions with the REF program, including overall experience with the application process, major benefits, suggestions for improvement, and lessons learned.
4. To offer potential recommendations or opportunities for improvement for the future of the REF program.

Documenting the retrospective benefits of the REF program using credible and transparent methods is crucial to demonstrating to taxpayers that REF funds were effectively spent in promoting energy savings, reducing emissions, and fostering local economic development within Alaskan local communities.

Beyond documenting savings and attribution, however, measurement and verification of the economic benefits generated by the REF program fosters more effective use of program resources and justifies an increased level of investment in Alaska's renewable energy programs in the long run.

Research Methodology

In order to assess the direct and indirect benefits generated by the REF program through 2022, BW Research conducted a targeted review of project-specific financial, economic, and performance data compiled by AEA, which included information on grant amounts received, project start dates, installed capacities, and goals for projects

funded by the REF.[16] BW Research also synthesized available data in order to populate missing values in the operational project dataset, classifying operational projects by technology type[17] and location status (on-grid vs. off-grid)[18].

For heat recovery projects lacking data on diesel gallons displaced (DGD), BW Research applied EIA conversion rates to goal net heat recovery rates to calculate DGD. For other types of projects for which DGD data was unavailable, BW Research calculated average DGD values by technology type based on available data and applied those values as a proxy for missing data. BW Research then applied data obtained from the U.S. Environmental Protection Agency (EPA) to calculate GHG emissions reductions and $PM_{2.5}$ pollutant reductions due to REF funding.

To calculate gross avoided energy costs, BW Research obtained historical data on Alaskan energy prices for 2008 to 2020 ($/MMBtu) from EIA and applied these prices to the volumes of diesel and natural gas displaced.[19] Net avoided energy costs were calculated after deducting annual biomass and on-grid electricity costs, as well as project costs.[20]

Then, BW Research conducted an economic benefits analysis to quantify:

Direct, indirect, and induced impacts for employment, Gross Regional Product (GRP or Value Added), and labor earnings (Employee Compensation) by sector

Employment by industry or industry group for each sector

[16] However, it should be noted that the impacts evaluation relied heavily upon data provided by the AEA. The BW Research team has not audited this data and can make no assurances regarding the reliability or the accuracy of the underlying data.
[17] BW Research extrapolated project types based on an analysis of project descriptions. Classification by project type allowed greater precision in calculating economic impacts of the REF, as different multipliers were applied to each of the technology types funded by the REF to quantify the levels of jobs created, and value added generated as the result of the funding of each type of project by the REF.
[18] BW Research obtained coordinates for each operational project for which location data was available, and mapped each project against Alaska's grid, to determine whether projects were located on- or off-grid. The determination of location status (on-grid vs. off-grid) allowed the BW Research team to more precisely calculate GHG emissions avoided due to the REF, as on-grid projects were assumed to emit different levels of GHG as compared to off-grid projects.
[19] Gross energy savings are defined as changes in energy consumption that are directly attributable to measures installed due to funding received from the REF program, regardless of why grantees participated in the REF program.
[20] The primary difference between gross and net energy savings represents free riders (participants who would have implemented the same or similar renewable energy projects absent REF program funding) and spillover effects (savings that result from actions taken due to the REF program, but which were not directly subsidized by the program).

BW Research created custom multipliers in IMPLAN, an input-output economic modeling software, leveraging existing BW Research models, National Renewable Energy Laboratory (NREL) technical data, and NREL's Jobs and Economic Development Impact (JEDI) models, to calculate the economic impact of grants awarded through the REF. Economic benefits were calculated using REF project information for select projects from Round 1 to 14, based on AEA's data and assumptions regarding project funding amount and type, project life, project benefit/cost ratios, fuel prices, utility rates, and future loads, for all scenarios.

BW Research then conducted a basic cost-benefit analysis for the REF, wherein the economic impacts per million dollars invested in funding the REF were calculated. As mentioned previously, a more complete methodology is outlined in Appendix A on page 36. Key inputs for the impacts analysis are presented in Appendix B on page 41.

Finally, BW Research conducted surveys with current and past grant recipients, as well as executive interviews with utility companies, energy cooperatives, and energy program managers that had knowledge of or had taken part in the REF program, in order to understand grantee experiences and perceptions with the REF program, including overall experience with the application process, major benefits, suggestions for improvement, and lessons learned.[21]

Report Structure

The preceding section provided an executive summary of the report, including a high-level overview of the findings of the REF program evaluation. The remainder of the report is organized as described below.

The **Objectives and Methodology** section provides a high-level overview of the research objectives and methodology applied in this report.

The **Impact Models** section summarizes the results of the impact analyses performed to quantify the overall impact of the REF on local communities in Alaska, including job growth, GHG emissions reductions, fuel displacement and cost savings.

The **Grantee Outreach** section summarizes survey results and anecdotal feedback obtained from grantees, including experience with and perceptions of the grant application process, primary benefits of the grant funding, and challenges or opportunities moving forward.

The **Conclusion and Recommendations** section summarizes the key results of the analyses and recommendations based on the results of the evaluation.

Appendix A provides a more detailed description of the methodology underlying the impact analyses, while Appendix B summarizes key inputs and assumptions used in the impact analyses.

[21] While 29 grant recipients participated in the survey, grant funding information was only available from 21 of those respondents, which provided information for 62 individual grants in aggregate.

IMPACT MODELS

This section describes the impact analyses conducted for the REF program to quantify the overall impact of the REF on local communities in Alaska, including job growth, GHG emissions reductions, and fuel displacement and cost savings. The analyses were based on data provided by AEA for projects funded by the REF program.

The project database included the following information:

- Grantee name
- Project name
- Grant amount ($)
- Project stage (Construction, Feasibility, or Final Design)
- Operation start date
- Diesel gallons displaced
- Installed capacity (MW)
- Goal net heat delivery (MMBtu/yr.)
- Goal electric generation (MWh/yr.)

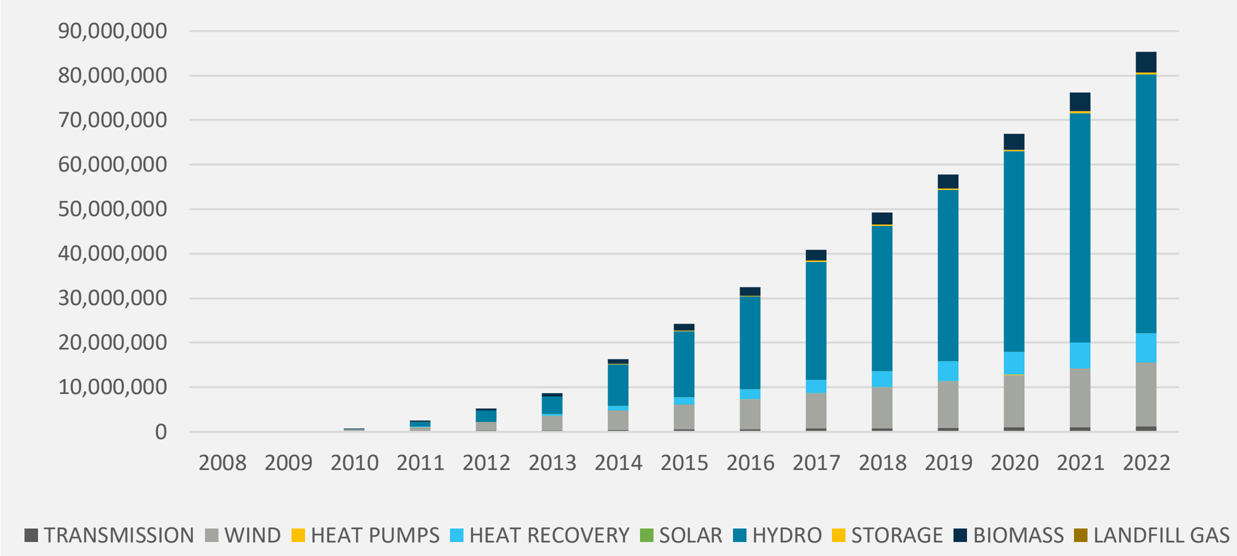
However, complete data was not available for all projects. Where data was unavailable, BW Research applied assumptions to populate the missing data, as described in the following sections.

Fuel Displacement Analysis

The purpose of the fuel displacement analysis was to identify any fuel switching or elimination resulting from projects funded by the REF program, and to calculate the cost savings or increases associated with such switching/displacement. Fuel displacement is a crucial element in Alaska's transition toward a clean economy, as reducing reliance on expensive diesel-fueled electricity in favor of more cost-effective renewable generation enhances both self-sufficiency and sustainability in Alaska's local communities.

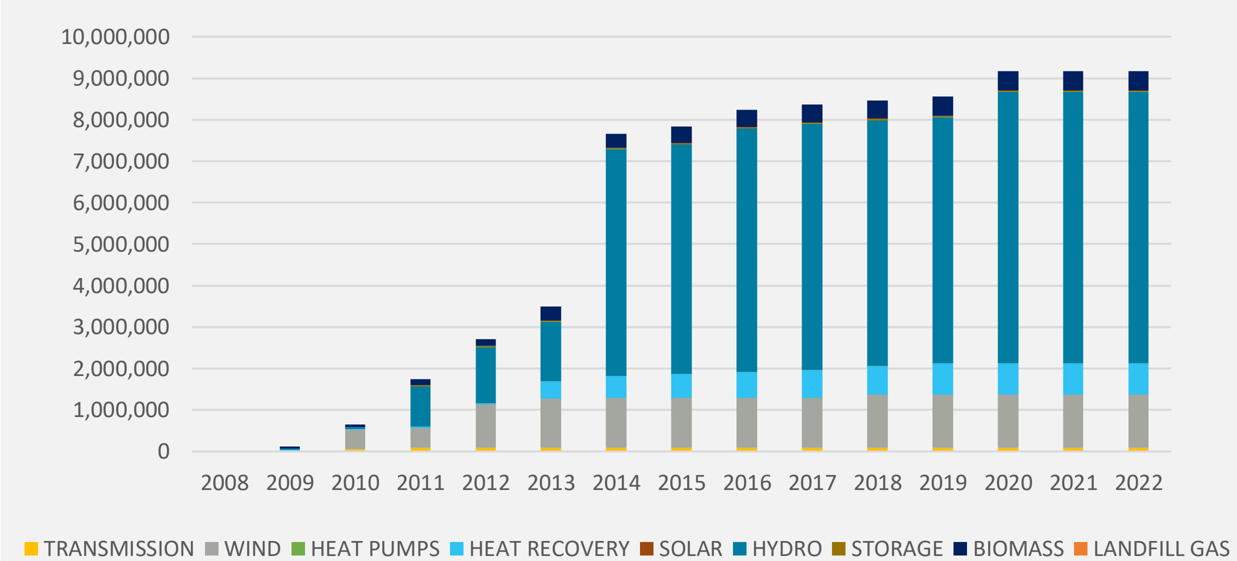
Figure 1 through Figure 4 summarize the results of the fuel displacement analyses by technology type. As shown in Figure 1, approximately 85 million gallons of diesel have been displaced cumulatively by REF-funded projects through 2022. Diesel displacement ramped up robustly between 2013 and 2014 and remained elevated through 2022.

Figure 1. Cumulative Diesel Gallons Displaced by Technology Type, 2008-2022



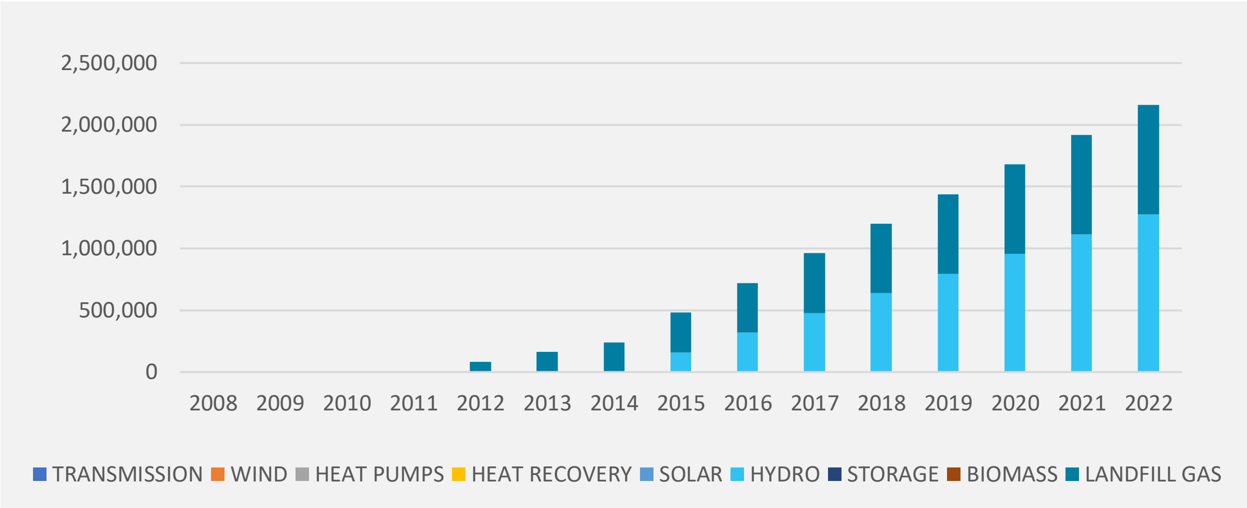
As shown in Figure 2, hydro projects account for the largest share of annual diesel gallons displaced, with an approximate 70 percent share from 2014 through 2022. Wind projects, heat recovery projects, and biomass projects accounted for the next highest shares of annual diesel gallons displaced through 2022. As of the end of 2022, approximately 9.2 million gallons of diesel were displaced annually by all projects funded by the REF program.

Figure 2. Annual Diesel Gallons Displaced by Technology Type, 2008-2022



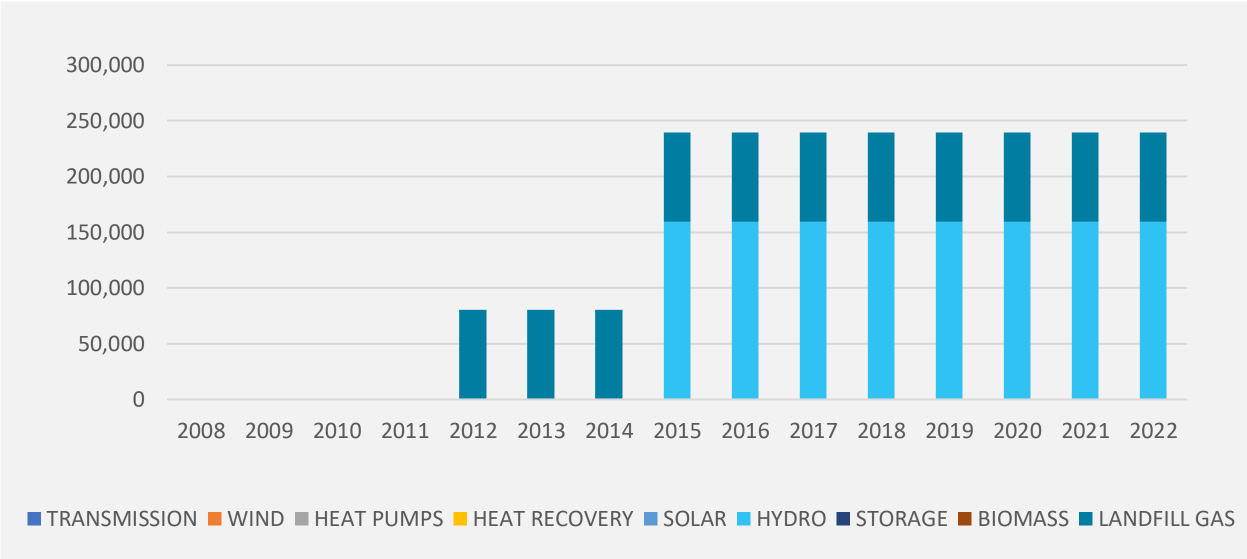
As shown in Figure 3, approximately 2.2 million cubic feet of natural gas has been displaced cumulatively by REF-funded projects through 2022.

Figure 3. Millions of Cubic Feet of Natural Gas Cumulatively Displaced by Technology Type, 2008-2022



As shown in Figure 4, from 2012 to 2014, one landfill gas project was solely responsible for all-natural gas displaced. Subsequently, from 2015 through 2022, hydro projects accounted for approximately two-thirds of natural gas displaced on an annual basis, with a single landfill gas project accounting for the remaining third.[22]

Figure 4. Millions of Cubic Feet of Natural Gas Displaced Annually by Technology Type, 2008-2022



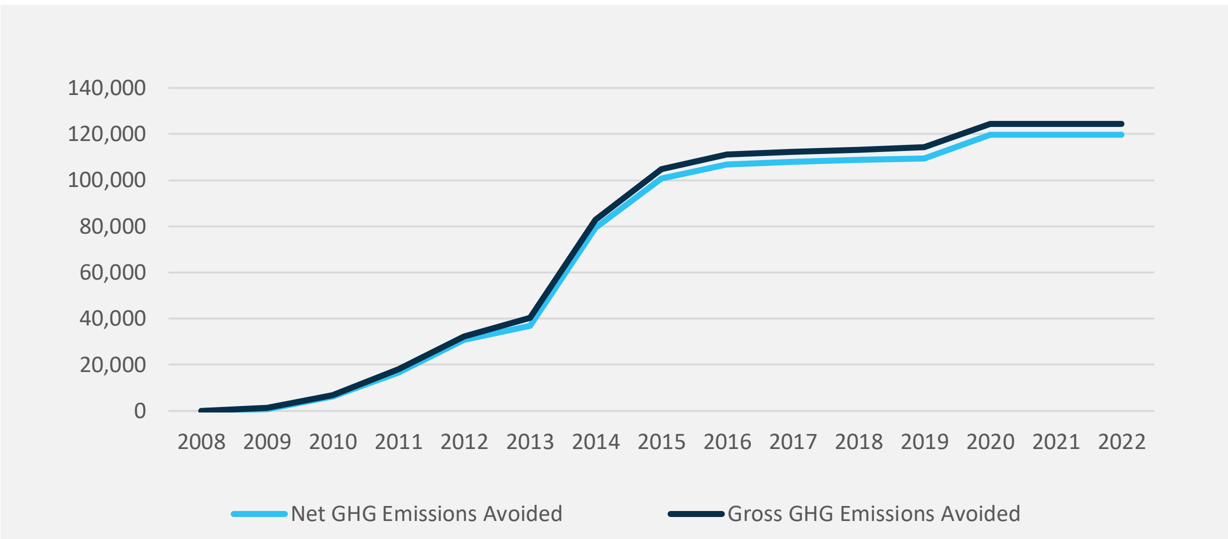
[22] Only a few projects were identified as having displaced natural gas, and the first project that did so became operational in 2012.

Environmental Benefits Analysis

The purpose of the environmental benefits analysis was to calculate GHG emissions reductions resulting from fuel switching/displacement for projects funded by the REF. GHG emissions have been implicated in long-term damage to agricultural productivity, human health, and other factors, so reduction of GHG emissions represents a significant benefit of the REF program.

Figure 5 illustrates gross and net GHG emissions avoided from 2008 through 2022. As shown, avoided GHG emissions increased gradually from 2008 to 2013, and rose sharply in 2013 and 2014. Avoided GHG emissions remained relatively stable between 2015 and 2019, increasing slightly in 2019 before plateauing in 2020 and remaining stable through 2022. Approximately 1,110,424 gross metric tons of CO_2 were mitigated cumulatively through 2022, and approximately 1,063,548 net metric tons of CO_2 were mitigated cumulatively through 2022.

Figure 5. Metric Tons of Gross and Net GHG Emissions Avoided, 2008-2022

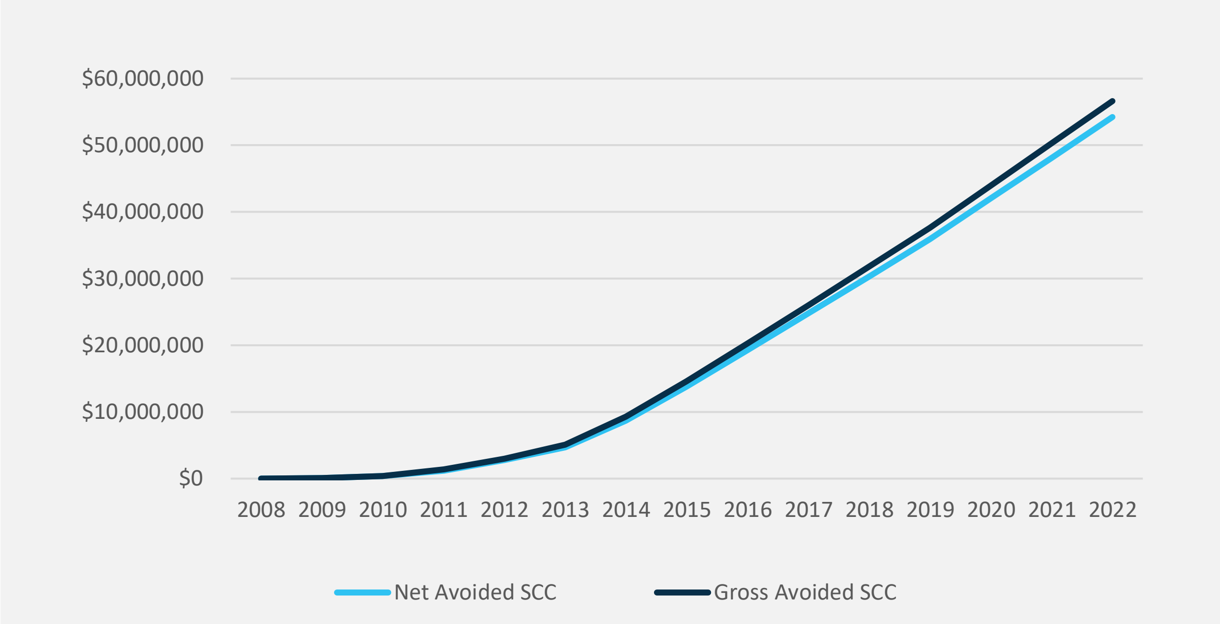


Diesel accounted for all CO_2 mitigated in off-grid projects. For on-grid projects, natural gas accounted for the majority of CO_2 mitigated, followed by diesel.

Avoided Social Costs

Figure 6 illustrates cumulative gross and net avoided SCC for projects funded by the REF. As shown, the cumulative net avoided SCC was calculated at $54 million, while the cumulative gross SCC was calculated at $57 million.

Figure 6. Cumulative Gross and Net Avoided Social Cost of Carbon ($), 2008-2022



Cost Savings Analysis

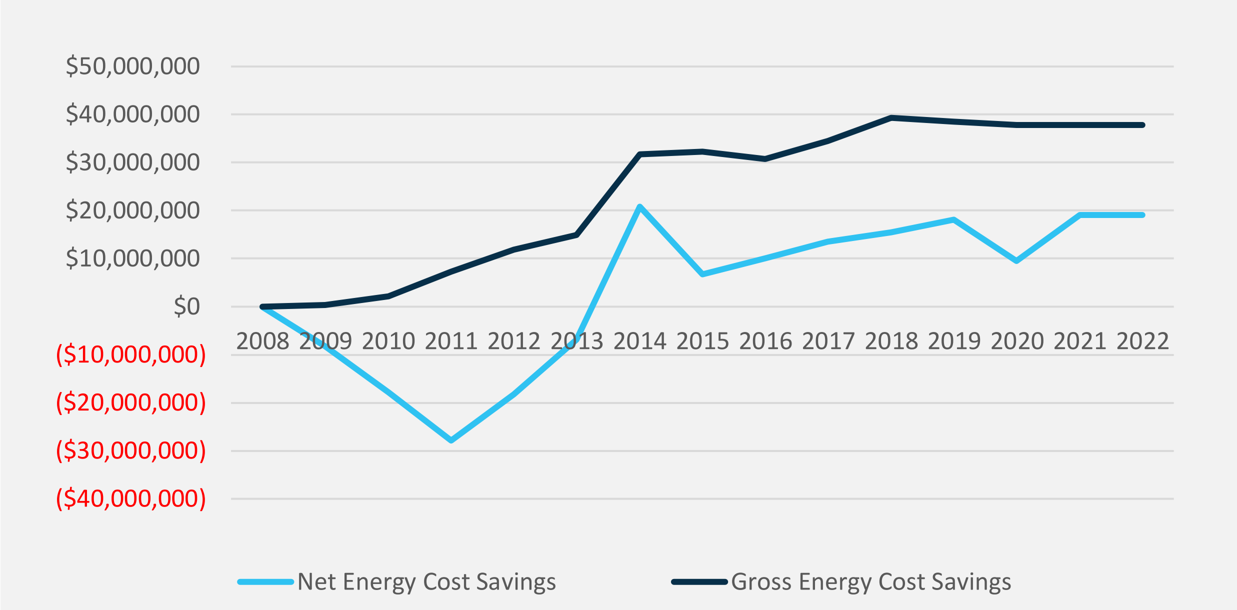
Subsequently, BW Research sought to quantify gross and net avoided energy costs for projects funded by the REF program. BW Research applied deemed savings calculations, applying engineering algorithms to calculate energy savings based on stipulated assumptions for various parameters.

Figure 7 illustrates gross and net energy cost savings from REF-funded projects over the period from 2008 to 2022. Net avoided energy costs are calculated by deducting annual biomass costs, on-grid electricity costs, and project costs from gross energy costs.[23] Netting out project costs results in negative net avoided energy costs in the early stages of a project, but as energy savings accrue over time, annual avoided energy costs turn positive.

As shown, as of 2022, total cumulative gross energy cost savings from REF-funded projects reached $357 million, while total cumulative net energy cost savings reached $53 million.

[23] Annual biomass and on-grid electricity costs are calculated by converting annual diesel and natural gas displaced to MMBtu of biomass and electricity consumption. On-grid electric generation projects result in 0 net cost savings, while off-grid electricity costs for hydro, solar, and wind are limited to project costs.

Figure 7. Gross and Net Energy Cost Savings ($), 2008-2022



Economic Benefits Analysis

The economic benefits analysis quantified the incremental economic activity generated by each grant, including capital expenditures, operational expenditures, cost savings, and other impacts. In the economic benefits analysis, BW Research calculated:

- Direct, indirect, and induced impacts for employment, Gross Regional Product (GRP or Value Added), and labor earnings (Employee Compensation) by sector
- Employment by industry or industry group for each sector

Economic benefits were calculated using REF project information for select projects from Round 1 to 14, based on AEA's data and assumptions regarding project funding amount and type, project life, project benefit/cost ratios, fuel prices, utility rates, and future loads, for all scenarios.

Table 1 and Figure 8 present the employment effects of the REF program by industry. As shown, a total of 2,931 jobs were created due to the REF program, including 1,672 jobs created through direct effects, 555 jobs through indirect effects, and 704 jobs through induced effects. Approximately 57 percent of jobs created were due to direct effects; 19 percent were created due to indirect effects, and 24 percent were created due to induced effects.

Table 1. Job Creation by Industry

Industry	Direct	Indirect	Induced	Total
Agriculture	28	8	2	**38**
Manufacturing	9	114	29	**151**
Mining & Extraction	0	6	0	**6**
Utilities	135	63	3	**201**
Wholesale Trade	0	21	10	**31**
Retail Trade	0	66	107	**172**
Transport	0	27	16	**43**
Distribution	0	5	5	**10**
Information	0	5	7	**12**
FIRE	0	40	60	**99**
Professional and Business Services	66	103	41	**211**
Education	0	0	14	**14**
Healthcare	0	0	175	**175**
Entertainment	0	3	27	**29**
Construction	1,432	51	57	**1,540**
Hospitality	0	9	73	**82**
Other	2	28	75	**105**
Government	0	8	2	**10**
All Industries	**1,672**	**555**	**704**	**2,931**

Furthermore, as shown in Figure 8, the Construction industry accounted for the largest share of new jobs, as 53 percent of all jobs created were in the Construction industry. The Utilities and Professional and Business Services industries generated the second-highest levels of job growth, with each accounting for seven percent of new jobs created; followed by the Healthcare and Retail Trade industries, which each accounted for six percent of new jobs created.

Figure 8. Job Creation by Industry

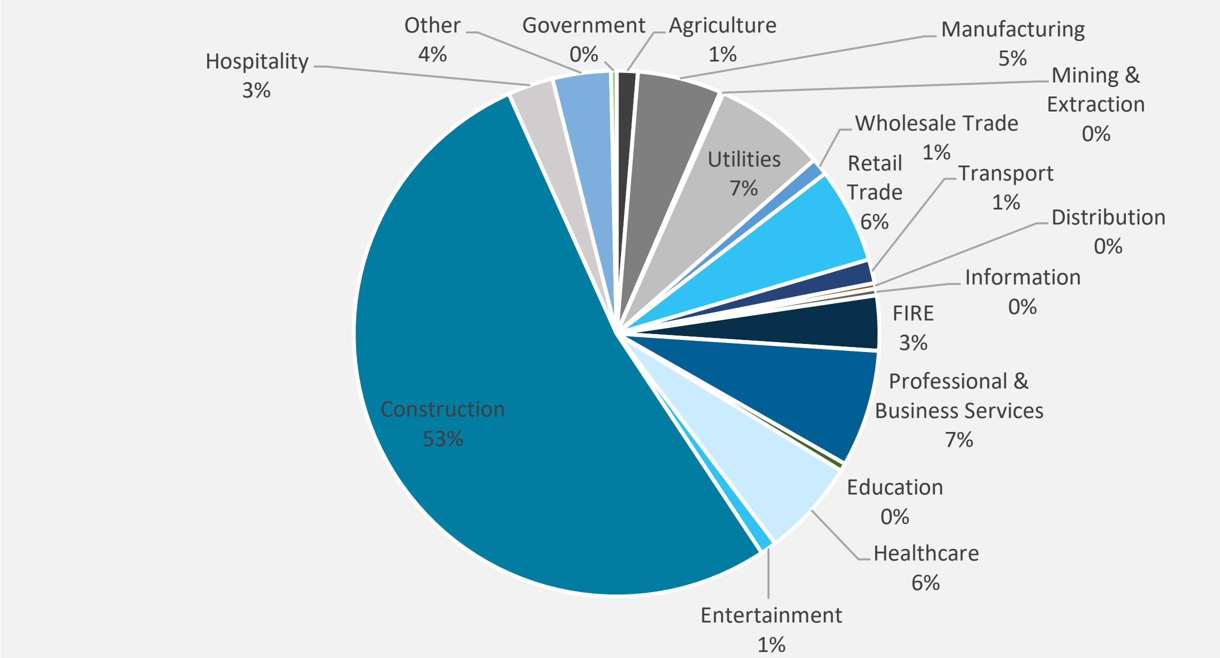


Table 2 summarizes the total economic impacts generated by the REF program. As shown, the program was responsible for generating 2,931 new jobs, $237 million in labor income, and $399 million in value added.

Table 2. Total Economic Impacts of the REF Program

	Employment	Labor Income	Value Added
Direct	1,672	$154,422,454	$251,188,991
Indirect	555	$41,110,106	$74,980,043
Induced	704	$41,152,349	$73,142,672
Total	**2,931**	**$236,684,909**	**$399,311,706**

Cost-Benefit Analysis

A cost-benefit analysis evaluates projects based on the direct cost (grant amount) and the savings and avoided costs for the project, and typically serves as the baseline assessment of the value of a particular project. The direct cost-benefit analysis provides crucial information on whether an investment ultimately saves more money than it costs in the long run and is thus often the first and primary metric developed to measure a project's success.

As shown below, BW Research calculated the economic impacts per million dollars invested, and per million dollars invested by the REF program. As shown, 12 jobs were created per million dollars invested by the REF program. In addition, 4,345 metric tons of net GHG emissions were avoided and $217,375 in net energy costs were avoided per million dollars invested in the REF program.

Table 3. Economic Impacts per $Million Invested by the REF Program

	Jobs Created
Direct	6.8
Indirect	2.3
Induced	2.9
Total	**12.0**

Table 4. Avoided GHG Emissions (Metric Tons CO_2) per $Million Invested by the REF Program

	Avoided GHG Emissions
Net	4,345
Gross	4,536

Table 5. Net and Gross Avoided Energy Costs ($) per $Million Invested by the REF Program

	Avoided Energy Costs
Net	$217,375
Gross	$1,458,725

GRANTEE OUTREACH

As part of the evaluation efforts for the REF program, the research team conducted outreach with current and past grant recipients. The following sections provide quantitative survey results and anecdotal feedback from grantees, including experience with and perceptions of the grant application process, primary benefits of grant funding, and challenges or opportunities moving forward.

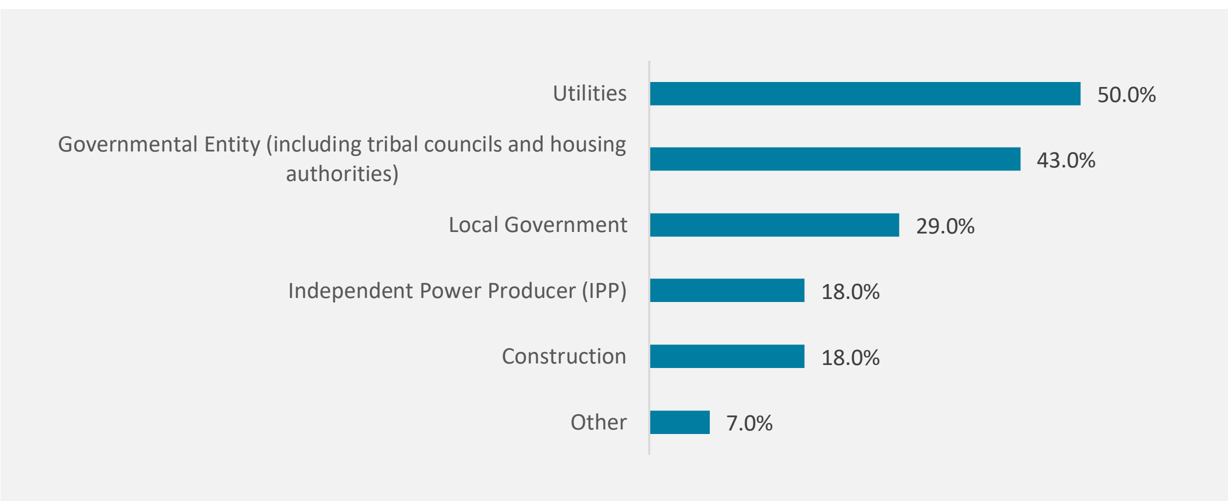
Survey Results

Grant Recipient Profile

Approximately 96 percent of survey respondents indicated that their business has been in operation in Alaska for 20 years or more, while the remaining four percent indicated that they have been operating in the state for 10 to 19 years. None of the surveyed organizations have been conducting business in Alaska for fewer than 10 years.

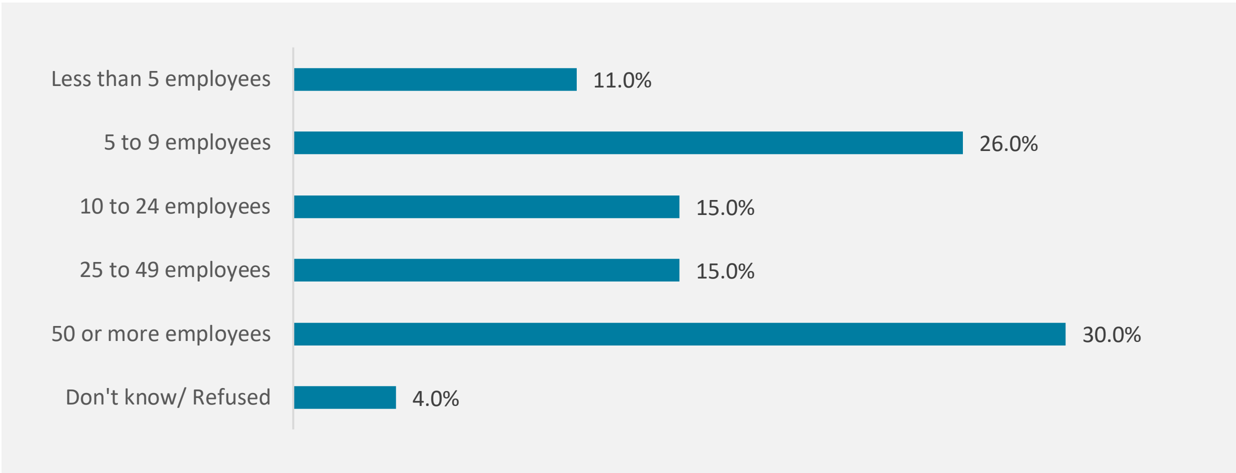
As shown in Figure 9, 50 percent of survey respondents indicated that they primarily work in the utilities sector, followed by a governmental entity, which includes tribal councils and housing authorities (43 percent), and local government (29 percent). Approximately 18 percent of respondents indicated that they are either an Independent Power Producer (IPP), and 18 percent indicated that they worked at a construction firm.

Figure 9. Industry Focus



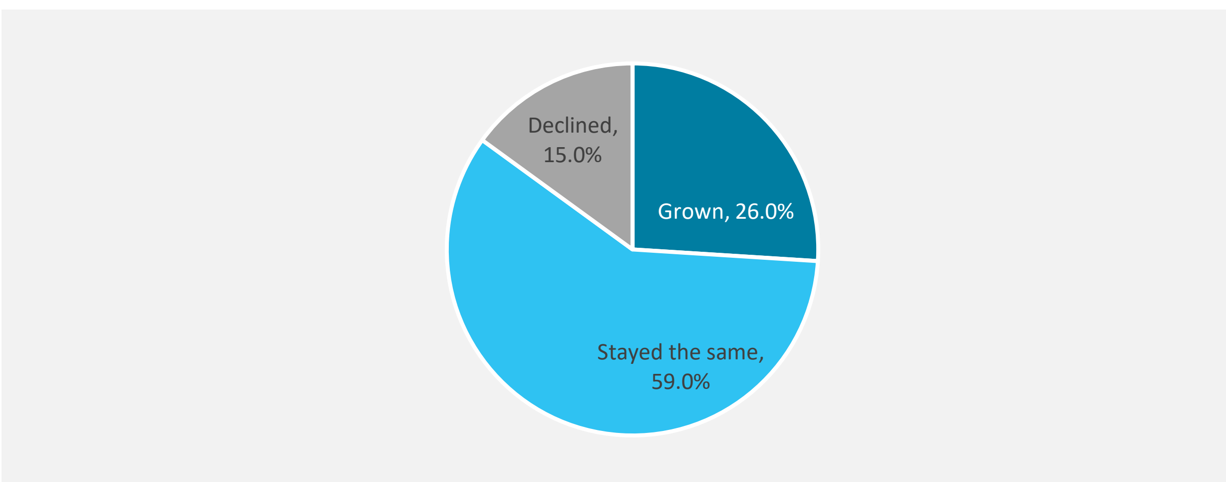
As shown in Figure 10, 30 percent of firms surveyed that received REF grant funding indicated that they have 50 or more employees, and 26 percent indicated that they have five to nine employees.

Figure 10. Firm Size



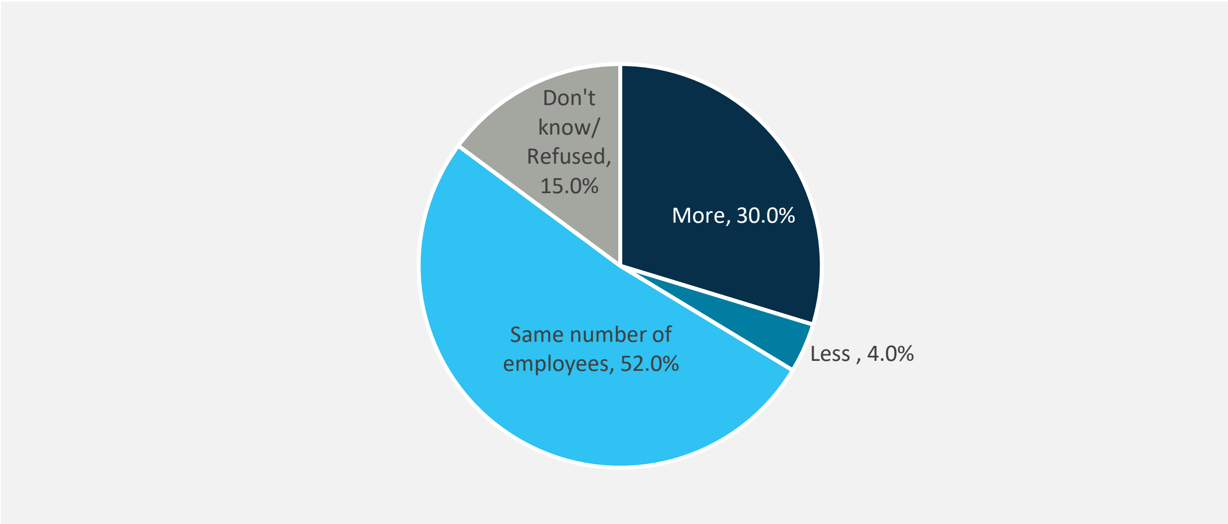
Furthermore, as shown in Figure 11, 59 percent of survey respondents indicated that employment at their organization has remained constant over the last three years, while 26 percent reported that employment has grown, and 15 percent reported that employment has declined.

Figure 11. Historical Employment Growth



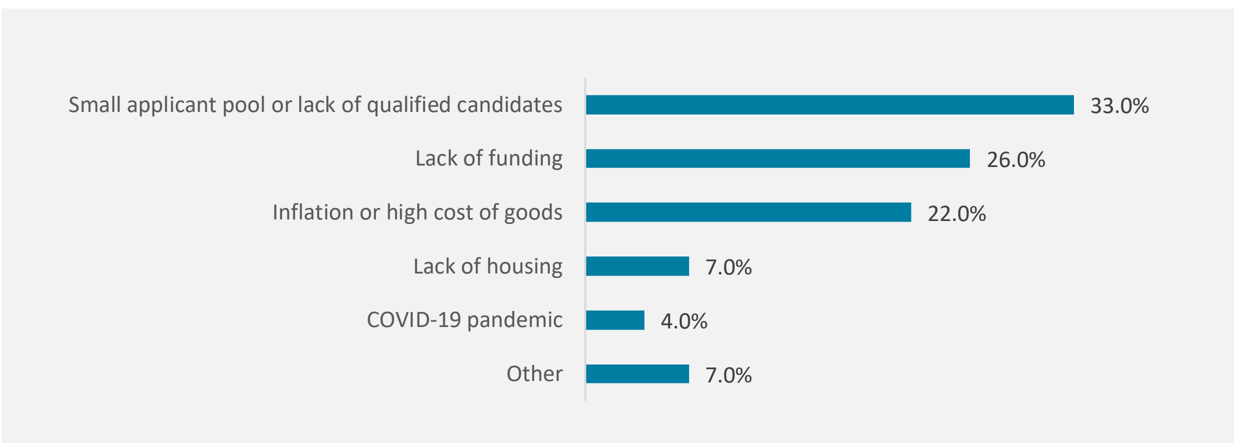
As shown in Figure 12, 30 percent of survey respondents reported that they expect their organization to grow in employment over the next 12 months, and 52 percent predicted that they would have the same number of employees in the next year. Only four percent of respondents expected a decline in employment over the next 12 months.

Figure 12. Employment Growth Projections



Approximately 33 percent of survey respondents indicated that the primary challenge to growing or maintaining their businesses/organizations is a small applicant pool or lack of qualified candidates. Approximately 26 percent reported lack of funding is a challenge, followed by inflation or the high cost of goods (22 percent), lack of housing (seven percent), and the COVID-19 pandemic (four percent) (Figure 13). These findings suggest that while finding funding is a significant challenge for many, finding qualified talent is an even more common challenge. Given Alaska's relatively fixed labor pool, it will be important to ensure that the clean energy workforce is prepared to support Alaska's growing portfolio of renewable energy projects and accompanying infrastructure.

Figure 13. Business Challenges

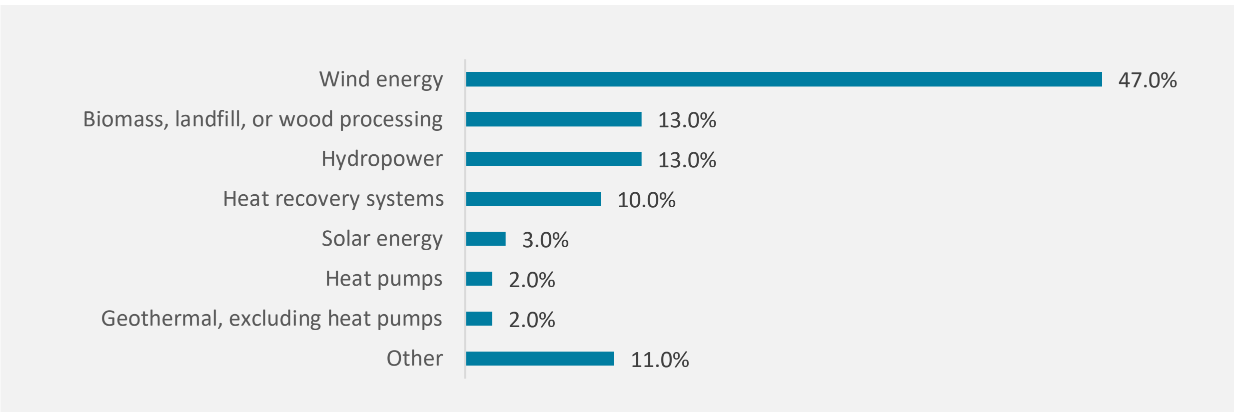


Grant Funding Overview

For the following section in Figure 14 through Figure 20, the topline data is based on responses from 21 grant recipients that provided information for 62 individual grants. As such, the data presented herein is based on these 62 grants.

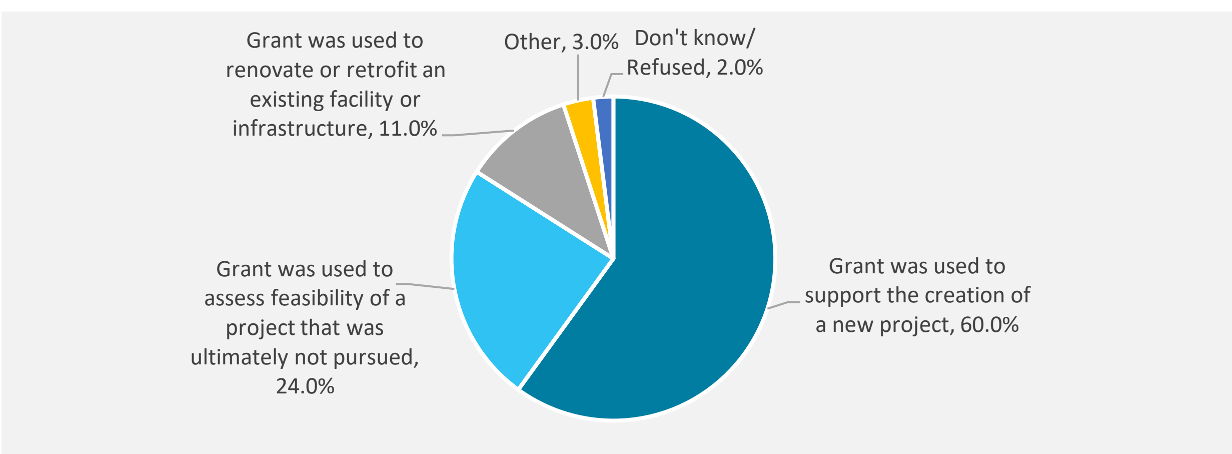
As shown in Figure 14, among surveyed grant recipients, the main technology that has received funding thus far is wind energy. Approximately 47 percent of survey respondents reported that the primary purpose of the REF grants their organizations have received was for a wind energy project. Biomass, landfill, and wood processing; hydropower; and heat recovery systems each accounted for at least 10 percent each of the grants received.

Figure 14. Primary Technologies Funded



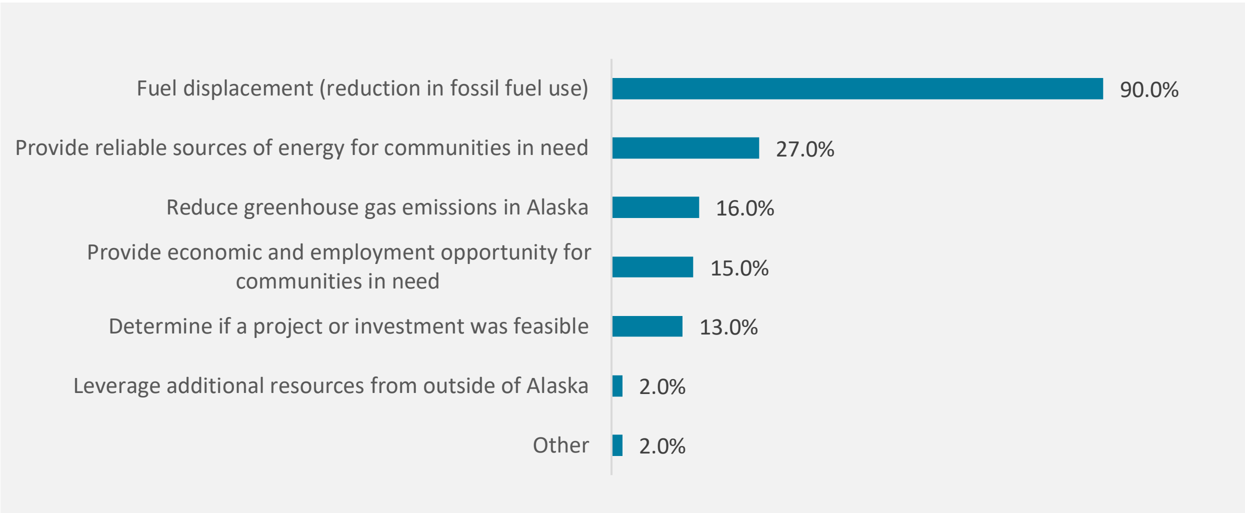
As shown in Figure 15, most grants supported the creation of a new project, with 60 percent of grants being used for this purpose. Approximately 24 percent of grants were used to assess feasibility of a project that ultimately was not built, and 11 percent of grants were used to renovate or retrofit an existing facility or infrastructure.

Figure 15. Grant Use/Reason for Funding



As shown in Figure 16, 90 percent of grant recipients indicated that the primary goal of grant projects was fuel displacement, or a reduction in fossil fuel use. Other goals or objectives of these projects included providing reliable sources of energy for communities in need (27 percent), reducing GHG emissions in Alaska (16 percent), providing economic and employment opportunities (15 percent), and determining if a project or investment would be feasible (13 percent).

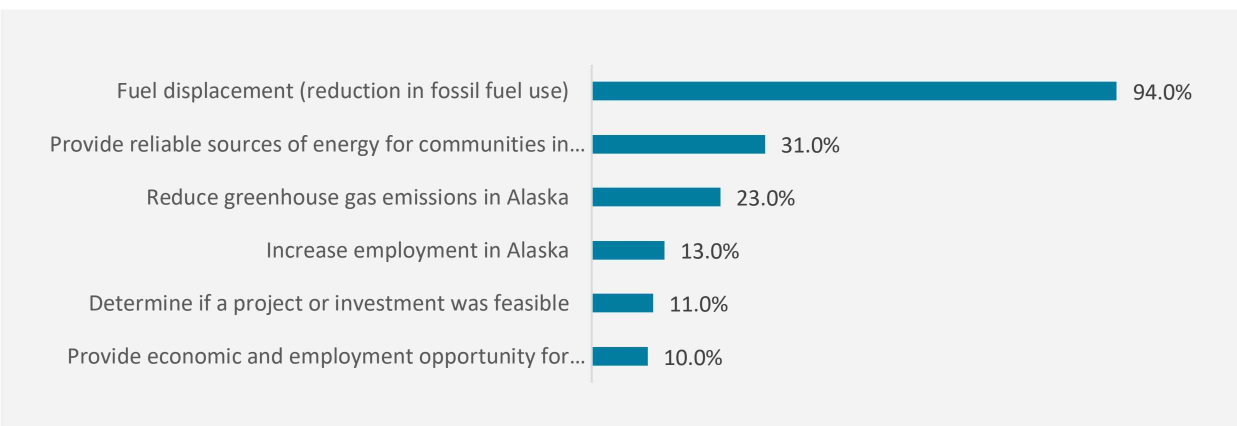
Figure 16. Primary Goals/Objectives of Grant Projects



Benefits & Challenges

Most grant recipients indicated that their projects ultimately achieved the primary goal of fuel displacement. As shown in Figure 17, 94 percent of grant recipients indicated that the primary benefit of REF funding was fuel displacement. Approximately 31 percent of grant recipients indicated that the primary benefit was the provision of reliable sources of energy for communities in need.

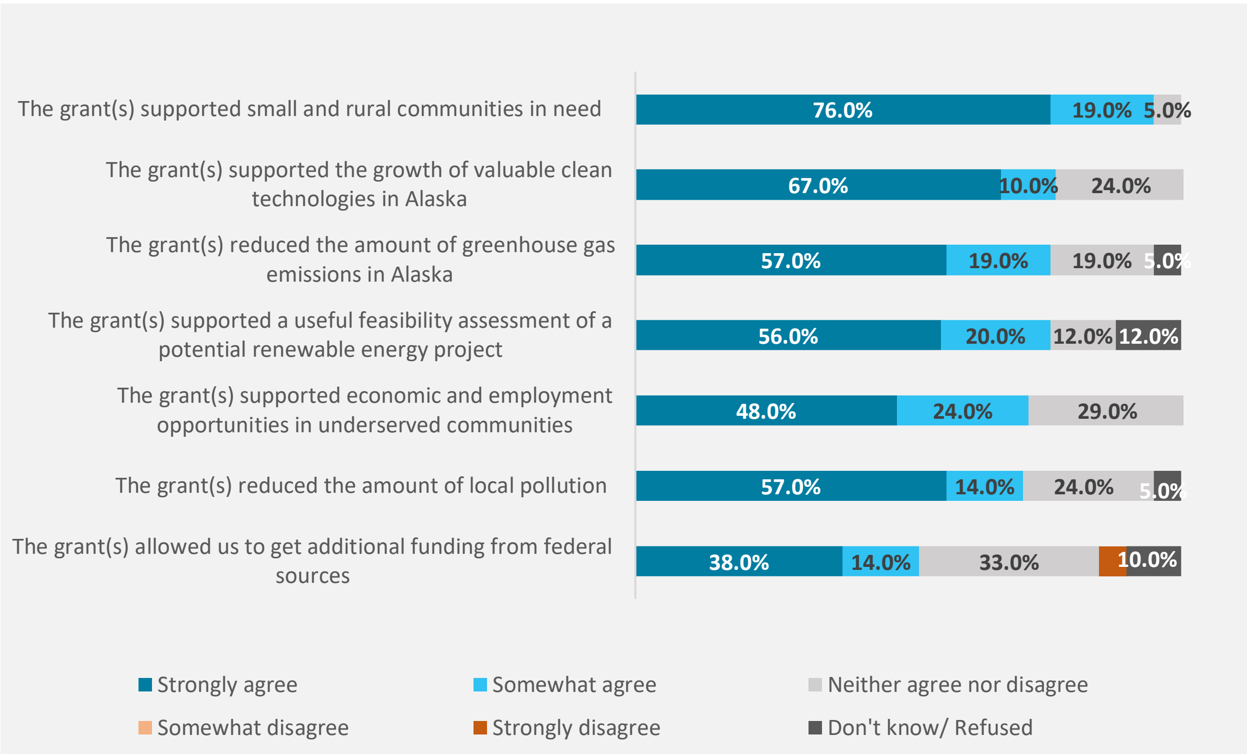
Figure 17. Reported Benefits Realized by Funded Projects



Furthermore, as shown in Figure 18, 95 percent of surveyed grantees felt that the grants they received supported small and rural communities in need. Approximately 72 percent also indicated that the grants supported economic and employment opportunities in underserved communities, and 52 percent also felt that the grants allowed them to obtain additional funding from federal sources.

Additionally, 77 percent of respondents indicated that the grants supported the growth of valuable clean technologies in Alaska, 76 percent felt that the grants reduced the amount of GHG emissions, and 71 percent felt that the grants reduced the amount of local pollution.

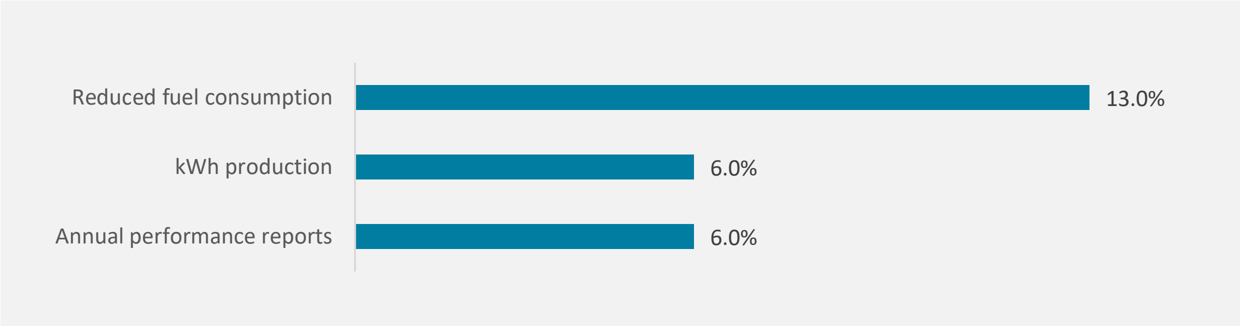
Figure 18. Additional Grant Benefits



Approximately 52 percent of grant recipients indicated that they track information measuring the impact of the project(s) that were supported through REF grant funding. However, 41 percent of grant recipients reported not knowing the types of impacts measured, or refused to respond when asked what types of impacts were measured. Approximately 19 percent of respondents indicated that they shared data with AEA.

As shown in Figure 19, for those respondents that provided additional information on impacts measured, 13 percent reported measuring amounts of fuel consumption reduced, six percent reported measuring kWh of electricity produced, and six percent reported measuring annual performance.

Figure 19. Types of Impacts Measured



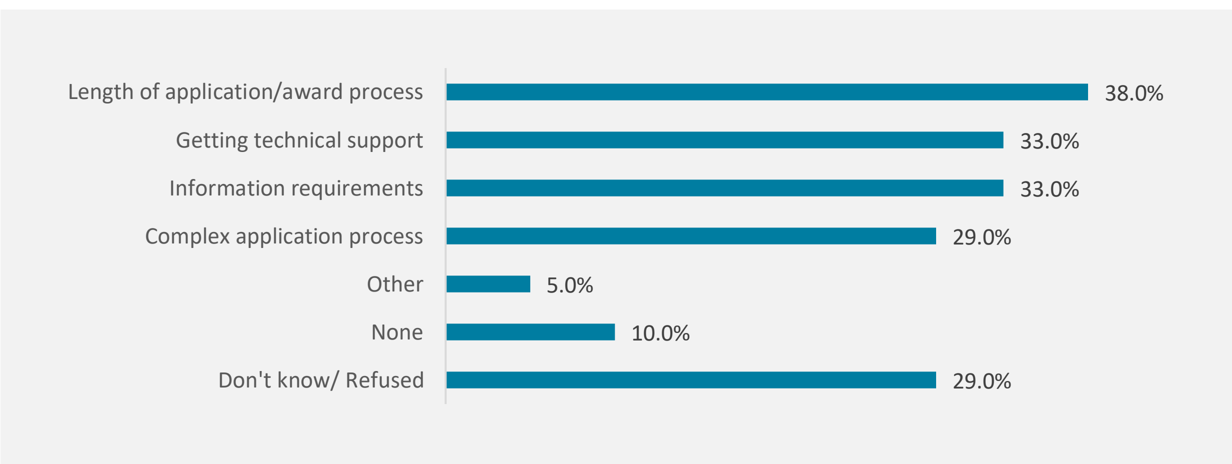
Grantees were also surveyed to determine perceived lessons learned from participation in the REF program. The key lesson learned from grantees is that proper funding is critical to project success; this was the top reported lesson learned by 24 percent of respondents. Approximately 14 percent of respondents also reported learning that community and local workforce are critical to project success, and approximately 10 percent reported learning that the development and operation and maintenance phases of their projects were critical to success.

Approximately 19 percent of respondents ultimately determined that their projects were not feasible following assessments. Furthermore, only 10 percent of respondents indicated that their projects had met or exceeded their expectations.

Figure 20 illustrates the primary challenges cited by respondents in working with the REF program. As shown, only 10 percent of respondents reported that they encountered no challenges in working with the REF program.

Of those grantees that indicated having faced challenges with the REF program, 38 percent cited the length of application/award process, 33 percent cited difficulties associated with getting technical support or assistance, 33 cited information requirements, and 29 percent cited the complexity of the application process as the primary challenges associated with the program.

Figure 20. REF Program Primary Challenges



Executive Interview Summaries

The following section summarizes the findings from executive interviews with six stakeholders across utility companies, energy cooperatives, and energy program managers that have knowledge of or have taken part in the REF grant program. The major themes discussed by the research team during these interviews included, but were not limited to, challenges and opportunities pertaining to the REF program, thoughts on the efficacy of the program, and suggestions regarding the program overall.

Grantee Experience & Perceptions

The Renewable Energy Fund contributed to improving the economy and environment of many communities. According to program recipients, their respective communities are thriving because of affordable energy rates, and state revenues are growing due to the REF program.

"AEA funds contribute to improving the economy of our community, its safety, prosperity, and positive impacts on the environment."

"The REF helps to reduce and stabilize electric rates for the economic drivers in the community, primarily, and that's awesome."

"We've participated in a lot of other grant and funding opportunities (...), and AEA's process by far is the best, from start to finish."

Although the program has become more competitive in recent years, program recipients consider the process fairly transparent and easier to access than other grants. Some program recipients have worked on obtaining grants from the state of Alaska prior to the REF's inception and remember it as a less onerous process. However, others applaud the transparency of the program regarding the type of projects they are looking to invest in and their responsiveness to inquiries.

"We've participated in a lot of other grant and funding opportunities (...), and AEA's process by far is the best, from start to finish. Reporting is streamlined and straightforward, reimburses you very quickly, and if you call with questions, you get answers and some guidance."

"I think the REF application process is kept at a level that is acceptable — it's not an overly onerous burden for the applicant to submit, especially compared to a lot of federal funding opportunities that are incredibly complicated and cumbersome in time and energy needed to put in a good application."

> "What has the program done for our community? Saved a boatload of diesel... [it's been] 10 years and we've already saved millions of dollars in diesel fuel."

Program Strengths & Weaknesses

The REF program is critical to displacing diesel generation in rural communities of Alaska. Several program recipients have explained that there were not as many grant opportunities targeted at creating renewable alternatives to diesel before the REF, which is making those communities less reliant on fossil fuel generation.

REF funds tend to attract other investors to projects in rural Alaska. Recipients of the fund have explained that such projects would rarely make economic sense on their own, and that being backed by state dollars lends them credibility. AEA has also allowed for cost-sharing with other grants, which gives utilities and cooperatives more opportunities to develop rural energy infrastructure.

"What has the program done for our community? Saved a boatload of diesel . . . REF has reduced our operations and maintenance, increased safety of projects, increased amount of diesel offsetting, resulted in substantial cost saving to our customers of every rate class . . . Just this year alone it saved $600,000 in diesel fuel... [it's been] 10 years and we've already saved millions of dollars in diesel fuel."

"It does help attract other investors, very few of these projects in rural Alaska make economic sense on their own, so it's hard to get other funding agencies to commit because they don't see the end product, but if they know the state has provided partial funding, it's easier to leverage other opportunities."

“The state providing cost share for the other grants provided by the federal government is very critical because we can get more projects in the pipeline done – this is really critical.”

Most program recipients complained about the lack of data tracking of projects that have received REF funding. Some recipients provide metrics to the state, in order to ensure continued program funding. However, recipients have argued that there needs to be more diligence pertaining to tracking key metrics and publishing quantitative and qualitative measures of success for past projects, in order to keep improving project development and funding allocation policies.

“The state providing cost share for the other grants provided by the federal government is very critical because we can get more projects in the pipeline done — this is really critical.”

“I would like to see better metrics about the program, as a funder I would like to see how well the program is contributing to the overall clean energy transition in Alaska. I think it would be really interesting to see with some sort of regularity... to know how many different types of projects have been funded. . . .That kind of report can be used to make important policy and funding decisions... a lot of that can be useful for determining what’s next for that community in terms of transitioning to locally available, cleaner, cheaper resources.”

CONCLUSION AND RECOMMENDATIONS

Based on the results of the analyses, the REF program has played a significant role in supporting the development of Alaska's renewable energy sector:

1. The REF has been crucial in helping Alaska transition to a clean economy and supporting grantee efforts to produce affordable renewable power to meet local energy needs.
2. The REF has helped local communities stabilize energy prices by reducing their dependence on diesel fuel for power generation and space heating.
3. The REF has reduced environmental pollutants, resulting in healthier communities and lower public health costs.
4. The REF has created new local jobs, fueling local economic growth, and has generated significant labor income and value added.
5. The REF has attracted other investors to projects in rural Alaska, effectively lowering barriers to project funding for grant recipients. Thus, the REF has allowed grant recipients to invest in new renewable energy projects that might not otherwise have been economically feasible.

Based on an investment of approximately $245 million in grant funding, the REF program has resulted in the following avoided costs/monetary benefits through 2022:

- Over $357 million in cumulative gross energy cost savings, and over $53 million in cumulative net energy cost savings due to fuel switching, as approximately 85 million gallons of diesel and 2.2 million cubic feet of natural gas were displaced as a result of REF program funding
- Approximately $54 million in net avoided SCC, as approximately 1.1 metric tons of GHG emissions were reduced due to REF program funding
- Up to $43 million in avoided costs associated with $PM_{2.5}$ pollutant reduction
- Approximately $237 million in labor income and $399 million in value added from 2,931 new jobs created, and the associated boost in spending for local communities generated from those new jobs.

Moreover, the REF program has been highly successful in supporting local communities, with 95 percent of grantees surveyed indicating that the grants they received supported small and rural communities in need and 72 percent of respondents noting that the REF program supported economic and employment opportunities in underserved communities. However, some challenges remain, particularly for potential first-time applicants and applicants from smaller communities.

Based on the stakeholder interviews, BW Research developed the following recommendations for improvements to the REF program to increase efficiency while maintaining high levels of participant satisfaction:

Reduce, simplify, or eliminate certain requirements for the application process.	As mentioned previously, a significant proportion of grant recipients indicated that the length of the award process was a challenge. Streamlining application requirements could increase both participation in, and participant satisfaction with, the REF program.
Maintain complete project records.	Numerous grant recipients indicated that they prefer a higher level of diligence in tracking key metrics and publishing quantitative and qualitative measures of success for past projects, to improve project development and funding allocation policies. Maintaining thorough project records will also support future program evaluations.

Appendix A: Methodology

Fuel Displacement

The first step in the analysis included categorizing the projects in AEA's database as "off-grid" or "on-grid," as different assumptions were employed to calculate fuel displacement for projects that were on-grid versus off-grid. To determine project location, BW Research searched for project coordinates and compared them to maps of Alaska's electricity grid.

Subsequently, BW Research sought to populate the missing values for annual DGD in AEA's dataset for operational projects.[24] Key assumptions for the extrapolation process by project type are listed below:

Biomass

BW Research calculated the average DGD by grant amount based on data for the 18 biomass projects for which annual DGD was available. For biomass projects lacking annual DGD data, BW Research applied the average DGD by grant amount as a proxy to estimate annual DGD.

Heat Recovery

BW Research calculated annual DGD for heat recovery projects with available data by applying an U.S. EIA conversion rate to available data on goal net heat delivered (MMBtu/year). For heat recovery projects lacking data, BW Research applied the average annual DGD by grant amount as a proxy to estimate annual DGD.

Heat Pump

Similarly, BW Research calculated annual DGD for heat pump projects with available heating data by applying an EIA conversion rate (Btu/gal Diesel) to actual goal net heat delivered. For heat pump projects lacking data, BW Research applied the average DGD by grant amount as a proxy to estimate annual DGD.

All Other Projects (Hydroelectric, Solar, Storage, Wind, Gas, & Transmission)

BW Research calculated annual DGD for projects with available goal net electric generation data (MWh/year) data, using EIA conversion rates (Btu/gal diesel, Btu/kWh). For projects lacking data, BW Research applied the average goal net electric generation per installed capacity (MW) as a proxy to estimate annual DGD.

Environmental Benefits Analysis

To calculate gross annual avoided GHG emissions, BW Research multiplied U.S. EPA data on GHG emissions for diesel and natural gas consumption by annual DGD and MCF natural gas displaced.

For on-grid renewable electric generation projects, annual fuel displacement was converted to emissions from electricity consumption, assuming current electricity usage and generation mix from U.S. EPA's Alaskan electricity output emissions data.

[24] BW Research was unable to extrapolate annual fuel displacement for non-operational projects included in the grant portfolio dataset because projects were listed as "closed," and no data existed from which extrapolations could be made (start/end date, technology, capacity, generation, heat delivery, etc.).

To calculate net avoided emissions, BW Research subtracted emissions from biomass consumption, assuming GHG emissions were approximately equal to fossil fuels, as per NREL's Biomass Energy Basics.[25] Renewable energy generation (solar, wind, storage, hydro), heat recovery, and ground source heat pumps were assumed not to produce GHG emissions during heat and electricity generation.

To calculate the avoided SCC, BW Research used annual avoided metric tons of carbon emissions, multiplied by the current SCC, $51.2.[26]

To calculate the social cost of $PM_{2.5}$ avoided, BW Research used annual avoided diesel gallons and MCF natural gas, multiplied by average emissions factors calculated by the Argonne National Laboratory.[27] This estimates the pounds of $PM_{2.5}$ emitted, which is then multiplied by two estimates of social cost of $PM_{2.5}$ emissions, to create a low and high estimate.[28] [29]

Cost Savings Analysis

For the cost savings analysis, BW Research first obtained data on Alaskan energy prices for 2008 to 2020 ($/MMBtu) from EIA. However, since data for 2021 and 2022 was unavailable, BW Research used 2020 prices as a proxy.

To calculate gross avoided energy costs, BW Research multiplied EIA prices by annual off-grid diesel gallons and MCF natural gas displaced (converted to MMBtu), and on-grid diesel gallons and MCF natural gas displaced.

To calculate net avoided energy costs, BW Research deducted annual biomass and on-grid electricity costs. These were calculated by converting annual diesel and natural gas displaced to MMBtu of biomass and electricity consumption.[30]

BW Research then deducted project costs. Costs from projects without dates were distributed across years based on the given annual cost distribution.[31]

Economic Benefits Analysis

For the economic benefits analysis, BW Research used project descriptive information to identify the technology funded by each grant, as not all projects listed within the database listed this information. The projects were then grouped into 10 sectors: Biomass, Energy Storage, Geothermal, Heat Pump, Heat Recovery, Hydroelectric, Solar, Transmission, Wind, and Various. The total spending in each sector is shown in Table 6.

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[25] https://www.nrel.gov/research/re-biomass.html#:~:text=Greenhouse%20Gas%20Emissions%20Reduction&text=Burning%20biomass%20releases%20about%20the,essentially%20%22new%22%20greenhouse%20gas.

[26] Ibid.

[27] https://publications.anl.gov/anlpubs/2012/07/73844.pdf

[28] https://cedmcenter.org/wp-content/uploads/2017/10/Public-Health-Costs-of-Primary-PM2.5-and-Inorganic-PM2.5-Precursor-Emissions-in-the-United-States.pdf

[29] Note that this was a gross analysis and did not account for $PM_{2.5}$ emissions from biomass consumption.

[30] On-grid electric generation projects result in net 0 cost savings, while off-grid electricity costs for hydro, solar, and wind are estimated to be limited to project costs.

[31] Netting out project costs results in negative annual avoided energy costs in early years, but as annual energy savings accumulate over time, annual avoided energy costs turn positive.

Table 6. Total Spending by Sector ($ Millions)

Technology	Renewable Energy Fund Budget	Renewable Energy Fund Actual	Community Contributions Budget	Community Contributions Actual	State, Other Actual	Federal Actual	Total Actual
Biomass	$27,681,228	$26,917,286	$8,579,424	$8,170,574	$185,109	$0	**$35,272,970**
Energy Storage	$2,325,000	$0	$600,000	$0	$0	$0	**$0**
Geothermal	$9,996,966	$9,996,966	$5,618,386	$5,835,311	$3,798	$94,001	**$15,930,077**
Heat Pump	$7,026,473	$6,389,473	$1,266,847	$3,038,625	$1,333	$0	**$9,429,431**
Heat Recovery	$18,093,800	$16,193,096	$3,752,300	$3,790,241	$324,606	$0	**$20,307,943**
Hydroelectric	$94,243,909	$81,995,267	$152,766,068	$174,482,032	$52,779,937	$221,651	**$309,478,888**
Solar	$5,140,635	$447,385	$2,359,661	$101,190	$1,665	$0	**$550,240**
Transmission	$9,123,521	$8,748,125	$705,236	$1,036,662	$150,446	$2,402,838	**$12,338,070**
Various	$5,781,485	$4,296,410	$982,691	$420,621	$10,060	$0	**$4,727,091**
Wind	$94,033,314	$89,792,948	$50,505,342	$49,982,067	$10,277,279	$0	**$150,052,294**
TOTAL	**$273,446,331**	**$244,776,957**	**$227,135,955**	**$246,857,324**	**$63,734,233**	**$2,718,490**	**$558,087,003**

BW Research then created custom multipliers in IMPLAN, an input-output economic modeling software, leveraging existing BW Research models, NREL technical data, and NREL's JEDI models, to calculate the economic impact of grants awarded through the REF. Sector-specific assumptions are detailed below:

- For the storage, solar, and biomass sectors, BW Research used NREL technical cost data leveraged from previous work.
- For the heat pump and heat recovery sectors, BW Research used commercial heating, ventilation, and air conditioning, or HVAC, spending patterns leveraged from previous work.
- For the hydroelectric, transmission, and various sectors, BW Research assumed a general split of spending on capex/construction activities versus activities the utility would handle (siting, engineering, operations), which BW Research leveraged from previous work splitting costs into capex/construction versus engineering/operations and maintenance.
- For the geothermal and wind sectors, BW Research used NREL's JEDI models for geothermal and land-based wind, for projects in Alaska.

Appendix B: Selected Inputs for the Impacts Analysis

Table 7. Alaska Historical Electricity Consumption (2008-2021) [32]

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2008	Total Electric Power Industry	Coal (Short Tons)	497,114
2008	Total Electric Power Industry	Petroleum (Barrels)	1,654,644
2008	Total Electric Power Industry	Natural Gas (Mcf)	44,153,394
2008	Electric Generators, Electric Utilities	Coal (Short Tons)	210,256
2008	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,574,120
2008	Electric Generators, Electric Utilities	Natural Gas (Mcf)	43,199,130
2008	Combined Heat and Power, Electric Power	Coal (Short Tons)	197,436
2008	Combined Heat and Power, Commercial Power	Coal (Short Tons)	89,422
2008	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	7,376
2008	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	0
2008	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	73,148
2008	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	954,264
2009	Total Electric Power Industry	Coal (Short Tons)	512,959
2009	Total Electric Power Industry	Petroleum (Barrels)	1,996,320
2009	Total Electric Power Industry	Natural Gas (Mcf)	38,950,168
2009	Electric Generators, Electric Utilities	Coal (Short Tons)	204,928
2009	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,907,675
2009	Electric Generators, Electric Utilities	Natural Gas (Mcf)	38,078,331
2009	Combined Heat and Power, Electric Power	Coal (Short Tons)	226,727
2009	Combined Heat and Power, Commercial Power	Coal (Short Tons)	81,304
2009	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	10,525
2009	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	0
2009	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	78,120
2009	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	871,837
2010	Total Electric Power Industry	Coal (Short Tons)	496,500

[32] Data obtained from the U.S. Energy Information Administration (EIA), as re-released in March 2023.

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2010	Total Electric Power Industry	Petroleum (Barrels)	1,622,296
2010	Total Electric Power Industry	Natural Gas (Mcf)	40,676,974
2010	Electric Generators, Electric Utilities	Coal (Short Tons)	188,767
2010	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,535,173
2010	Electric Generators, Electric Utilities	Natural Gas (Mcf)	39,731,774
2010	Combined Heat and Power, Electric Power	Coal (Short Tons)	218,160
2010	Combined Heat and Power, Commercial Power	Coal (Short Tons)	89,573
2010	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	10,111
2010	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	4,329
2010	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	77,012
2010	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	940,871
2011	Total Electric Power Industry	Coal (Short Tons)	511,662
2011	Total Electric Power Industry	Natural Gas (Mcf)	42,590,510
2011	Total Electric Power Industry	Other Gases (Billion Btu)	36
2011	Total Electric Power Industry	Petroleum (Barrels)	1,613,261
2011	Electric Generators, Electric Utilities	Coal (Short Tons)	175,018
2011	Electric Generators, Electric Utilities	Natural Gas (Mcf)	41,737,759
2011	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,516,863
2011	Combined Heat and Power, Industrial Pow	Natural Gas (Mcf)	833,555
2011	Combined Heat and Power, Industrial Pow	Other Gases (Billion Btu)	36
2011	Combined Heat and Power, Industrial Pow	Petroleum (Barrels)	92,213
2011	Combined Heat and Power, Electric Power	Coal (Short Tons)	230,632
2011	Combined Heat and Power, Commercial Pow	Coal (Short Tons)	106,012
2011	Combined Heat and Power, Commercial Pow	Natural Gas (Mcf)	19,196
2011	Combined Heat and Power, Commercial Pow	Petroleum (Barrels)	4,185
2012	Total Electric Power Industry	Coal (Short Tons)	530,213
2012	Total Electric Power Industry	Natural Gas (Mcf)	40,382,971
2012	Total Electric Power Industry	Other Gases (Billion Btu)	42
2012	Total Electric Power Industry	Petroleum (Barrels)	1,710,072
2012	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	606,410
2012	Combined Heat and Power, Industrial Power	Other Gases (Billion Btu)	42
2012	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	86,440
2012	Combined Heat and Power, Commercial Power	Coal (Short Tons)	105,118

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2012	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	18,151
2012	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	8,863
2012	Combined Heat and Power, Electric Power	Coal (Short Tons)	218,715
2012	Electric Generators, Electric Utilities	Coal (Short Tons)	206,380
2012	Electric Generators, Electric Utilities	Natural Gas (Mcf)	39,758,410
2012	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,614,769
2013	Total Electric Power Industry	Coal (Short Tons)	729,018
2013	Total Electric Power Industry	Natural Gas (Mcf)	34,801,335
2013	Total Electric Power Industry	Petroleum (Barrels)	1,385,776
2013	Electric Generators, Electric Utilities	Coal (Short Tons)	184,629
2013	Electric Generators, Electric Utilities	Natural Gas (Mcf)	33,943,685
2013	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,306,653
2013	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	820,797
2013	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	73,554
2013	Combined Heat and Power, Electric Power	Coal (Short Tons)	210,117
2013	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2013	Combined Heat and Power, Commercial Power	Coal (Short Tons)	334,272
2013	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	36,853
2013	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	5,569
2014	Total Electric Power Industry	Coal (Short Tons)	486,750
2014	Total Electric Power Industry	Natural Gas (Mcf)	32,851,046
2014	Total Electric Power Industry	Petroleum (Barrels)	1,261,465
2014	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	892,416
2014	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	89,263
2014	Combined Heat and Power, Commercial Power	Coal (Short Tons)	44,317
2014	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	14,630
2014	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	3,829
2014	Combined Heat and Power, Electric Power	Coal (Short Tons)	212,780
2014	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2014	Electric Generators, Electric Utilities	Coal (Short Tons)	229,653
2014	Electric Generators, Electric Utilities	Natural Gas (Mcf)	31,944,000
2014	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,168,373
2015	Total Electric Power Industry	Coal (Short Tons)	555,683

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2015	Total Electric Power Industry	Natural Gas (Mcf)	31,139,120
2015	Total Electric Power Industry	Petroleum (Barrels)	1,345,877
2015	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	932,522
2015	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	79,029
2015	Combined Heat and Power, Commercial Power	Coal (Short Tons)	43,830
2015	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	6
2015	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	7,297
2015	Combined Heat and Power, Electric Power	Coal (Short Tons)	219,555
2015	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2015	Electric Generators, Electric Utilities	Coal (Short Tons)	292,298
2015	Electric Generators, Electric Utilities	Natural Gas (Mcf)	30,206,592
2015	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,259,551
2016	Total Electric Power Industry	Coal (Short Tons)	443,129
2016	Total Electric Power Industry	Natural Gas (Mcf)	28,498,217
2016	Total Electric Power Industry	Petroleum (Barrels)	1,453,554
2016	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	267,317
2016	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	68,079
2016	Combined Heat and Power, Commercial Power	Coal (Short Tons)	36,687
2016	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	6,932
2016	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	3,202
2016	Combined Heat and Power, Electric Power	Coal (Short Tons)	157,949
2016	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2016	Electric Generators, Electric Utilities	Coal (Short Tons)	248,493
2016	Electric Generators, Electric Utilities	Natural Gas (Mcf)	28,223,968
2016	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,382,273
2017	Total Electric Power Industry	Coal (Short Tons)	414,067
2017	Total Electric Power Industry	Natural Gas (Mcf)	29,215,559
2017	Total Electric Power Industry	Petroleum (Barrels)	1,584,761
2017	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	260,609
2017	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	62,155
2017	Combined Heat and Power, Commercial Power	Coal (Short Tons)	36,223
2017	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	21,555
2017	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	5,408

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2017	Combined Heat and Power, Electric Power	Coal (Short Tons)	152,073
2017	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2017	Electric Generators, Electric Utilities	Coal (Short Tons)	225,771
2017	Electric Generators, Electric Utilities	Natural Gas (Mcf)	28,933,395
2017	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,517,198
2018	Total Electric Power Industry	Coal (Short Tons)	496,101
2018	Total Electric Power Industry	Natural Gas (Mcf)	25,668,703
2018	Total Electric Power Industry	Petroleum (Barrels)	1,453,797
2018	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	273,251
2018	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	59,259
2018	Combined Heat and Power, Commercial Power	Coal (Short Tons)	35,669
2018	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	2,554
2018	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	6,345
2018	Combined Heat and Power, Electric Power	Coal (Short Tons)	148,123
2018	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2018	Electric Generators, Electric Utilities	Coal (Short Tons)	312,309
2018	Electric Generators, Electric Utilities	Natural Gas (Mcf)	25,392,898
2018	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,388,193
2019	Total Electric Power Industry	Coal (Short Tons)	555,952
2019	Total Electric Power Industry	Natural Gas (Mcf)	24,686,921
2019	Total Electric Power Industry	Petroleum (Barrels)	1,608,212
2019	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	285,775
2019	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	64,665
2019	Combined Heat and Power, Commercial Power	Coal (Short Tons)	31,540
2019	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	140
2019	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	8,385
2019	Combined Heat and Power, Electric Power	Coal (Short Tons)	154,717
2019	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2019	Electric Generators, Independent Power Producers	Petroleum (Barrels)	4,967
2019	Electric Generators, Electric Utilities	Coal (Short Tons)	369,695
2019	Electric Generators, Electric Utilities	Natural Gas (Mcf)	24,401,006
2019	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,530,195
2020	Total Electric Power Industry	Coal (Short Tons)	587,878

YEAR	TYPE OF PRODUCER	ENERGY SOURCE (UNITS)	CONSUMPTION for ELECTRICITY
2020	Total Electric Power Industry	Natural Gas (Mcf)	23,109,741
2020	Total Electric Power Industry	Petroleum (Barrels)	1,783,540
2020	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	268,152
2020	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	71,882
2020	Combined Heat and Power, Commercial Power	Coal (Short Tons)	40,822
2020	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	263
2020	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	3,709
2020	Combined Heat and Power, Electric Power	Coal (Short Tons)	157,946
2020	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2020	Electric Generators, Independent Power Producers	Petroleum (Barrels)	4,548
2020	Electric Generators, Electric Utilities	Coal (Short Tons)	389,110
2020	Electric Generators, Electric Utilities	Natural Gas (Mcf)	22,841,326
2020	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,703,401
2021	Total Electric Power Industry	Coal (Short Tons)	590,542
2021	Total Electric Power Industry	Natural Gas (Mcf)	25,782,213
2021	Total Electric Power Industry	Petroleum (Barrels)	1,593,555
2021	Combined Heat and Power, Industrial Power	Natural Gas (Mcf)	271,618
2021	Combined Heat and Power, Industrial Power	Petroleum (Barrels)	65,851
2021	Combined Heat and Power, Commercial Power	Coal (Short Tons)	51,356
2021	Combined Heat and Power, Commercial Power	Natural Gas (Mcf)	305
2021	Combined Heat and Power, Commercial Power	Petroleum (Barrels)	1,440
2021	Combined Heat and Power, Electric Power	Coal (Short Tons)	146,844
2021	Combined Heat and Power, Electric Power	Petroleum (Barrels)	0
2021	Electric Generators, Electric Utilities	Coal (Short Tons)	392,342
2021	Electric Generators, Electric Utilities	Natural Gas (Mcf)	25,510,290
2021	Electric Generators, Electric Utilities	Petroleum (Barrels)	1,526,264