GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

Alaska Microgrid Partnership Overview

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Alaska Microgrid Project Team

GMLC-XXXXX

Alaska Microgrid Project Overview Memo

INTRODUCTION

This memorandum summarizes the activities conducted under the Alaska Microgrid Partnership (AMP). The specific work described in this memorandum was funded by the Department of the Energy (DOE) under the Grid Modernization Laboratory Consortium (GMLC), project GMLC 1.3.21.

AMP Member Organizations

National Renewable Energy Laboratory (NREL)	Lawrence Berkeley National Laboratory (LBNL)
Sandia National Laboratory (SNL)	Pacific Northwest National Laboratory (PNNL)
Intelligent Energy Systems (IES)	Renewable Energy Alaska Project (REAP)
Alaska Center for Energy & Power (ACEP) at the University of Alaska Fairbanks (UNAF)	Institute of Social and Economic Research (ISER), University of Alaska Anchorage

The overall purpose of AMP is to accelerate the development and deployment of high-contribution renewable energy-diesel power systems for remote community energy applications. This project developed and demonstrates an example pathway for developing islanded microgrids, tests the pathway using two pilot projects, and makes the pathway available for other communities to follow using an online platform, the Alaska Energy Gateway (https://akenergygateway.alaska.edu/). Unlike past efforts that focus on technical designs and only electrical energy needs, this project worked to include detailed financial analysis that would allow expanded private sector investment and included all community energy needs under its focus. In short, through this project, we hoped to develop the conceptual tools to allow communities to move from their current energy state to one that is more reliable on local, indigenous energy sources in a financially viable way. Work under AMP included:

- Development of community capacity indicators (human, financial, technical) to allow communities to assess their readiness to plan and execute renewable energy retrofit projects.
- Detailed techno-economic modeling of the power systems at two communities (Chefornak and Shungnak) to help identify the most cost optimal renewable energy (RE) and retrofit options. The analysis accounted for a general Energy Efficiency (EE) retrofit effort but stopped short of identifying specific EE retrofit options.
- Further development of a document that provides a preliminary conceptual framework of hard and soft equipment requirements and systems believed to be necessary for high contribution renewable energy retrofits to meet electricity and space heating needs in a model remote community.

- Laboratory testing of diesel generators to determine the difference in fuel consumption (if any) between operation under steady loads and operation under the varying loads that are encountered by diesel generators in medium contribution hybrid power plants.

- Drafting a paper that provides an Alaska-specific examination of electricity storage options for remote communities.

- Business case analyses that examine financing options to implement the cost-optimal designs identified in the techno-economic modeling of Chefornak, Shungnak, and Kokhanok. (Techno-economic modeling for the latter was conducted under a separate project, the Department of Interior funded "Remote Communities Renewable Energy (RCRE) project.)

- Collaboration with the Alaska Center for Energy and Power (ACEP) and the Institute of Social and Economic Research (ISER) to upgrade the Alaska Energy Data Gateway (AEDG) web portal. This website hosts community-specific energy data, allows users to visualize where critical financial, technical, and human capacity data exists; and contains documents produced under the AMP.

Appendix A lists the specific tasks and deliverables in the project scope of work.

Appendix B lists the documents produced under this project.

ACCOMPLISHMENTS

Task 1: Project Management

AMP conducted an extensive outreach effort that engaged with a wide variety of stakeholders. AMP assembled a project advisory committee comprised of a diverse group of Alaska stakeholders to advise and provide feedback to the project. In addition, members of the AMP team presented on the project at several conferences within and outside of Alaska.

Task 2: Community Capacity Metrics and Data

The AMP team created a set of 25 community capacity indicators to help communities assess their capability to plan and develop power system upgrades. As part of this task, the AMP team—via our network of local partners (University of Alaska, First Alaskans Institute)—also collected additional information about rural Alaska communities. New and/or updated datasets include:

- Fuel surveys from the Alaska Housing and Finance Corporation

- Energy prices from University of Alaska-Fairbanks Cooperative Extension Service

- Industry, occupation, and worker data from the Alaska Department of Labor

- Municipal tax records; information about payments and applications under the state community aid program; and vocational training data from the Alaska Energy Authority

- Financial statements for electric utilities from the Regulatory Commission of Alaska

Task 3: Community System Analysis

The AMP team conducted detailed techno-economic modeling of the remote communities of Chefornak and Shungnak to explore the most cost-effective RE retrofit options (in conjunction with EE upgrades) to achieve high levels of imported fuel displacement (for both electricity and heat). Analysis indicates that for communities with an excellent wind resource, a combination of extensive energy efficiency implementation (focused on weatherization) and high contribution RE retrofits, total fuel consumption for electricity and heat can be reduced by up to 50%. Another major activity under this task is the further development of a document that provides a preliminary conceptual framework of hard and soft equipment requirements and systems believed to be necessary for HPWD energy to meet electricity and space heating needs in a model remote community.

Task 4: Microgrid Hardware Assessment

This task included two major activities. The first activity was laboratory testing at the Alaska Center for Energy and Power (ACEP) of diesel generators to determine the difference in fuel consumption (if any) between operation under steady loads and operation under the varying loads that are encountered by diesel generators in medium contribution hybrid power plants. Test results indicate that operation under varying loads results in little or no change in fuel consumption compared to operation under steady state loads. The second activity was the drafting a paper that provides an Alaska-specific examination of electricity storage options for remote communities. A general conclusion of the paper is that with current equipment performance and cost parameters, the most cost-effective storage for community based power systems is short-term storage (on the order of an hour) that allows for the safe dispatch of a smaller diesel generator, or for diesel-off operation altogether, by providing spinning reserve to cover short term lulls in the wind resource or spikes in electrical demand.

Task 5: Business and Financing Case Analysis

Under this task the AMP team conducted a business case analysis to explore financing options to implement the RE and EE retrofits identified in the techno-economic modeling of Chefornak, Shungnak, and Kokhanok. In addition to the analyses specific to those communities, the team produced a generic business case analysis for use as a template for other communities. (Techno-economic modeling for the latter was conducted under a separate project, the Department of Interior funded “Remote Communities Renewable Energy (RCRE) project.)

Task 6: Development of a Knowledge Sharing Portal

This task involved collaborating closely with the Alaska Center for Energy and Power and the Institute of Social and Economic Research to upgrade the Alaska Energy Data Gateway (AEDG) web portal. This website hosts community-specific energy data, allows users to visualize where critical financial, technical, and human capacity data exists; and contains documents produced under the AMP. A number of new and updated datasets were also uploaded to the AEDG as part of the overall project (see details above for Task 2).

OBSERVATIONS, CONCLUSIONS & LIMITATIONS

Wish some modest addition cost reductions in wind turbine deployment costs, system architectures (at least those based on wind energy) that displace total imported fuel (electricity and heat) by 50% are technically feasible for communities with a good wind resource when combined energy efficiency. However, when considering this fact, it is important to stress that in a typical Alaska remote community, the quantity of fuel used for heat is 2-3 times the quantity fuel used for electricity. Thus, any strategy to significantly displace imported energy must address thermal loads, particularly energy efficiency efforts. In part because the conversion ratio of fuel to heat is roughly twice that of fuel to electricity, a kWh of fossil-fuel based heat is much less expensive than a kWh of fossil-fuel based electricity. So while RE technologies such as wind energy may be competitive compared to diesel generated electricity, they are less competitive when compared to burning fuel for heat.

It is also important to consider that community readiness can make executing these changes in communities difficult in practice. The AMP team ranked the readiness of more than 20 remote communities when considering which ones to choose as pilots. While most of these could have been chosen for a pilot, there are more than 180 other remote communities in Alaska, many of which are probably not ready to take on the challenge of reducing total fuel imports by 50%. A number of different education and training efforts would increase the readiness in many of these communities. In any case, community readiness should be explored closely before decisions to implement expensive, often complex generation projects. Important community entities and markets must be aligned to smooth efforts that must be made to find financing and install new equipment. Market segmentation is a challenge. A power provider may have the ability to impact RE contribution but have no ability to address widespread adoption of EE. On the other hand, while a consumer can impact their own energy use, they have less ability to impact EE adoption more generally or the deployment of alternatives to imported fuel for power generation.

Energy storage costs, while decreasing, are still not low enough to permit extended energy storage on a time scale of tens of hours, or days for larger isolated power systems. The main value of the battery bank, converter, and integration equipment is that they allow for diesel-off operation (when the RE system is producing significant energy), by providing spinning reserve to cover short term lulls in the wind resource, or spikes in electrical demand. However, as the displacement of imported energy increases, energy storage needs shift from providing energy during transitional periods to providing bulk power or expanding the use of excess energy for heating. With current technology performance and cost, it is still more economical to use excess wind energy to displace heating oil than to install a sufficiently large battery bank to store it.

The techno-economic modeling results are most generalizable to wind-diesel systems in communities with a large thermal load and a good wind resource which are typical of communities in northern climates. The results may not directly apply to the integration of other renewable energy technologies in other climatic regions, although an effort has been made to identify likely parallels based on ongoing deployment experiences.

Alaska's heating and power systems in remote communities have been designed for more than a half of century around importing diesel fuel and heating oil for electricity generation and heating, respectively. Though few heating subsidies exist, the Power Cost Equalization subsidy for residential electrical use is not well aligned with renewable energy systems. The stakeholder consensus is that human capacity, institutional, market, and regulatory barriers are as important as the technical challenges in slowing the deployment of renewable energy in remote communities. Of specific critical consideration is the availability of private sector capital to support the development of isolated power systems that rely on more renewable energy sources in communities with relatively little cash flows.

RECOMMENDATIONS FOR FUTURE WORK

This section describes additional efforts that could be undertaken to support the expanded development of isolated power systems that focus on using local energy sources.

Support more detailed study and analysis to investigate the feasibility of installing utility-scale turbines in remote Alaska communities. In the Lower 48 states, utility scale turbines, (turbines with a rated power of ~1.5 MW or greater) are by far the most cost-effective, both in terms of per kW installed cost and levelized cost of energy. Until recently, it was not generally considered feasible to install turbines of this size in remote Alaska communities although recent technology advances, positive experiences with 900 kW turbines in the "hub" communities of Nome and Kotzebue and the availability of larger cranes across coastal Alaska are changing viewpoints.

Continued cost reductions (both capital & O&M) are needed for wind turbines in the range of 50 kW to 500 kW. A promising approach is the deployment of used turbines that have been rebuilt/refurbished with current technology.

Support the continued collection and upload of financial, technical, and human capacity data into the AEDG portal for communities located across rural Alaska. Additional technical, financial, and human capacity information will inform project developers in their assessment of the risk and reward of proposed rural energy projects.

Support the collection and posting of data on energy use for transportation in remote Alaska communities as a prelude to investigating fuel displacement in the transportation sector.

Expand technical assistance efforts to communities and community support organizations so that more communities can analyze energy supply options and carry out energy system retrofit projects that reduce their dependence on imported energy sources.

Support the development of mechanisms for large-scale financing of energy system retrofits projects. An example would be a state "green" bank that pulls private investment capital into the state and lowers the perceived project risk through project loan guarantees, loan loss reserve funds and other means.

Explore the development of mechanisms to plan, finance, and execute energy efficiency projects on a community wide scale. This is a different problem than planning, financing, and executing energy system retrofits. The latter typically only involves one entity, the utility. The former involves all (or most of) the homeowners in the village (20, 40, 100, etc.), as well as the owners of the community buildings. A state green bank could also be used for EE projects.

Current energy storage performance and costs are barriers to achieving a greater proportion of displaced fuel. More work is needed to reduce the costs of storage to allow economical storage of electrical energy on the order of tens of hours or days for community sized systems.

Appendix A – AMP Tasks and Major Deliverables

Task	Major Deliverables
Task 1: Stakeholder Outreach	• N/A
Task 2: Community Capacity Metrics & Data	• Development of metrics to assess community capacity • Collect community capacity indicators for pilot communities • Collect community capacity indicators for non-pilot communities
Task 3: Community System Analysis	• Microgrid analysis tool suitability analysis • Generic community system specification • Techno-economic analysis for Chefornak • Techno-economic analysis for Shungnak • Design Basis Framework for hybrid systems
Task 4: Microgrid Hardware Assessment	• Report on test results for diesel operations in high-contribution power systems • Storage options report
Task 5: Business and Financing Case Analysis	• Chefornak business case analysis • Shungnak business case analysis • Kokhanok business case analysis • Generic business case analysis
Task 6: Develop Knowledge Sharing Portal	• Online data portal for energy related data and information about remote Alaska communities

Appendix B – AMP Publications

Publication	Description
AMP Overview Memo (This document)	Provides an overview of the Alaska Microgrid project, including major findings, a list of deliverables, and a listing of project publications
Community Capacity Metrics	Provides a list of metrics that can be used to assess the capacity of a remote community to plan, finance, and execute a renewable energy project.
Microgrid Optimization Tools Summary	Provides an overview of some existing microgrid analysis and design tools (https://www.nrel.gov/docs/fy18osti/70578.pdf)
Kokhanok Retrofit Analysis	Provides a summary of techno-economic analysis of renewable energy retrofit options for the community of Kockhanok, AK (https://www.nrel.gov/docs/fy18osti/70575.pdf)
Shungnak Energy Configuration Options	Provides the results of a techno-economic analysis of renewable energy retrofit options for the community of Shungnak, AK. (https://akenergygateway.alaska.edu/alaska_microgrid_communities/)
Chefornak Energy Configuration Options	Provides the results of a techno-economic analysis of renewable energy retrofit options for the community of Chefornak, AK. (https://www.nrel.gov/docs/fy18osti/70581.pdf)
Generic Community System Specification	Provides a proposed format for reporting the results of microgrid renewable energy retrofit modeling and analysis. (https://www.nrel.gov/docs/fy18osti/70581.pdf)
Diesel Generator Fuel Consumption Testing Results	Provides a comparison of diesel generator fuel consumption with and without dynamic loading. (https://akenergygateway.alaska.edu/media/AMP/AMP%20General/Genator%20Fuel%20Consumpion%20Under%20Dynamic%20Loading%20201710.pdf)
The Role of Storage in Grid Modernization	Provides an overview of current electricity storage options (performance and cost) for remote Alaska communities
Shungnak business case analysis	Provides an analysis of options for financing the RE retrofit options identified in “Shungnak Energy Configuration Options”. (https://akenergygateway.alaska.edu/alaska_microgrid_communities/)
Chefornak business case analysis	Provides an analysis of options for financing the RE retrofit options identified in “Chefornak Energy Configuration Options”.

	(https://akenergygateway.alaska.edu/alaska_microgrid_communities/)
Kokhanok business case analysis	Provides an analysis of options for financing the RE retrofit options identified in “Kokhanok Analysis Results and Conceptual Design”. (https://akenergygateway.alaska.edu/alaska_microgrid_communities/)
Generic Business Case Analysis	Provides a proposed format for documenting financing options for proposed RE retrofits to remote power systems

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