Final Technical Report Cover Page

Recipient Organization: Hughes Village Council

Project Title: Sustainable Solar Energy for Hughes Village (Hudotl'eekkaakk'e Tribe)

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Table of Contents

1.0 Executive Summary

Hughes Village Council is the local Tribal government for Hughes, Alaska. With the funding from this project, the Village Council designed and installed a 120kW solar Photo Voltaic (PV) array with a 250 kW/335kWh lithium-ion battery bank that has offset diesel consumption in the community by an estimated 10% per year. This translates to approximately 6,000 gallons of fuel per year. The goal is to reduce diesel consumption and turn the diesel generators off for certain periods of the Alaskan summer when solar PV is abundant and electrical loads in the community are low. Daily generator logs from the community show an average load of approximately 50kW-60kW with peaks ranging from 100kW-160kW. This project aligns with the tribe's mission to work towards tribal energy sovereignty, utilizing sustainable energy technologies, and their overall goal of 25% clean energy by 2025.

2.0 Background

Hughes, Alaska is a Koyukon Athabascan village situated alongside the Koyukuk River in the interior of Alaska. Hughes, Alaska is a small remote community of long standing. Its population has been relatively stable for over 20 years. As such, its demand for electrical power has continued to grow slowly over the years, to its current demand of nearly 460,000 kWh. During the course of this Department of Energy (DOE) funded project, the community has made tremendous improvements, adding new subdivisions with several brand new homes, expanded its road infrastructure, and constructed a brand new community hall. That being said, expansion in remote Alaska has its difficulties, namely the cost and reliability of supplying power, overall impact to community sustainability.

The community consists of a water treatment facility, washeteria, the electric utility (diesel power plant), landfill, health clinic, bulk fuel storage, airport (state contract), U.S. post office (federal contract), general store, roads, nearly 40 homes, a school, and a community hall. Hughes falls within the interior climate zone, characterized by extreme temperature differences (lowest temperature -57 F; highest recorded temperature 85 F; snowfall averages 102" with recorded snowfall up to 9 months per year). This climate zone encompasses most of the central part of the state and Hughes experiences extremely cold winters and warm summers. The potential for extreme low temperatures has implications for equipment design, which has been addressed in the final design of the solar PV and battery system. The Koyukuk River is generally ice-free from June through October. River barge service, however, can be unreliable due to shallow water and, as such, fuel and heavy freight are historically being brought in by air. For decades, fuel was brought in using Korean war era DC-4 planes that would fly in fuel for prices up to $10/gallon during historical high fuel prices. Since the advent of this DOE funded project, the community has invested heavily into bulk fuel storage. The community has nearly 80,000 gallons of bulk diesel storage, which has allowed for barge companies to come to Hughes to supply nearly a year's supply of fuel. Due to the economics of local barge services, prior to Hughes having bulk fuel storage capacity of less than 40,000 gallons, it was not an economically feasible option for a barge service to make an annual trip to Hughes. The community of Hughes still will fly in fuel during emergency situations, or during periods of high demand in the non-summer months. All this being stated, reliable power in Hughes depends highly on ensuring that there is enough fuel storage capacity for its diesel generators; but in a great turn of events the DOE has allowed for there to be energy sovereignty in the community of Hughes with local, tribally generated power from the sun.

In September 1994, flood waters destroyed and swept away nearly all the community's buildings, homes, and food caches for the winter. Residents have rebuilt homes and facilities. The potential for flooding has taken unprecedented consideration in the final design, namely: location of the energy systems, sizing, and controls. Climate variability may be a threat to predictable barge service in the future, resulting in more freight and fuel being flown into the community at increasing cost. In addition to the cost of fuel, restrictions on engine manufacturers to meet clean-air emissions standards are making the operation of diesel gensets more complicated and thus more expensive. The community's demand for electrical power has continued to grow slowly over the years, to its current demand of nearly 460,000 kWh. It is anticipated that the community will continue to make improvements, slowly add new homes and residences, and invest in infrastructure to improve the quality of life for its citizens. Communities in this size range are deeply concerned about cost and reliability of supplying power, and how those costs affect community sustainability.

3.0 Project Objectives

The main goal of the project is to "solarize" the community of Hughes, Alaska in a way that will reduce diesel consumption and costs in the community of Hughes.

With this, the objective of the Sustainable Solar Energy for Hughes Tribe Project is to:

(1) Increase tribal energy security and tribal resilience through the design and installation of a 120kW solar PV array that will produce an approximate 30% reduction in fuel use for electricity production in the community;

(2) Develop a replicable PV-diesel hybrid electric system that can be deployed in Alaska Native Villages across the state; and

(3) Implement a financial model that allows for tribal ownership of such a system while not negatively affecting the payments to the community through the state of Alaska PCE program.

The small Alaskan Native Village of Hughes, Alaska is located approximately 200 air miles northwest of the nearest major transportation hub of Fairbanks. Prior to the project, all the electricity for the 78 member community, which is 96% Alaskan Native is produced from diesel generators at the community powerhouse and all fuel burned to generate electricity is flown into the community on 50 year old Douglas (DC-6) planes. The Hughes Village Council has created this project to reduce the community's 100% reliance on imported diesel fuel.

Every drop of fuel for the village electrical system, which is 100% diesel run, must be flown into the community by DC6 airplanes that have been flying since the Korean War. This makes the tribe and the community 100% energy dependent on outside fuel supply and transportation. Their limited bulk storage means that if there was ever another break in air traffic such as was the case after 9/11, the community of Hughes could be without electricity or heat for their vital buildings. This project will increase energy security, tribal resiliency and energy independence in Hughes Alaska and easily accomplish goal #1.

In 2015, TCC energy staff travelled to Star Island, NH to tour a working solar PV-diesel hybrid system that was installed using Schneider Electric Equipment and lead-acid batteries on an isolated micro-grid in Portsmouth Harbor. The system has been operational for over a year and has offset approximately 50% of the diesel the community burns each season. After consultation with the design team from Schneider Electric that helped design the system, TCC believes it can be a functional model for rural Alaskan tribes that are reliant on similar diesel micro grids. Unfortunately, in Alaska we need a test-case to prove that this will work and that it can be replicated. By working with Schneider Electric and Intelligent Energy Systems (IES), which has 20 years of experience integrating renewable energy into rural Alaskan micro-grids, this project can install a system in the community of Hughes that will benefit micro-grids across the state. TCC staff has been working with communities to integrate renewable energy into rural electric grids since 2009 and we are confident that with the project partners involved here we can accomplish that goal in Hughes.

One of the largest impediments to the broader implementation of renewable energy into Rural Alaskan micro-grids is the complication of designing an economic model that will allow renewable integration to work with the diesel-based Power Cost Equalization formula to benefit the end user. After numerous conversations with the Regulatory Commission of Alaska and a review of the Power Cost Equalization program we believe that by adding renewables into the expense category of the PCE calculation rather than as they are commonly added, as “free kwh’s” we can create a model that will not reduce state PCE payments. As part of this project, we will be working to further streamline that model and implement a system that allows the use of renewable energy kwh’s while not reducing power cost equalization payments to the utility.

4.0 Description of Activities Performed

Summary: The result of this project is the installation a high penetration solar PV array with lithium ion batteries on the remote village microgrid in Hughes, Alaska with the goal of reducing annual diesel used in the powerhouse by 30%. These systems exist in islanded grid communities in different parts of the world and the US but, prior to this project, had not yet been successfully installed in Alaskan micro grids. One reason for this is the challenge of engineering both foundational and electrical and the cost of inputting the renewable energy into a village micro-grid that is receiving a diesel based subsidy such as the Alaska Power Cost Equalization program subsidy.

Task 1. Engineering and Economic Modeling

Task Summary: This task required work with the selected design Vendor and project partners to download specific load profile information from the Hughes Village powerhouse and input that into the design Vendor's model to determine the most efficient combination of solar PV, solar PV orientation and battery storage. The design Vendor worked with the recipient to specify the optimal inverter, battery system and charge controller components to use for the system and produced a plan set that can be followed for the installation of components inside the existing Hughes Village Powerhouse.

Task Details: With this task the Recipient finalized costs for the project and determined the final space requirement for the solar PV components and batteries.

Subtask 1.1: Complete modeling of an optimal PV-diesel system using local solar isolation data, verify fuel curves on the existing generators through a review of recording fuel consumption and power output, use optimal PV production estimates from the model to determine the orientation of the PV arrays.

Subtask 1.2: Complete design of the system including final sizing for the inverters, charge controllers and battery bank. Send to selected equipment Vendor for approval.

Subtask 1.3: Work with selected equipment Vendor to verify that the design is acceptable and within the range of their power electronic equipment.

Subtask 1.4: Complete final design of the optimal orientation of each solar PV array and use this to determine final size of the pad on which solar PV farm will be located. Review alternate foundation systems for potential cost savings and select final foundation. Complete full system integration plan for Subtask 1.5.

Subtask 1.5: complete final engineering plans for the solar PV-diesel hybrid system.

Subtask 1.6: Finalize Battery/Control system design, review plan-set and final System design with DOE Program Monitors (Subtask 1.6 is only applicable if "go" decision is determined in Subtask 1.5).

Subtask 1.7: Begin work on economic models to determine optimal charge to be paid or set aside by the City/Tribe to determine a reasonable number to include as an "expense" line item on PCE reports.

Task 2: Hughes Solar Farm Construction

Task Summary: Worked with the Hughes Village, City of Hughes and any electricians/certified solar PV installers on the construction and installation of the solar PV farm and foundation system. Secured equipment on the ground in Hughes and began construction.

Subtask 2.1: The site was cleared to the south of the Hughes power plant using local labor in Hughes and oversite by the City.

Subtask 2.2: Complete bid packets for the purchase and shipping of solar PV system and foundation components to Fairbanks, receive and stage for shipment to Hughes.

Subtask 2.3: Ship products to Hughes and secure in place, weather will determine start of construction.

Subtask 2.4: Work with TCC, local labor, City and Tribe to complete construction of solar PV panels, and racking in correct orientation on the solar farm pad in Hughes.

Subtask 2.5: Complete trenching for conduit wiring runs between solar PV arrays and Hughes power plant

Subtask 2.6: Work with electricians to install inverters in Hughes power plant and complete wiring between the solar PV array and the powerhouse.

Task 3: Project Commissioning and Operation

Task Summary: The Commissioning and operation phase involved the integration of the 120kw solar PV project into the Hughes electrical grid via the installation of an AC-DC inverter, SCADA system, Ageto microgrid controller and a PCS100 grid-forming inverter. This allows the community to run their existing diesel generators with the solar PV reducing the load in the community.

Task Details: The largest risk in this section is that the community of Hughes does not have the capacity to maintain the system, although the Recipient believes this can be effectively mitigated with proper training, oversight by the TCC project manager, adherence to the O&M schedule and economic modeling. The method of risk reduction is to sign a contract with an outside entity to manage the O&M of the new system.

Subtask 3.1: Commission system into the Hughes power plant, secure warranty for at least 1 year and operate system

Subtask 3.2: Work with design Vendor, TCC, and the City of Hughes operators to ensure reliability, develop O&M plan for the system and complete the operator training.

Subtask 3.3: Make monitoring of the system publicly available for other remote villages in Alaska, track fuel savings, detail problems and solutions to help make the project replicable.

<u>Task 4: Battery Integration and Commissioning</u>
Task Summary: The Battery Integration and Commissioning involved the purchase and installation of a 240kWh Saft battery storage module. The integration of the above battery storage system into the Hughes power plant and the full commissioning of the system was completed and includes at least 1 year of vendor support

Subtask 4.1: Purchase Saft battery module and shed.

Subtask 4.2: Construct battery shed in Hughes and ship battery.

Subtask 4.3: Integrate battery into the Hughes micro-grid and begin running diesels off during parts of the year.

Subtask 4.4.3: Work with Hughes Village, City of Hughes, Regulatory Commission of Alaska (RCA) to complete PCE reports that detail out sufficient expenses from the system to maintain current PCE level, adjust as necessary which may include a formal Power Purchase Agreement (PPA) between the City of Hughes and Hughes Village.

Subtask 4.5: Monitor system for a full year, report results to other TCC communities and tribes through various publications and annual program review.

5.0 Conclusions and Recommendations

The Hughes Village Council, serving as the local Tribal government for Hughes, Alaska, has spearheaded an innovative initiative showcasing the potential of renewable energy within their community. Through strategic funding, the Village Council orchestrated the design and implementation of a robust 120kW solar PV array accompanied by a 250 kW/335kWh lithium-ion battery bank. This visionary endeavor has resulted in a commendable reduction of diesel consumption by an estimated 10% annually, equivalent to sparing approximately 6,000 gallons of fuel per year. The primary aim is to curtail diesel reliance, particularly during the sun-drenched Alaskan summer months, by harnessing the abundant solar energy and alleviating electrical demands. Notably, meticulous analysis of daily generator logs reveals an average load of approximately 50-60kW, with occasional peaks ranging from 100-160kW. Beyond immediate benefits, this pioneering project resonates profoundly with the Tribe's overarching mission of advancing tribal energy sovereignty and fostering sustainability. It stands as a shining exemplar not only within the confines of Hughes but also as a replicable model for tribal communities across Remote Alaska, epitomizing the transformative potential of clean energy initiatives.

Figure 1. Aerial View of Solar Array with Battery Energy Storage System and Powerplant in the background

Figure 2. Aerial View of a sub-array of the solar system and closer look of the Battery Building along with the Powerplant

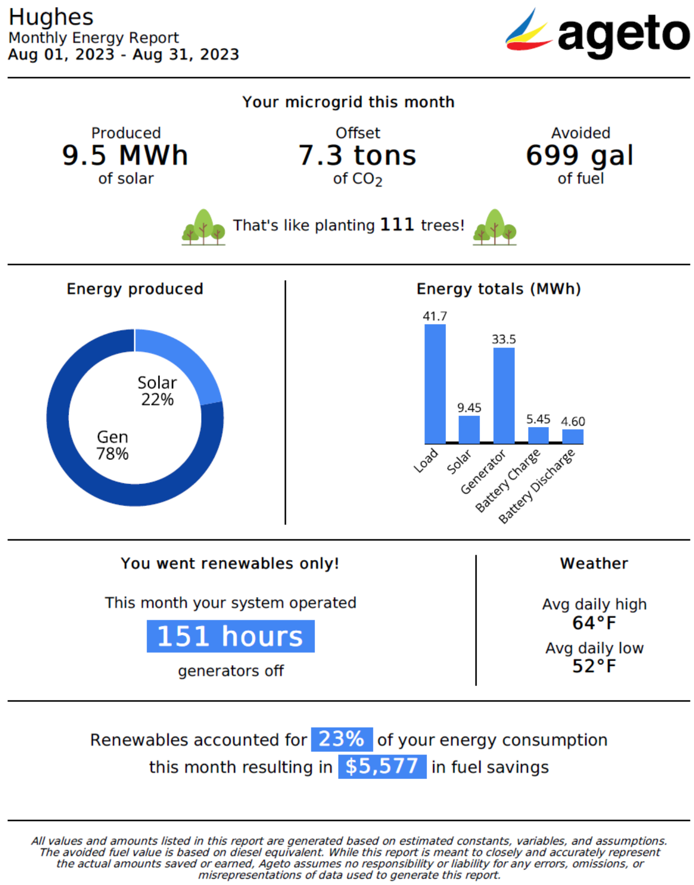

Figure 3. Monthly Report that Hughes (City and Tribe) receive, describing the impact from the hybrid Battery/Solar System

6.0 Lessons Learned

Despite encountering formidable challenges such as the disruptions caused by the COVID pandemic, logistical hurdles in material transportation, and supply chain constraints, the Hughes Village Council persevered in realizing their renewable energy vision. By capitalizing on local labor and leveraging traditional knowledge alongside the expertise of skilled contractors and engineers, the project navigated these obstacles with resilience and ingenuity.

This approach not only facilitated the successful completion of the solar and battery installation but also fostered a sustainable framework for future endeavors. It empowered the region to achieve self-sufficiency in implementing similar energy projects, cultivating a sense of community ownership and resilience. This combination of local labor and expert guidance not only ensures the success of individual projects but also contributes significantly to the broader goal of tribal energy sovereignty, setting a precedent for sustainable development in remote regions.