Kokhanok Mini-grid Business Case Analysis

November 2017

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Abstract

A business case analysis was performed for the Village of Kokhanok for an islanded mini-grid. The business case analysis evaluated the optimal mini-grid configuration from the technical analysis performed by the National Renewable Energy. The optimal configuration provided for repairing the two Vestas 17 (90 kW) wind turbine controllers and added electric thermal stoves and a battery. The project cost $0.5 million. The direct cost of electricity would likely decline from $0.69/kWh to $0.39/kWh. The direct costs don't include administrative and distribution costs. The repair of controller and the addition of electric stoves reduced fuel consumption by 63% or approximately 22,000 gallons. The reduction in cost provides an opportunity for the Kokhanok Village Council to obtain financing through grants and loans to install renewable energy and reduce diesel fuel consumption to the cooperative.

Summary

Kokhanok requested an analysis of a potential renewable energy retrofit of their diesel mini-grid that could lower their consumption of diesel fuel. HOMER, a mini-grid analysis tool developed by the National Renewable Energy Laboratory (NREL), was used to evaluate options that minimized the net present cost to the village and its utility. The options were compared to the net present cost of current diesel generation and the thermal load of the village. The options evaluated included combinations of solar, wind, hydro, batteries, and electric thermal stoves to use renewable electricity that would otherwise be spilled. Electric thermal stoves allow excess renewable energy to be used when village electric demand is less than the renewable generation available. The lowest net present cost option became the basis for the business case analysis.

Kokhanok currently has two Vestas V17 (90 kW) wind turbines with no mechanical problems but are not functioning as a result of controller problems; they are disconnected from the mini-grid. Thus, a mini-grid design consisting of reconnecting and operationalizing the two existing wind turbines was analyzed in conjunction with the potential to expand renewable energy and reduce diesel fuel dependency. The lowest net present cost option restored operation of the two Vestas wind turbines (180kW) and added 125 kW of electric thermal stoves and a 120 kW battery and costs an approximate $0.5 million.

The direct cost of electricity would be reduced from an estimated $0.690/kWh to $0.387/kWh[1] if provided by Kokhanok Village Council, the village utility company rather than an energy services company (ESCO). The analysis assumes that the utility purchases the electric thermal stoves and customers pay approximately $0.030/kWh hour for their usage. If no residents wish to use (although unlikely) the electric thermal stoves, the direct cost of electricity would rise to $0.401/kWh to cover the costs of the stove. The amount of diesel fuel consumption declines from just more than 35,000 gallons per year to less than 13,000 gallons, reducing total fuel consumption by 22,000 gallons (63% reduction) for Kokhanok. The significant reduction in fuel is offset by the added costs of fixing the turbines and adding batteries and electric thermal stoves. If residents don't use the electric thermal stoves, approximately 181,000 kWh of wind turbine generation output would be wasted. Residents could afford to pay up to $0.25/kWh and still break even on the estimated cost of residential fuel oil based on the current 2017 price of home fuel oil.

The best case presented above was one of forty alternative mini-grid designs that were evaluated including the base case consisting of no improvements in energy efficiency (EE) and discount rates at 4% and 8%. Wind generation was evaluated from 180 kW to 450 kW in 90 kW increments, equal to the power rating of a single turbine. Batteries were optimized and in some cases reached 120 kW. Hydroelectric generation and solar were considered, but never included in the least cost set of mini-grid components.[2]

The diesel generation capacity at the village is currently 452 kW provided by four diesel generators varying in size between 60 kW and 160 kW. Each mini-grid design considered adds more renewable resources to the baseline, reducing the amount of diesel fuel (and heating oil due to the electric thermal

[1] The direct costs of electricity don't include any administrative or distribution costs. They contain only the costs of the fuel, O&M, and initial capital and replacement costs. Thus the costs discussed should be considered as relative costs. The savings between the baseline and the option provide the best alternative.
[2] D. Olis, T. Jiminez. June 2017. "Kokhanok Energy Configuration Analysis and Conceptual Design." National Renewable Energy Laboratory, NREL/PR-5000-70575.

stoves) that are required to meet electricity and heating needs up to the capacity of the village electricity demand is met. However, there is a large step in the cost of wind turbines when moving from two to three turbines as the third turbine must be installed whereas the first two are already in place.

The selected 180 kW wind system with batteries, converters and thermal stoves costs $0.5 million repaired and installed. The tribal utility is assumed to require a 4% rate of return on their investment, their weighted average cost of capital plus risk premium whether the capital comes from equity, grants and/or loans. Tribal entities need to recover the cost of debt, which could be the municipal bond market, bank for cooperatives, grants, or bank loans. The municipal bond market is based on the credit worthiness of the institution borrowing money. Small villages are unlikely to have a bond rating to provide a basis for repayment risk. They may be able to receive grants and government subsidized loans to add to their infrastructure to reduce diesel oil consumption.

The primary risk associated with adding renewable energy to the village is failure to repay any funds borrowed to finance the project. Based on review of the options available, the project will need to find a grant for a portion of the capital costs and debt for the remaining costs as it appears that grants no longer fully fund projects. The village's track record of not keeping the wind turbines operating makes this the primary risk if grants to fully fund the project aren't available. In addition, regardless of how the village chooses to fund the project (as part of the Kokhanok Village Council, a limited liability company, or contract with an energy services company (ESCO)), the electricity price risk falls primarily upon the customers of that company. They may face increased electricity rates should an unexpectedly large portion of the electricity be provided by the diesel generators instead of underperforming renewable generation. The increased diesel generation will result in a higher variable cost of electricity. The PCE subsidy may ameliorate the risk as long as residential consumption doesn't rise above 500 kWh per household.

An ESCO reflects returns for a for-profit entity and brackets the upper end of the return required. ESCO operators would require a 7%-10% cost of capital. ESCO's would provide electricity as service to the village rather than using the tribal utility. The optimal facility and the capital required might be large enough to attract an outside entity. The price of electricity given the 10% return would require an approximate $0.37-$0.38/kWh, significantly above that of the local utility but still below the assumed direct price of diesel ($0.46/kWh) and diesel O&M ($0.22/kWh). In addition, there is some risk that the production tax credit (PTC) would expire by the time construction begins. The PTC for wind expires December 31, 2019. In addition, the PTC provides only 40% of the original $0.023/kWh, or $0.009 for 10 years for projects qualifying in 2019.[3]

[3] DSIRE. 2016. "Renewable Electricity Production Tax Credit (PTC)." Last updated May 24, 2016. Accessed August 24, 2017 at http://programs.dsireusa.org/system/program/detail/734

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The authors would like to thank Virginia Fay of University of Alaska Anchorage's Institute of Social and Economic Research for her guidance and feedback in understanding the unique challenges of rural communities in Alaska.

Acronyms and Abbreviations

CREBS – Clean Renewable Energy Bonds
Elec – Electricity
ESCO – Energy Services Company
EPC – Engineering, Procurement and Construction
FY – Fiscal year
Gal – Gallon
HOMER – Hybrid Renewable and Distributed Generation System
ITC – Investment Tax Credit
kW – kilowatt
kWh – kilowatt hour
MW – megawatt
MWh – megawatt hour
NEPA – National Environmental Protection Act
O&M – Operations and maintenance
PTC – Production tax credit
PV – Photovoltaic
RE – Renewable Energy
REAP – Rural Energy for America Program
USDA – US Department of Agriculture
USDOE – US Department of Energy

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1.0 Introduction

Kokhanok requested an analysis of a potential renewable energy retrofit of their diesel mini-grid that could lower their consumption of diesel fuel. This paper provides the business case for the optimal solution undertaken by the technical team reviewing potential options for Kokhanok. HOMER, a mini-grid analysis tool developed by the National Renewable Energy Laboratory was used to evaluate options that minimized the net present cost to the village and its utility. The options were compared to the net present cost of current diesel generation and the thermal load of the village. The options evaluated included combinations of solar, wind, hydro, batteries, and electric thermal stoves to use renewable electricity that would otherwise be spilled. Electric thermal stoves allow excess renewable energy to be used when village electric demand is less than the renewable generation available. The lowest net present cost alternative became the basis for the business case analysis.

Kokhanok currently has two Vestas V17 (90 kW) wind turbines with no mechanical problems but are not functioning as a result of controller problems; they are disconnected from the mini-grid. Thus, a mini-grid design consisting of reconnecting and operationalizing the two existing wind turbines was analyzed in conjunction with the potential to expand renewable energy and reduce diesel fuel dependency. The lowest net present cost option restored operation of the two Vestas wind turbines (180 kW) and added 125 kW of electric thermal stoves and a 120 kW battery and costs an approximate $0.5 million.

2.0 Background

Kokhanok is a rural village located in Lake and Peninsula Borough in Southwest Alaska with a population of 152 in 2016.[4] Currently, Kokhanok obtains all its electricity through diesel-fueled generators. However, they have two Vestas V17 wind turbines that no longer operate because of controller failure. Most of the homes are not thoroughly insulated nor do they have energy-efficient appliances.

The village receives its electricity from four diesel generators with a total combined capacity of 452 kW. Current diesel electricity generation provides 0.42 MWh per year to the community, and is assumed to stay constant over the 20-year analysis. Peak electric demand for the year occurs in March at just over 80 kW. [5] Diesel consumption for 2016 increased to 35,332 gallons[6] at an average price of $4.11/gallon[7], down from 41,365 gallons in 2015. The diesel price for Kokhanok was higher in May-October 2013, reaching $6.36/gallon.[8] Residential housing is primarily heated by fuel oil. In the analysis, the price of home heating fuel oil is assumed to be $8.03/gallon. Low temperatures during the winter can reach as low as -31°C with a January average of -9.5 °C.

The base rate for electricity is $0.90/kWh. The average rate, calculated across all kWh sold to all consumers, was $0.55/kWh in 2016. The State of Alaska Power Cost Equalization (PCE) program attempts to lower the price of electricity in rural areas of Alaska based on electric rates in Anchorage, Fairbanks and Juneau. The program primarily offsets the price of energy for the first 500 kWh of electricity used per month for residential customers. In Kokhanok for 2016, the PCE program reduced the effective price of electricity to residential consumers by $0.49/kWh cents (from $0.90) to $0.31/kWh. The nonfuel expenses were reported at $0.15/kWh.[9]

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[4] State of Alaska Department of Department of Labor and Workforce Development, Accessed October 4, 2017 at http://live.laborstats.alaska.gov/pop/index.cfm

[5] D. Olis, T. Jiminez. June 2017. "Kokhanok Energy Configuration Analysis and Conceptual Design." National Renewable Energy Laboratory, NREL/PR-5000-70575.

[6] Alaska Energy Authority; Remote Alaska Communities Energy Efficiency Competition: Phase II Summary and Strategic Energy Efficiency Plan – Kokhanok; 2016 Aug 19

[7] Alaska Energy Authority. 2017. Power Cost Equalization Program: Statistical Data by Community – Reporting Period: July 1, 2015 to June 30, 2016. Accessed at http://www.akenergyauthority.org/Portals/0/DNNGalleryPro/uploads/2017/2/28/FY16PCEAnnualCommunity.pdf

[8] Alaska.edu. Alaska Data Gateway – Community Data Summary: Kokhanok. https://akenergygateway.alaska.edu/community-data-summary/1400188/#detail-fuel

[9] *Alaska Energy Authority; FY 2012 – FY2016 Annual PCE Statistical Reports by Community. http://www.akenergyauthority.org/Programs/PCE*

Figure 2-1: Regional map of Kokhanok. Source: Google Maps

See Table 2-1 for diesel prices from FY2012-FY2016. The table also indicates the cost of electricity sold over the same period. In addition, note the high line losses shown in 2012 (8.2%) and 2013 (9.6%). Powerhouse consumption has been rising, up from 6% in 2013 to 9% in 2016.

Table 2-1: PCE statistics, 2012-2016[10]

Year (FY)	FY2012	FY2013	FY2014	FY2015	FY2016
Diesel cost ($/gal)	$5.58	$5.99	$5.96	$4.95	$4.11
Diesel consumption (gal.)	34,353	33,184	39,466	41,365	35,332
Elec. cost ($/kWh)	$0.59	$0.64	$0.95	$0.78	$55.00
Elec Generation (MWh)	483,843	509,361	437,928	416,261	420,600
Elec Consumption (MWh)	414,418	428,518	372,327	354,821	363,116
Line loss (%)	8.2	9.6	7.3	6.9	4.8

[10] Ibid.

Figure 2-2: Aerial view of Kokhanok. Source: Google Maps

3.0 Project Objective

The Project retrofits the mini-grid for Kokhanok composed of renewable energy resources including a mix of wind, batteries, and thermal stoves. The retrofit replaces electricity generated by existing diesel generators to reduce the dependence on expensive diesel-fuel generated electricity. Diesel prices for electricity generation rose as high as $6.36/gallon in 2013 and averaged $5.32/gallon over the years 2012-2016. The analysis assumed a $5.60/gallon diesel price for electricity generation. The project expects to reduce diesel fuel consumption for electricity generation by 63% as compared to baseline levels due to the repair of the wind facilities and installation of the thermal electric stoves, converters and batteries. The battery bank and converter are sized to cover lulls in the wind during diesel-off operation.

The project will also reduce the demand for heating oil through the use of electric thermal stoves that use surplus renewable energy (energy generated by renewable resources that exceeds the demand for electricity). Electric stoves bought by the utility and leased to customers (only if they opt in) with low-cost renewable electricity may provide a greater return to the utility on renewable energy that will otherwise be spilled. In addition, proposed energy efficiency projects for buildings will reduce the demand for electricity and fuel oil reducing overall demand for diesel and heating oil. This business case only provides an analysis of the mini-grid developed for the village and assumes that any energy efficiency improvements are realized by other means and assumed to be completed prior to the beginning of the operation of the upgraded mini-grid. These upgrades provide a reduced thermal and electrical load on which the mini-grid operates over the project life.[11] The technical project analysis evaluated renewable energy resources with and without the energy efficiency upgrades and the renewable energy and energy efficiency cases provided the lowest net present cost. The project expects to reduce the cost of electricity and improve environmental conditions through the use of renewable resources.

The business case evaluated the feasibility of the Tribal Council utility retrofitting their mini-grid with the renewable resources in this plan. The tribal utility has a multitude of incentives that can be used to improve the internal rate of return. In this analysis, the utility was assumed to obtain a grant for the equity portion and a loan from one of the funding agencies available to tribal entities. The following programs may provide funding: Alaska Native corporations, the Power Project Loan Fund, Renewable Energy Grant Program. Clean Renewable Energy Bonds (CREBS), and the USDA – Rural Energy for America Program (REAP) Grants. The Renewable Energy Grant from the Alaska Energy Authority (AEA) currently has received no new funding and has a waiting list. In addition, if investment requirements are met, Kokhanok Village Council could potentially obtain financing through other alternatives such as the DOE loan guarantee program. The DOE loan guarantee program is administration dependent, although there is $4.5 billion authorized as of October 2015.

[11] D. Olis, T. Jiminez. June 2017. "Kokhanok Energy Configuration Analysis and Conceptual Design." National Renewable Energy Laboratory, NREL/PR-5000-70575.

4.0 Project Description

The retrofitted mini-grid proposed includes the repaired 180 kW of wind combined with a 120 kW battery and 125 kW of electric thermal stoves (Figure 4-1). The total cost of the proposed installed project is $0.5 million. The project will also include the accompanying switchgears, controllers and software required to operate the mini-grid. The proposed option was the optimal configuration based on an analysis using HOMER and was selected from an array of options that included wind, solar, batteries and thermal stoves. The mini-grid installed will supplement and reduce diesel consumption used in current generation by almost 19 thousand gallons per year.

The installed costs, operating costs and assumed lifetimes for each of the resources are shown in Table 4-1. The installed costs reflect the harsh climate in Alaska as well as the remoteness of the community. No values for diesel generators were included; any existing generation in the village was assumed to be new and is treated as sunk costs. The diesel generators are assumed to last 60,000-100,000 hours and due to their low usage in the optimal solutions, they were not replaced during the 20-year project lifetime. The renewable resources are expected to have a 20 year life. The assumptions are based on the baseline values in HOMER.

Fixed O&M costs for diesel generation are not avoidable while diesel fuel costs are avoidable. Note that some non-fuel O&M costs associated with the diesel are hourly, meaning that they are only incurred if the diesel generator is operating. Thus if diesel generation is to be maintained in the village, fixed O&M costs are required regardless of the extent to which the diesel operates, but hourly O&M and fuel charges change by the amount of time the diesel generation is operated. Similarly, O&M for renewables such as wind and solar are considered variable because they are still future costs and can't be avoided. They are also dependent on run-time hours.

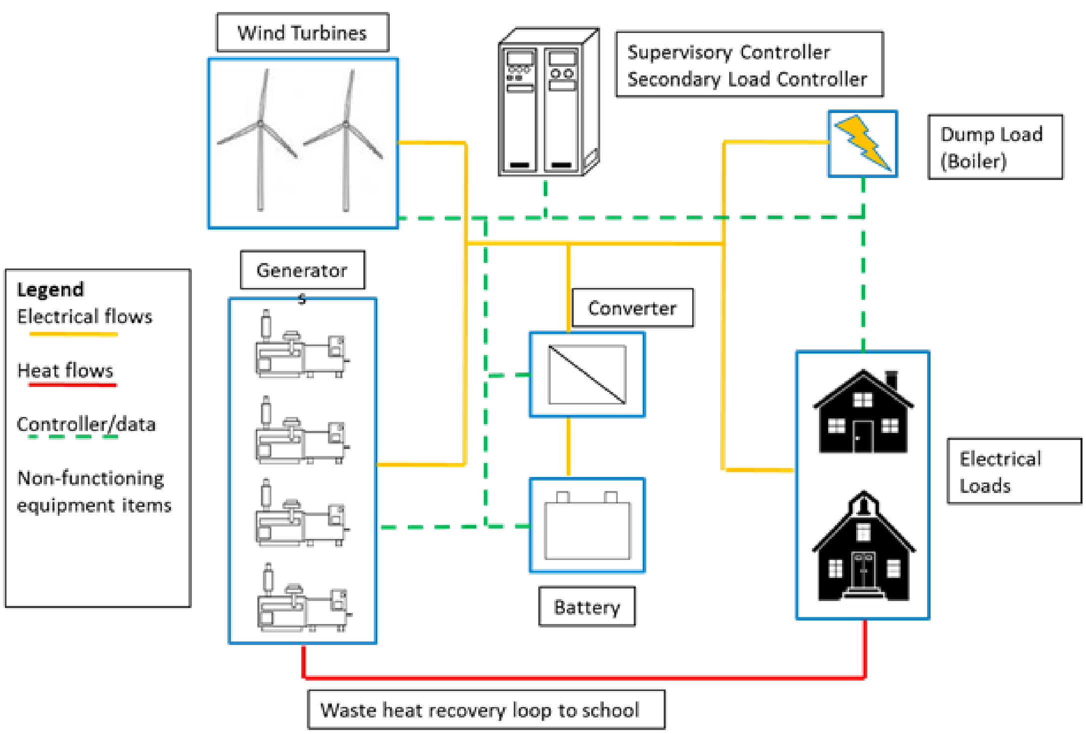

Figure 4-1: Project schematic of the mini-grid retrofit to be implemented

Table 4-1: Resources and assumptions used in the analysis

Wind Turbines (No. of 90 kW)	2	3	4	5
Installed Capital Cost ($/Turbine)	200,000**	900,000	1,600,000	2,300,00
O&M ($/kW)	80	80	53	27
Lifetime (years)	20	20	20	20
Solar PV (kW)	100	300	500	800
Installed Capital Cost ($/kW)	5,000	5,000	5,000	5,000
Solar PV O&M ($/kW)	20	20	20	20
Lifetime (years)	20	20	20	20
Batteries (kW)	120	400		
Installed Capital Cost ($)	134,000	382,000		
Battery Replacement Cost ($)	112,125	178,500		
Batteries O&M ($/year)	4,000	6,000		
Lifetime (Number of Cycles)	Number of years option dependent			
Converter capacity (kW)	60	320		
Converter Installed Costs	102,500	382,000		
Replacement Costs ($)	90,142	178,000		
O&M ($/year)	1,600	2,400		
Lifetime (years)	15	15		
Electric Thermal Stove Capacity (kW)	100	300	600	900
Installed Cost	60,000	160,000	310,000	460,000
Diesel 60 kW O&M ($/hr)	6.00			
Diesel 60 kW fuel ($/kWh)	0.3347			
Diesel 117 kW O&M ($/hr)	11.70			
Diesel 117 kW fuel ($/kWh)	0.3317			

*Data were not available for the Diesel 115 and 160 kW /and therefore weren't used in the modeling.
**The cost for the two turbines is the cost of repairing the system.

The characteristics of the batteries used in the analysis are shown in Table 4-2. Note the largest size in the table is 100 kW/100 kWh. The battery has a $50,000 integration cost and then is estimated to cost $700/kW for the first 200 kW and $480/kW over 200 kW installed. The replacement costs are slightly lower with an initial cost of $37,500 instead of $50,000. Converter upfront costs are similar. Replacement of the battery was assumed to be at end of year 10 while replacement of the converter was assumed to occur at the end of year 15. Normally battery life is cycle specific and thus not based on years.

Table 4-2: Battery statistics by size

Item	Bat 100/100	Bat 50/50	Bat 10/10
Cost	$150,000	$100,000	$60,000
Operational Cost	$0 Dollars/Hour	$0 Dollars/Hour	$0 Dollars/Hour
Charging Efficiencies	89.4%	100%	89%
Discharging Efficiencies	89.4%	100%	89%
Energy Capacity	100 kWh	50 kWh	10 kWh
Max Charge Rate	100 kW	50 kW	10 kW
Max Discharge Rate	100 kW	50 kW	10 kW
Min State of Charge	10%	10%	10%
Max State of Charge	90%	90%	90%
Desired State of Charge	0.7	0.7	0.7

5.0 Alternatives Studied

Twenty alternatives were evaluated using HOMER[12] (see the technical report); a base case (existing diesel-only configuration) was created in order to create a baseline against which the diesel fuel consumption in the prospective mini-grid configurations could be compared. Each alternative also included an option on whether electric thermal stoves could be used as an alternative load for otherwise unneeded renewable energy. Additionally, evaluations were made with and without the assumptions of energy efficiency upgrades being made prior to the operational period of the mini-grid.

The renewable alternatives evaluated the level of wind, the kW and kWh of storage of the battery, and the total installed capacity of the electric thermal stoves that minimized the net present cost. Alternatives for wind up to 5 turbines were considered. Battery capacity was evaluated between 0 and 120 kW, while electric thermal stoves were evaluated between 0 and 400 kW (each stove being rated at 6 kW). The number of electric thermal stoves that could be installed was limited by the estimated thermal load for the village. Solar PV was considered but did not enter any of the solution alternatives because it was not cost effective. Hydro generation was not considered due to a lack of an available resource.

The diesel generation capacity at the village is currently 452 kW. The diesel generators use about 32 thousand gallons of fuel each year in the baseline analysis or about, 13.7 gallons per hour per generator. Each alternative generation option adds more renewable resources to the baseline, reducing the amount of diesel fuel and heating oil that are required to meet electricity and heating needs.

The option that provides the lowest net present cost to the village repairs the two Vestas with a capacity of 180 kW and adds 120 kW of batteries and 125 kW of electric thermal stoves at a 4% discount rate. The wind turbines generate 0.41 million kWh per year, 0.18 million kWh of which are used by the electric thermal stoves. The option reduces diesel fuel consumption (used for electricity generation) by more than 63% and overall fuel consumption by only 25% (Table 5-1). The 180 kW wind facility with batteries and electric thermal stoves was selected for displaying the sources and uses, income statement and cash flow pro forma for the Kokhanok Village Council.

Table 5-1: Annual heating and diesel fuel expenditures in the Baseline and Optimal cases

	Baseline Case	Optimal Case
Total $	$714,000	$446,000
Heating fuel	$518,000	$373,000
Diesel fuel	$196,000	$73,000

[12] D. Olis, T. Jiminez. June 2017. "Kokhanok Energy Configuration Analysis and Conceptual Design." National Renewable Energy Laboratory, NREL/PR-5000-70575.

6.0 Permitting

Major wind permitting issues may not exist for Kokhanok to repair their wind system. However, if federal funding is required to implement the repairs and battery placement, federal permits may be required to assure that all the federal requirements have been complied with. Local and/or state land-use permits may be required for battery placement due to the hazardous waste components involved and the containment issues usually required to avoid spillage. Disposal issues may need to be addressed before construction begins due to replacement at the end of year 10 and at project completion.

The project will need to determine the state and local permits required to site wind and battery facilities at the village. Alaska's Department of Environmental Conservation, Department of Natural Resources, State Historic Preservation Office, Regulatory Commission and Department of Transportation and Public Facilities need to be contacted to determine what permits are required for the sites to be used for renewable energy. In addition, Federal agencies such as the Bureau of Land Management, Environmental Protection Agency, Federal Aviation Administration, the US Army Corps of Engineers and the Bureau of Indian Affairs may be involved in the permitting process.[13] These agencies will help address the permits required to address land use, land access, noise, navigable air space, subsistence and cultural impacts, biological resource impacts, visual impacts, wetland disturbance, water quality and public health and safety. The lists below are some of the permits that may be required but is not all inclusive.

Federal permits are dependent on whether the project is sited on federal land or includes federal involvement such funding or loan guarantees. The National Environmental Protection Act (NEPA) requires compliance if the project is on federal land or has federal funds involved. Federal Special Use Permits and Right of Ways may be needed if facility is on federal land or uses federal land to access the project. A permit may be needed for response to the Endangered Species Act. If the project imposes a hazard to air traffic, a hazard determination will need to be undertaken. Impacts to the Clean Water Act will require permits.

State permits will be required if the project impacts fish-bearing waterways, impact cultural, historic or archaeological sites. State permits may also be required if the project crosses state lands.

Local village authorities need to be consulted as well to meet local planning commissions and zoning issues. Local permits may include building codes, setbacks and zoning restrictions.[14]

Typical federal permits include:

- National Environmental Policy Act. The lead agency will depend on land jurisdiction and requires a review of the environmental impacts of proposed actions. The permit is needed if the project is on federal lands; there is a need to access a federally owned transmission line; or there is any funding from federal grants.
- Federal Special Use Permits and Right of Ways. The lead agency will vary depending the land jurisdiction. The permit is required when turbines are placed on federal land.

[13] Alaska Energy Authority. 2011. Community Wind Toolkit: A Guide to Developing Wind Energy Projects in Alaska. Renewable Energy Alaska Project (REAP). Accessed October 5, 2017 at http://www.akenergyauthority.org/Content/Programs/AEEE/Wind/PDF/WindToolkit_For%20web_FINALMarch24_2011.pdf

[14] Renewable Energy Alaska Project. March 2011. "Community Wind Toolkit: A guide to Developing Wind Energy Projects in Alaska." Access June 7, 2017 at http://www.akenergyauthority.org/Content/Programs/AEEE/Wind/PDF/WindToolkit_For%20web_FINALMarch24_2011.pdf

- Notice of Proposed Construction. The Federal Aviation Administration requires permits when structures are higher than 200 feet (~60 meters). Additionally, the permit is required when tower is within 20,000 feet of a public use airport with a 3,200 foot runway or is within line of sight of an air defense facility.
- Endangered Species Act. The US Fish and Wildlife service regulates activities where construction or turbine operation threatens endangered species.
- Bald and Golden Eagle Protection Act. The US Fish and Wildlife service regulates activities where construction or turbine operation threatens bald or golden eagles. Golden eagle nests may need to be moved.
- Migratory Bird Treaty. The US Fish and Wildlife service regulates activities where construction or turbine operation threatens migratory birds.
- National Historic Preservation Act. National Historic Preservation Act. The Advisory Council on History Preservation and the Tribal Historic Preservation have jurisdiction to review any impacts to historic and Tribal resources. Action required if the activity impacts tribal resources or the site contains property eligible or listed on the National Register of Historic Places
- Clean Water Act. The Environmental Protection Agency regulates impacts on waters of the United States when there is a potential for discharge due to construction of wind facilities. The US Army Corps of Engineer may be included if construction activity includes dredging or fill material into waterways or wetlands.

Typical state permits include:

- Fish and Essential Fish Habitat. Alaska Department of Fish and Game provides for mitigation measures if a wind turbine site impacts fish habitat. The permit is required if construction requires crossing a fish-bearing water.
- Cultural, Historic and Archeological Resource Consultation/Studies/Permits. The State Historic Preservation Office requires permits when a site is identified that could impact or alter cultural resources.
- Alaska Coastal Management Program. The Alaska Department of Natural Resources regulates sites that are within the Coastal Zone area which includes land up to 200 miles from the coast.
- Land Use, Easements and Right of Ways. The Alaska Department of Transportation regulates projects that have transmission or property on or along property managed by the department.
- Hazardous Materials Permit. Department of Transportation requires permits for hauling batteries due to their hazardous waste content.

7.0 Risks

There are a number of risks faced by Kokhanok utility. The risks include repayment, fuel price, human capital and operational, costs, regulatory, technical, contracting, interest rates and Federal incentives. Each of these risks may have more than one root cause. In addition, other considerations such as sinking funds, project size and collateral issues should be considered. The risks stated here need to be evaluated and included in the analysis when a complete risk analysis of the project is undertaken.

7.1 Financial risks

Repayment risk. The primary risk associated with adding renewable energy to the Kokhanok is repayment risk. The leading cause of the repayment failure is lower than expected renewable generation. Wind generation may not follow historical patterns and less electricity could be generated. In addition, the harsher climate in Alaska may cause more downtime than occurs in milder climates. Both of these issues lead to more diesel generation and higher electricity costs. As a result, consumers face increased electricity rates over those anticipated. The higher rates, in turn, may lead to more payment delinquency. Increasing costs could exacerbate the repayment risk. Due to the potential for higher than expected bills, financiers may evaluate this risk and ask for a working capital fund to make payments in case of a revenue shortfall. Even though working capital earns interest, it still increases the cost of the project as it is either funded from equity (which is higher cost) or from the operating loan, both of which have higher costs than the potential interest earned.

Fuel prices. If fuel prices are lower than expected, less savings would occur and renewable energy could be more costly than diesel fuel-driven electricity from a full cost perspective. Higher future oil prices would provide even more savings and make the ESCO option profitable. However, if the project is already in place, lower than expected fuel prices would decrease the cost of electricity, because once the equipment is installed most of the costs are fixed and only a relatively small renewable O&M cost is required. Renewable energy will likely still be less expensive from a variable cost perspective.

Human capital risk. Human capital risk is higher in remote villages where the access to labor with the correct skills to operate and maintain a mini-grid may be more limited than in larger urban areas. The opportunity cost to individuals with the skills required to manage, operate and maintain a mini-grid may be higher than remote villages can afford. The individuals need product knowledge of the mini-grid equipment as well as an understanding of the proposed renewable energy systems. They will need knowledge and understanding of the electrical systems including batteries and the capability to manage a more complex distribution system and managing administrative and business management issues. The issue for Kokhanok is not clear about what type of human capital risk is being faced. However, the system has not been repaired which will be a concern to potential financiers. The village may need to use a cooperative or ESCO approach if they don't believe they have the expertise to operate the wind facility. An ESCO may be an alternative, as well, if a cooperative won't undertake the project. However, the ESCO costs are estimated to be greater than the fuel costs of the current facility which would mean that electricity costs could rise to ensure that the ESCO's required rate of return or hurdle rate is met.

Cost Risk. Cost risks have the potential to reduce operating income. Unexpected increases in the costs of labor, materials and supplies in conjunction with projects that have a limited ability to raise prices and thus revenue, can adversely affect operating income. For an ESCO, changing tax rates can also provide a source of cost risk to the project, although it is only lowering the after-tax return rate. The project should remain financially feasible.

Regulatory risk. Financiers will want to see regulatory risk well-defined and the process well-established for obtaining all permits required to begin construction. Without a well-established permitting process and with the time to completion of permitting unknown, financing will need to be from alternative sources such as grants and/or village equity. They will also evaluate the impact of potential changes in regulations and whether they could adversely impact permitting time and designs and in turn the construction costs. Thus, having the project well defined and the permitting, design and construction period confined to a defined period will reduce regulatory risk. Drawn out processes increase the potential for regulatory change.

Technical risk. Financiers are also going to look at technical risk as it impacts the revenues and costs. Construction schedule slippage increases the costs of construction through both direct, overhead and interest costs. Added costs lead to a higher total loan costs during operations. In addition, poor quality construction cost estimates may lead to much higher construction costs. Financiers also review the maturity of the technology being implemented to assure that equipment operates as designed. Failures that reduce capacity factors impact revenue. In the case of the systems designed for the Kokhanok, the systems are mature. The risk is whether the technology will operate as expected in Alaska winters. Financiers will also evaluate whether any fixes they believe are necessary to make the system work as expected in Alaska's harsh winters may make the project financially infeasible. They will also investigate whether the operating parameters associated with O&M are well understood and the range of potential costs do not impact project debt coverage ratios.

Engineering, Procurement and Construction (EPC) risk. Financiers will also look at the EPC contracts to make sure that contracting risk is acceptable. They will look to see whether the dispute resolution process is defined and provides for cost-effective changes. The financiers will also evaluate default consequences for both community and the contractor and assure themselves the financial institution is not at risk. They will also assure themselves that if the project terminates that their losses are acceptable and minimized.

Interest rate risk. The project could face interest rate risk in the short and long term should the project be attractive to financiers. Construction interest rates may change during the design and permitting period. That could make the project less attractive. In addition, as the project goes forward, interest rates could rise during the construction period making the interest rates for the operating period less attractive. Lastly, as the project moves forward, the riskiness of the project could increase, swelling the spread between the index and the debt rate.

Federal and state incentives risks. Renewable incentives associated with most types of renewables have already expired. The renewable energy federal production tax credit (PTC) provides a tax credit (adjusted for inflation) per kWh of electricity produced. The wind PTC expires at the end of 2019. In 2017, the credit is $0.0184/kWh. The credit declines 40% in 2018, and 60% in 2019 from the 2016 base of $0.023. The PTC for all other technologies expired in 2016.[15] A 30% federal ITC is available for solar PV and thermal projects through 2019, after which there is a phased reduction in value of the credit until 2022 when the credit becomes 10% permanently.[16] The ITC is 26% in 2020 and 22% in 2021 (26 USC § 48(a)(6)). In addition, state incentives are not always completely funded. There is some risk the Alaska Energy Authorities Power Cost Equalization program may reduce incentives or that the Alaska legislature will not fully fund all of the incentive programs.

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[15] DSIRE – Database of State Incentives for Renewables & Efficiency. 2016. "Renewable Electricity Production Tax Credit (PTC)." Accessed January 2017 at http://programs.dsireusa.org/system/program/detail/734 (last updated May 24, 2016).

[16] DSIRE – Database of State Incentives for Renewables & Efficiency. 2015. "Business Energy Investment Tax Credit (ITC)." Accessed February 15, 2017 at http://programs.dsireusa.org/system/program/detail/658 (last update December 21, 2015).

7.2 Other issues associated with financing

Sinking funds. Once financing alternatives are investigated, the village may need to get grants to provide the upfront equity which will allow the financiers to see a minimum debt coverage ratio of 1.25. If there appears to be inadequate coverage for unusual events, the financier will probably require sinking funds to be set up to prepare for those shortfalls. The sinking funds may be associated with the capacity factor risk and other revenue shortfall risks such as rising fuel prices, capital replacement and major O&M repairs. Revenue risk may arise due wind speed variability, insolation variability, system downtime, equipment failure, and the time require to repair equipment in remote locations.

Project size. Another issue that may detract from ESCO participation is the project size. The project is somewhat small with the proposed mini-grid providing less than 180 kW of renewables which is only being repaired. Additionally, total investment is not significant at $0.5 million. The project may not provide adequate cash flow to provide an appetite for investment by an ESCO. In addition, ESCOs usually like to see short payback periods. If the project can payback in 7 years or less, investors are more inclined to participate. The project at a 10% rate of return pays back in 7-8 years.

Collateral issues. There may also be issues with what is considered acceptable collateral from the community. Renewable energy projects have little value if they are in remote areas and the power can't be exported and sold elsewhere. Additionally, the financier will want to see that the mortgagee has acceptable bookkeeping and billing systems to assure that repayment is made. In addition, communities may be forced to look for lenders of last resort because the remoteness and the amount of investment required may be too small to attract major lenders.

8.0 Financial Analysis of Selected Option

The project costs $0.5 million installed. The project *pro forma* assumes a weighted average cost of capital approach to the cost financing as the financing approach at this time is unknown. The Kokhanok Village Council as a village utility would likely require a nominal 4% rate of return as the cost of their capital if borrowed could be as high as 3% and inflation is assumed to add another 1% to the required rate of return. A source of funds could be Native Alaska corporations. There is a growing number of renewable energy projects financed for the production tax credits.[17] However, tax equity availability could shrink as the production tax credit expires. In addition, tribal corporations may qualify for the Tribal Energy Grant Program.[18]

An energy service company (ESCO) could provide an alternative approach that provides delivery of electricity services for a rate of return above that which the Tribal Council might require. As such the cost of electricity may rise but renewable energy resources may be more likely to remain viable. The ESCO require a cost of capital in the 6.8%-10% range after tax at least. We evaluated the ESCO at a 10% rate of return. The ESCO would have to pay Federal, state and/or local taxes depending on their location. (There could be tax implications based on the ownership of projects on tribal lands and should be investigated.) Complete equity financing is expensive so debt would probably be included. Thus, between a not-for-profit and an ESCO we have bracketed the relative electricity costs.

Bank financing is usually short term and based on points above the London Interbank Offered Rate (LIBOR). The 12-month LIBOR rate ranged between 2.7 and 3.0 over the last six months.[19] In addition, renewables projects have been financed with tax equity. Typical renewable energy developers don't have an appetite to reduce taxes so they partner with companies that do pay taxes and wish to reduce them. The tax equity usually requires 7.5-9.5% return on equity after taxes.[20] They usually require $75-$100 million in projects, so the ESCO would need more projects than an Alaska village to reach the tax equity appetite. The ESCO could also finance the projects based on its balance sheet which obtains debt secured by its assets. Corporate bond rates ranged as follows over the last five months: 10 year BBB+ bonds 3.79 to 4.02% and AAA 2.77 - 3.04%. Thirty year BBB+ bonds yielded between 4.9 and 5.24% over the last five months.[21] Thirty year US treasury rates are around 2.7-3.0% during May – October 2017. Institutional debt would be based on risk of the project above the treasury rate.

Municipal and cooperative entities need to recover the cost of debt, which could be the municipal bond market, bank for cooperatives, grants, or bank loans. The municipal market is based on the credit worthiness of the institution borrowing money. Over the last five months 30-year, AA municipal debt ranged between 2.75 and 3.88%.[22] Twenty-year debt is about 0.15% lower.

Small villages are unlikely to have a bond rating to provide a basis for repayment risk. They may be able to receive grants and government subsidized loans to add to their infrastructure to reduce diesel oil

[17] Currently, production tax credits are scheduled to end December 31, 2019.

[18] See DSIRE at http://programs.dsireusa.org/system/program/detail/918

[19] Global-rates.com. "12 month US Dollar LIBOR interest rate." Accessed October 4, 2017 at http://www.global-rates.com/interest-rates/libor/american-dollar/usd-libor-interest-rate-12-months.aspx

[20] Woodlawn Associates. 2017. "Tax Equity 101: Structures." Accessed May 30, 2017 at https://woodlawnassociates.com/tax-equity-101/

[21] New York Times. May 30, 2017. "Business Day Markets". Accessed May 30, 2017 at http://markets.on.nytimes.com/research/markets/bonds/bonds.asp

[22] fms bonds, Inc. 2017. "Municipal Bond Offerings." Accessed May 30, 2017 at https://trading2.fast-trade.com/fmsbonds/bondsearch.do?pager.offset=70

consumption. The following provides a short discussion of alternatives: Power Project Loan Fund, Renewable Energy Grant Program, Clean Renewable Energy Bonds (CREBS), and USDA – Rural Energy for America Program (REAP) Grants.

Power Project Loan Fund. The Alaska Industrial Development and Export Authority provides loans for renewable energy projects to local government, and municipal and cooperative utilities up to $5 million. Projects over $5 million require legislative approval. The interest rate varies but the highest rate is tied to municipal bond rates and maturity is set to useful project life. The power project loan fund can be a lender of last resort.[23]

Renewable Energy Grant Program. Upon state appropriation, renewable energy projects can receive grants to cover their costs. The legislature didn't appropriate funds for projects in 2016, so projects are being held over for funding on the next round. Projects are funded directly by the legislature depending on public benefit. The funding can be obtained by investor-owned, municipal, or cooperative utilities, state or local government, utilities, tribal government, and retail suppliers.[24]

Clean Renewable Energy Bonds (CREBS). CREBS can be issued by Tribal, local and state governments, and cooperatives to fund renewable energy projects. The bondholder receives federal tax credits to cover the interest cost while the issuer must pay the principal portion, thus an interest free loan from the issuer's perspective.[25]

USDA – Rural Energy for America Program (REAP) Grants. REAP grants are provided for installing renewable energy systems. The grants and loans are provided to commercial and agricultural producers and to entities that USDA chooses to fund. Grants can be up to 25% of project cost including design, permitting and construction. The remaining funds are provided in the form of a loan. Loan guarantees can't exceed $25 million.[26]

Some combination of the above funding sources might be used to meet the project funding requirements. In addition, the project may benefit from tax incentives if the utility pays federal, state or local taxes. Alaska provides for property tax exemptions for renewable energy systems. The federal government provides an investment tax credit (ITC) for solar which remains at 30% through 2019 and then declines to 10% by 2022. Geothermal receives a 10% ITC. Large wind receives an 18% ITC in 2018 and 12% in 2019 and none thereafter. Small wind receives no credit. Large wind is greater than 100 kW.[27] Large wind can receive a $0.0184/kWh production tax credit in 2017. The credit is reduced by 40% in 2018 and 60% in 2019 from the 2016 level of $0.023/kWh and discontinued thereafter.[28] The federal tax credits, however can only be used by entities that pay federal taxes.

The sources and uses of funds sheet shows that $0.5 million of funding is required from a mix of sources listed above. The marginal cost of electricity is $0.69/kWh for diesel generation only, with fuel providing

[23] DSIRE. 2015. "Power Project Loan Fund." Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/115

[24] DSIRE. 2016. "Renewable Energy Grant Program." Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/3080

[25] DSIRE. 2015. "Clean Renewable Energy Bonds (CREBs). Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/2510

[26] DSIRE. 2016. "USDA – Rural Energy for America Program (REAP) Grants." Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/917

[27] DSIRE. 2017. "Business Energy Tax Credit. Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/658

[28] DSIRE 2016. "Renewable Electricity Production Tax Credit (PTC)." Accessed May 30, 2017 at http://programs.dsireusa.org/system/program/detail/734

$0.460/kWh of the total. A price of $0.433/kWh will be required for an ESCO to breakeven to reach a 10% return after taxes without the production tax credit and $0.426/kWh with the tax credit assuming construction begins by December 31, 2019. Prices for electricity would need to increase approximately $0.01/kWh to recover the extra cost of the electric thermal stoves and additional wind capacity to operate the stoves if consumers would not accept the stoves. They make economic sense so consumers probably will accept them. In the ESCO/Cooperative approach, the ESCO was assumed to acquire the diesels free of charge.

The Kokhanok Village Council would need to repay the funding over the 20-year project life. Debt coverage ratios should never be lower than 1.25, a lender minimum. The utility will probably have to set up a sinking capital fund to cover replacement costs for the battery and converter as cash flow is negative in year 11. The utility would need to charge customers an average of $0.387/kWh for the electricity alone, should they decide to operate the facility. The prices would be $0.401/kWh if no one chose to use the electric thermal stoves. The remaining differences between projected prices and the prices listed here are distribution costs and overhead or General and Administrative (G&A) costs. See table 8-1.

Table 8-1: Marginal price of village utility and ESCO options

Alternatives	Kokhanok Utility	ESCO
Direct Electricity Price with Thermal Stoves used	$0.387/kWh	$0.433/kWh
Direct Electricity Price with Thermal Stoves not used	$0.401/kWh	$0.447/kWh

The two different prices for the utility provide a price range for the utility because of the uncertainty associated with consumer acceptance of electric thermal stoves. The electric thermal stoves breakeven for the consumer if the costs charged to them by the utility for electricity for the stoves is less than $0.25/kWh. In this case, consumers could be charged $0.030/kWh which is the annualized cost per kWh of stove use. The two different prices for each entity provide the range for the cost to the utility of the extra wind capacity should consumers opt 100% to lease stoves and 100% opt not to lease the stoves. The thermal stoves electricity cost less than the consumer's use of heating oil, thus the use of the thermal stoves are cost effective. However, to the extent that customers are unwilling to use the electric thermal stoves, the cost of electricity to the village will need to rise to cover the extra renewable energy generation capacity installed only for the use of the electric thermal stoves.

The primary non-financial benefits to the community resulting from reduced diesel fuel consumption would be reduce particulate pollution and improved air quality. The particulate matter includes ash, carbon, metallic abrasion particles, sulfates and silicates. The effects of particulate matter exposure include dizziness, headache, and irritation of the eye, nose and throat. Long-term exposure increases the risk of cardiovascular, cardiopulmonary, lung cancer, and respiratory problem.[29] An additional benefit is that it reduces the risk of rising electricity prices as diesel fuel prices rise because the village is no longer so directly dependent on diesel fuel for electricity and home heating.

The Sources and Uses of Funds (Table 8-2) evaluates the installed cost of capital and the costs of alternative sources of funding. The statement of earnings in Table 8-3 for the Kokhanok utility indicates that operating earnings provide adequate earnings at a 4% weighted average cost of capital to recover the facility costs over time. The cash flow statement (Table 8-4) provides the basis for the internal rate of return calculation.

[29] OSHA – Occupational Safety and Health Administration. 2013. Diesel Exhaust/Diesel Particulate Matter. Accessed October 4, 2017 at https://www.osha.gov/Publications/OSHA-3590.pdf

Table 8-2: Sources and uses of funds

USES OF FUNDS, in Millions of Mixed Year Dollars — Go To Main Menu — DEVELOPER'S SOURCES OF FUNDS — Table 5 of 24

Case Study:
Kokhanok
Microgrid Retrofit
Optimal Solution Kokhanok with Thermal Stoves (No demand growth)
Kokhanok Non-profit

Total Plant Cost (Overnight) w/ real esc 0.0%.				
Sales Tax	0.0%	0.000000		
PV	0.0%	0.000000		
Wind	39.3%	0.200000		
Diesel 100 kW	0.0%	0.000000		
Diesel 371 kW	0.0%	0.000000		
Li Ion 1 kWh Battery	26.3%	0.134000		
System Converter	20.1%	0.102500		
Electric Stoves	14.2%	0.072500		
Home Office OH	0.0%	0.00		
Misc. Depreciable Cost (last year of construction)		0.00		
Sales Tax on Misc. Depr. Cost (CTRL-M, Option 3)		0.00		
Of which, P&E - Renewable System	0.3620 *	depr		
(71.1% renewable * 100.0% depreciable)				
Plant & Equipment - Other	0.1 **	depr		
Geoth Depletable Base	0.0	depl		
Geoth First Year Exp.	0.0	exp		
AFUDC Debt - Renewable	0.00 *	depr	0.00	
Debt - Other	0.00 **	depr		
Debt - Deplet'bl	0.00	depl		
Debt - Exp	0.00	exp	yes	
Equity	0.00	20-yrs		

	0.00			
Debt Closing	30.0%	0.0	} amort	
Debt Underwriter/Broker	40.0%	0.0	} life of	
Debt Printing, Other	30.0%	0.0	} debt	
Equity Organizt'l Fee	30.0%	0.0	amort 5 yr	
Equity Tax Advice	30.0%	0.0	exp	
Equity Underwriter/Broker	40.0%	0.0	no write-off	
Startup/Inventory		0.0	non	
Land (for power plant)		0.0	non	
Debt Service Reserve (for Priv. ROR mode only)		0.0		
Other Reserve		0.0		

CHECK: Total Items (before credits)		0.51	vs. Yr. 1 Rate Base	0.51
		======	+ non-deduct eq exp	------

*** Debt	0.0%	0.0	@ 3.0% for 20 yrs
Equity	100.0%	0.5	@ 4.0% for 20 yrs
Disallowed Equity Broker		0.0	

		0.5	
*** 1: level, mortgage-style debt payments			

WEIGHTED COST OF CAPITAL COMPARISON^^
==============================

Before Tax	Constant $	Nominal $
Developer	4.00%	4.00%
Utility	2.23%	3.25%
After Tax		
Developer	2.97%	4.00%
Utility	2.23%	3.25%

^^A true comparison is not possible since the utility equity return is not taxed within the model.

TAX TREATMENT
======== ===

Combined Rate	Federal Rate: 0.0%	State Rate: 0.0%	
Sum of Renewable Depreciable Items		0.4 *	
Tax Credits ITC	0.0%	0.0	
ETC	0.0%	0.0	
state	0.0%	0.0	* (1 - 0.0%)
combined		0.0	
* Fedl Renew Deprec Base		0.4	@ 5yrs w/50%tax cred. reduction
State Renew Deprec Base		0.4	@ 20yrs w/100%tax cred. reduction
** Fedl Other Deprec Base		0.1	@ 15 yrs
** State Other Deprec Base	0.1		@ 50 yrs
Depletable Basis		0.0	
Geothermal Expensed		0.0	
Amortized - debt life		0.0	@ 20 yrs
Amortized - 5 years (Sec 709, 248)		0.0	
Expensed		0.0	
No write-off (Sec 709)		0.0	
20-yr equity AFUDC normalization		0.0	
Land/Startup		0.0	
Reserves		0.0	

		0.5	

Table 8-3: Income statement of project

EARNINGS STATEMENT | Go To Main Menu | **ROR MODE** | Kokhanok | AK | Microgrid Retrofit

	Tax Book Accounting	0	1	2	3	4	5	6	7	8	9	10
	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Byproduct Credit		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Reserve Interest Earned		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity Revenues		0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17
	Thermal Revenues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Municipal REPI		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A{	**Total Revenues**	0.00	0.1556	0.1572	0.1587	0.1603	0.1619	0.1635	0.1652	0.1668	0.1685	0.1702
	Feed One		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Feed Two		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Variable O&M		0.09394	0.09488	0.09583	0.09679	0.09776	0.09874	0.09972	0.10072	0.10173	0.10274
	Fixed O&M		0.01757	0.01775	0.01793	0.01811	0.01829	0.01847	0.01866	0.01884	0.01903	0.01922
	Land Rental		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
B{	Major Maintenance Expense		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Genl & Admin Exp		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Royalty Fee (on electric rev, NOT sum)		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Property Tax		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Insurance		0.00257	0.00260	0.00262	0.00265	0.00267	0.00270	0.00273	0.00276	0.00278	0.00281
	Gross Receipts Tax (on electric rev)		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Total Operating Expenses		0.11409	0.11523	0.11638	0.11755	0.11872	0.11991	0.12111	0.12232	0.12354	0.12478
C{	**Operating Income (A-B) B=Expenses**		0.0415	0.0419	0.0424	0.0428	0.0432	0.0436	0.0441	0.0445	0.0450	0.0454
	Interest Exp		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tax Depreciation		0.14	0.11	0.07	0.05	0.05	0.01	0.01	0.01	0.01	0.01
	Repair Depreciation		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D{	IDC & Depletion		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Amortization		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	State Income Tax (0 unless BT36=1)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	REPD Tax Deduction		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Interest, Depreciation, Depletion		0.14	0.11	0.07	0.05	0.05	0.01	0.01	0.01	0.01	0.01
E{	**Taxable Income (C-D) D=Fed Tax Deduct.**		(0.10)	(0.1)	(0.0)	(0.01)	(0.01)	0.03	0.04	0.04	0.04	0.04
	(Taxes Paid) Benefit	0.0 %Tax rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tax Credits		0.0000									
	REPC Tax Credit		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F{	Total Federal Income Taxes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Federal Taxes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Book Profit After Tax (E-F)		(0.10)	(0.07)	(0.03)	(0.01)	(0.01)	0.03	0.04	0.04	0.04	0.04

Table 8-3: Income statement of project (cont'd)

EARNINGS STATEMENT | Go To Main Menu | Optimal Solution Kokhanok with Thermal Stoves Kokhanok Non-profi Table 7 of 24

Tax Book Accounting

		0	11	12	13	14	15	16	17	18	19	20
	Year	2017	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
	Byproduct Credit		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Reserve Interest Earned		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity Revenues		0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19
	Thermal Revenues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Municipal REPI		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A{	**Total Revenues**	0.00	0.1719	0.1736	0.1753	0.1771	0.1789	0.1807	0.1825	0.1843	0.1861	0.19
	Feed One		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Feed Two		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Variable O&M		0.10377	0.10481	0.10586	0.10692	0.10799	0.10907	0.11016	0.11126	0.11237	0.11
	Fixed O&M		0.01941	0.01961	0.01980	0.02000	0.02020	0.02040	0.02061	0.02081	0.02102	0.02
	Land Rental		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
B{	Major Maintenance Expense		0.12509	0.00000	0.00000	0.00000	0.00000	0.10570	0.00000	0.00000	0.00000	(0.07)
	Genl & Admin Exp		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Royalty Fee (on electric rev, NOT sum)		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Property Tax		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Insurance		0.00284	0.00287	0.00290	0.00293	0.00295	0.00298	0.00301	0.00304	0.00307	0.0031
	Gross Receipts Tax (on electric rev)		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00
	Total Operating Expenses		0.25112	0.12728	0.12856	0.12984	0.13114	0.23815	0.13378	0.13511	0.13647	0.06450
C{	**Operating Income (A-B) B=Expenses**		(0.0792)	0.0463	0.0468	0.0472	0.0477	(0.0575)	0.0487	0.0492	0.0497	0.12
	Interest Exp		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tax Depreciation		0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Repair Depreciation		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D{	IDC & Depletion		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Amortization		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	State Income Tax (0 unless BT36=1)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	REPD Tax Deduction		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Interest, Depreciation, Depletion		0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
E{	**Taxable Income (C-D) D=Fed Tax Deduct.**		(0.09)	0.04	0.04	0.04	0.04	(0.06)	0.05	0.05	0.05	0.12
	(Taxes Paid) Benefit 0.0 %Tax rate		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tax Credits											
	REPC Tax Credit		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F{	Total Federal Income Taxes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Federal Taxes		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Book Profit After Tax (E-F)		(0.09)	0.04	0.04	0.04	0.04	(0.06)	0.05	0.05	0.05	0.12

Table 8-4: Cash flow statement for project based on 4% rate of internal return

CASH FLOW | Go To Cases Worksheet | Go To Main Menu | **ROR MODE** | Kokhanok | AK | Microgrid Retrofit

	Accounting of Actual N $'s Flowing Due to Project	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
G{	Total Revenues (=A on Earnings Stmnt)		0.15560	0.157	0.159	0.160	0.162	0.164	0.165	0.167	0.168	0.170
H{	Expenses (=B on Earnings Statement)		(0.114)	(0.115)	(0.116)	(0.118)	(0.119)	(0.120)	(0.121)	(0.122)	(0.124)	(0.125)
I{	Principal Payment		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
J{	Interest Expense (from ROW 370)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K{	Def Tax Depst/Wthdrwl(=0 IF $DEBT_TYPE =1)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sinking Fund		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
L{	Major Maint Deposit		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M{	Pre-Tax Cash Flow (G+H+I+J+K)		0.042	0.042	0.042	0.043	0.043	0.044	0.044	0.045	0.045	0.045
N{	State Taxes Paid (from ROW375)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
O{	Fed Taxes Paid (=F on Earnings Stmnt)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sinking Fund Payoff											
	After-Tax Cash Flow (M+N+O)		0.042	0.042	0.042	0.043	0.043	0.044	0.044	0.045	0.045	0.045
	Equity Investment excluding eq underwriter	(0.51)										
		(0.509)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05

Minimum Cash Flow (0.1)

NPV= (0.0) **IRR=** 4.00% Solved! Including equity underwriter, IRR is 4.00% Current $ after ta

Initial IRR Guess= 4.0 (%)

Table 8-4: Cash flow statement for project based on 4% rate of internal return (cont'd)

CASH FLOW | Go To Cases Worksheet | Go To Main Menu | Optimal Solution Kokhanok with Thermal Stoves Kokhanok Non-profit | Table 8 of 24

	Accounting of Actual N $'s Flowing Due to Project	2017	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
G{	Total Revenues (=A on Earnings Stmnt)		0.172	0.174	0.175	0.177	0.179	0.181	0.182	0.184	0.186	0.188
H{	Expenses (=B on Earnings Statement)		(0.251)	(0.127)	(0.129)	(0.130)	(0.131)	(0.238)	(0.134)	(0.135)	(0.136)	(0.065)
I{	Principal Payment		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
J{	Interest Expense (from ROW 370)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K{	Def Tax Depst/Wthdrwl (=0 IF $DEBT_TYPE =1)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sinking Fund		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
L{	Major Maint Deposit		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M{	Pre-Tax Cash Flow (G+H+I+J+K)		(0.079)	0.046	0.047	0.047	0.048	(0.057)	0.049	0.049	0.050	0.123
N{	State Taxes Paid (from ROW375)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
O{	Fed Taxes Paid (=F on Earnings Stmnt)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sinking Fund Payoff											
	After-Tax Cash Flow (M+N+O)		(0.079)	0.046	0.047	0.047	0.048	(0.057)	0.049	0.049	0.050	0.123
	Equity Investment excluding eq underwriter	(0.51)										
		(0.509)	(0.08)	0.05	0.05	0.05	0.05	(0.06)	0.05	0.05	0.05	0.12

Minimum Cash Flow (0.1)

NPV= (0.0) **IRR=** **0.51** **$Mil** **After tax discount rate** **4.00%**

Initial IRR Guess= 4.0 (%)

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