Connecting Remote Alaskan Villages using an Energy Storage Ready Medium Voltage DC Intertie

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Fig. 1: Proposed ~25-mile intertie between Ambler and Shungnak.

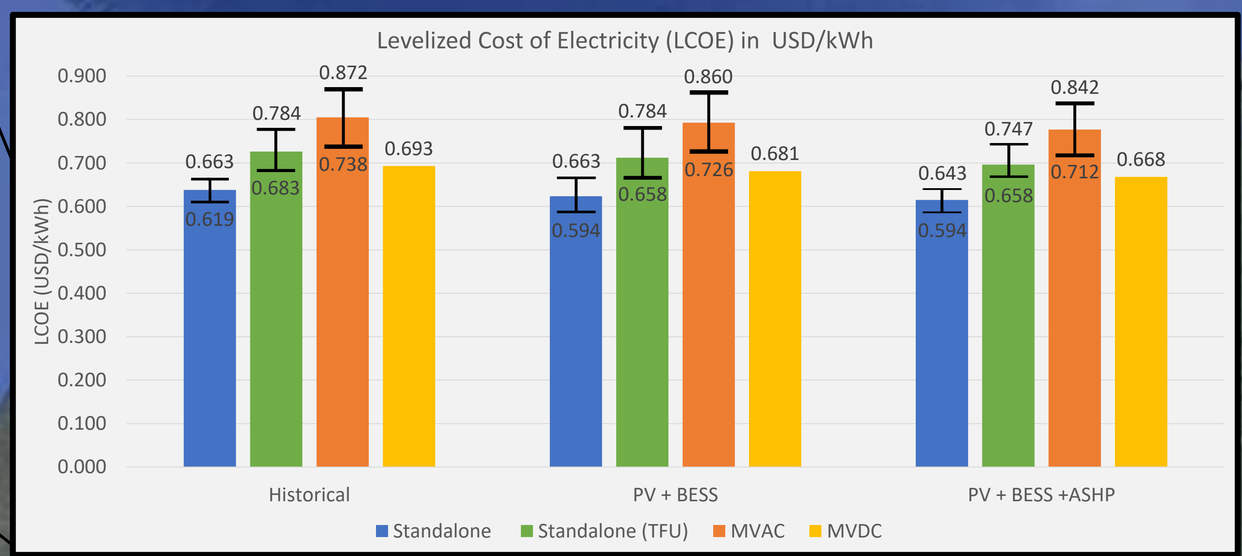

Fig. 2: Standalone and Standalone TFU (Tank Farm Upgrade) represent the weighted average of the communities. The range presented for medium-voltage AC (MVAC) results from uncertainty in required capital investments. PV + BESS and ASHP refer to existing solar PV, battery storage, and air-source heat pump installations in Ambler and Shungnak.

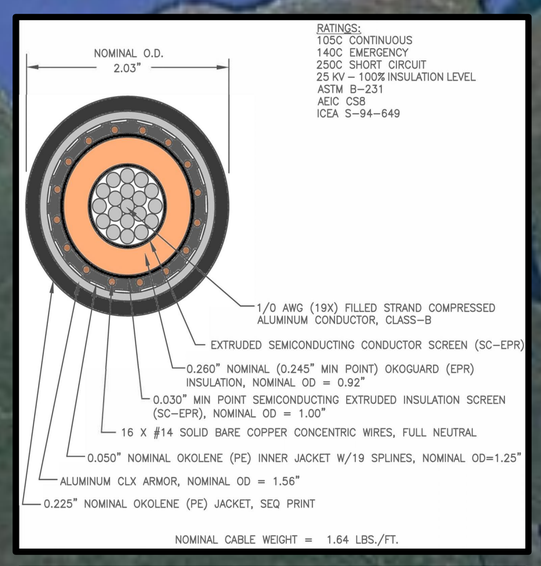

Fig. 3: MVDC 25kV Cable Section (provided by Okonite)

Background:

- The cost of generating power in remote Alaskan communities is very high and can exceed $1.00/kWh
- Electrically connecting communities can lead to decreased power generation costs and higher power security

Objectives and approach:

- Compare incurred cost of energy for Ambler, Shungnak, and Kobuk by comparing operation as:
  - Two standalone microgrids
  - Medium Voltage AC Intertie
  - Medium Voltage DC Intertie
- Identify most viable option from economic perspective
- Improve model accuracy to provide more well-grounded economic values and consider future developments

Case Study:

- Ambler and Shungnak have some of highest power rates in the Alaska Village Electric Cooperative service area due to fuel delivery by plane. In Ambler it is required due to undersized fuel tank farm and in Shungnak due to changing river conditions prohibiting delivery by barge (by season).
- A 25-mile intertie between Ambler and Shungnak coupled with a tank farm upgrade in Ambler would allow barge-only fuel delivery to Ambler, reduced maintenance and operating costs, and facilitate DC-coupling of future battery energy storage systems
- The intertie may prove helpful for integration of potential large-scale hydro in the region
- Table 1 compares the costs of an overhead MVAC and buried MVDC intertie. The MVAC costs are based on standard estimates by Alaska Village Electric Cooperative (AVEC) for installation in challenging terrain. Table 3 breaks down the installed costs of buried MVDC in more detail. The cable, converter, and amphibious equipment costs are based on manufacturer quotes.
- Figure 2 shows the LCOE for the different scenarios, accounting for recent installations of 223 kW bifacial solar PV and 250 kW/384 kWh BESS in Shungnak and approx. 65x12,000 BTU ASHP in Ambler

Cost breakdown	Overhead MVAC 500 kVA, 12.47 kV	Buried MVDC, 1 MW, 25 kV
Intertie installed cost per mile	$ 350K - 750K	$ 232K
Substations installed cost	$ 200K	-
Converters installed cost	-	$ 1,100K
Total cost for 25 mile intertie	**$ 8,950K - 18,950K**	**$ 6,892K**

Table 1: Breakdown of installation costs for AC and DC interties.

	DC			AC		
Voltage (Conductor)	15 kV (#2 AL)	15 kV (1/0 AL)	25 kV (1/0 AL)	12.47 kV (#2 AL)	12.47 kV (1/0 AL)	25 kV (#2 AL)
Voltage-drop at peak load	11.1 %	7.0 %	2.5 %	11.2 %	8.3 %	2.8%
Power loss at avg. load	5.7 %	3.6 %	1.3 %	4.5 %	2.9 %	1.1 %

Table 2: Comparison of voltage drop and power loss for different conductor types (DC: left, AC: right)

Category / Item	Itemized Cost	Category Cost
#2 25 kV armored cable on steel reels (Okonite)	$ 1,128k	
Two 500 kVA 480 Vac / 25 kVdc converters (Resilient Power Systems)	$ 1,100k	
Misc (concrete, splicing materials, field work enclosures)	$ 99k	
Materials Total		$ 2,327K
Amphibious trencher platform (Wetlands Equipment)	$ 715k	
Amphibious excavator (Wetlands Equipment)	$ 550k	
Bulldozer (rental) and Side by Side	$ 31k	
Equipment Total		$ 1,296K
Labor Total (Preconstruction, mobilization, field work, and demob)		$ 543K
Mobilization and Demobilization		$ 110K
Services Total (Freight, travel, commissioning support)		$ 562K
Overhead, General and Administrative, Fee, Contingency, and Tax		$ 2,055K
Total		**$ 6,892K**

Table 3: Detailed breakdown of installation costs for buried MVDC intertie.

Partners and Stakeholders:

- Alaska Center for Energy and Power, University of Alaska Fairbanks, Sandia National Laboratories, Alaska Village Electric Cooperative, Northwest Arctic Borough, Cordova Electric Cooperative (C. Koplin), Golden Valley Electric Association (D. Bishop)

Period of Performance:

- August 22nd, 2018 – October 18th, 2021

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In progress:

- Developing real time switching level simulations and expanding the economic analysis to encompass simultaneous regional energy developments.

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