Connecting Alaska Remote Villages using Energy Storage Ready Medium Voltage DC Interties

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Fig. 1. Proposed 25-mile intertie between Ambler and Shungnak. Source: Google earth.

Fig. 2. Wetland Equipment Company amphibious vehicle used to lay cable on soft in wetlands and boggy tundra. Source: https://wetlandequipment.com/photo-gallery/5, accessed 2020-09-14

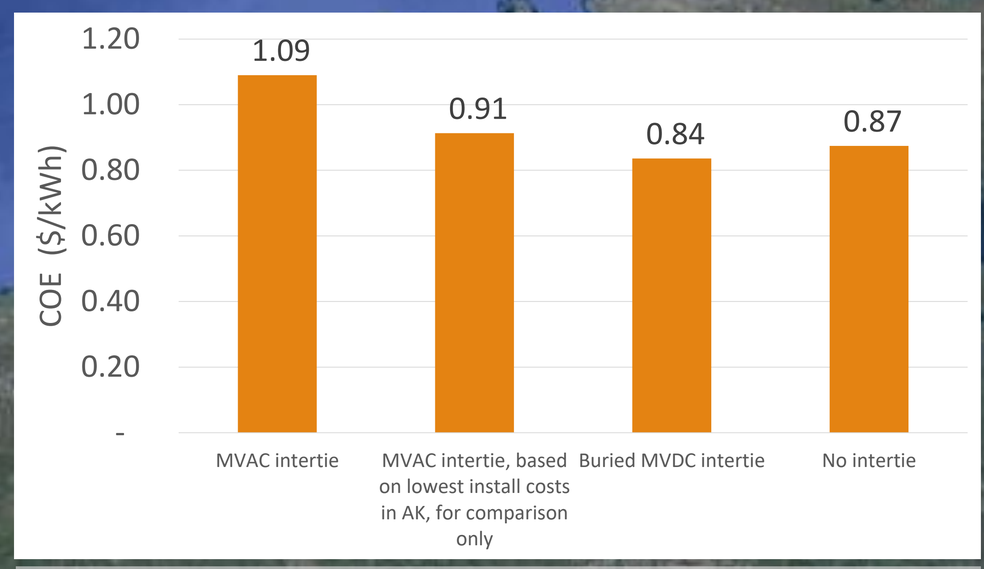

Fig. 3. Comparison of the Cost of Energy (COE) for overhead MVAC, buried MVDC and no intertie between Ambler and Shungnak.

Background:

- The cost of generating power in remote Alaskan communities is very high and can exceed $1.00/kWh
- Electrically connecting communities allows lower operating costs. However, the high capital cost of overhead medium voltage alternating current (MVAC) lines and the short range of cable-based MVAC limit their applicability.

Objectives and approach:

- Compare the cost of delivering power to remote communities operating as standalone microgrids, interconnected via overhead MVAC and interconnected via buried medium voltage direct current (MVDC) cable.
- Identify the most promising MVDC converter topology for scaling to sub-MW applications and facilitating the interconnection of energy storage systems
- Develop real time switching level simulations to validate the operation of energy storage ready point to point and multi-terminal MVDC networks connecting multiple remote communities

Table 1. Breakdown of costs for overhead MVAC and buried MVDC interties.

Cost breakdown	Overhead MVAC 500 kVA, 12.47 kV	Buried MVDC, 500 kW, 10 kV
Intertie installed cost per mile	High: $750K Low: $350K	$200K
Substations installed cost	$200K	-
Converters installed cost	-	$600K
Total cost for 25 mile intertie	High: $18,950K Low: $8,950K	$5,600K

Case Study:

- Ambler and Shungnak have some of highest electrical rates in the Alaska Village Electric Cooperative service area due to fuel delivery by plane: required in Ambler due to undersized fuel tank farm; required in Shungnak due to changing river conditions prohibiting delivery by barge period.
- A 25-mile intertie between Ambler and Shungnak would reduce the cost of energy (COE) by allowing barged fuel only to Ambler and reduced operating costs. A buried cable would additionally reduce maintenance cost.
- Table 1 compares the costs of overhead MVAC and buried MVDC. MVAC installation costs are highly dependent on terrain with the range shown for Alaskan installations. Costs for the Ambler-Shungnak intertie will approach the high estimate due to challenging terrain. Table 2 breaks down the installed costs of buried MVDC. The cable, converter, and amphibious equipment costs are based on manufacturer quotes from Okonite, Resilient Power Systems, and Wetland Equipment Company respectively.
- Figure 3 shows the COE for the different scenarios based on Homer simulations. Buried MVDC reduces the COE relative to continued stand-alone operation and to interconnection via MVAC intertie. In addition, the MVDC intertie would **facilitate DC-coupling of future battery energy storage systems** and PV and wind power plants.

Table 2. Breakdown of costs for buried MVDC interties.

Item	Cost
Materials Total	$1,190K
Equipment Total	$1,280K
Labor Total (Preconstruction, mobilization, field work, and demob)	$745K
Services Total (Freight, travel, commissioning support)	$590K
Overhead, General and Administrative, Fee, Contingency, and Tax	$1,795K
Total	**$5,600K**

Partners:

- Alaska Center for Energy and Power, University of Alaska Fairbanks, Sandia National Laboratories, Alaska Village Electric Cooperative

Period of Performance:

- August 22, 2018 – August 21, 2021

Activities to date:

- Identified utility partner and target region for techno-economic analysis; Identified cable and power converter manufacturer partners.
- Identified dual-active bridge (DAB) in conjunction with low voltage AC-DC as most promising topology for this relatively low voltage and power application.
- Compared the cost of delivering power to remote Alaskan communities via stand-alone operation, overhead MVAC intertie, and buried MVDC intertie

In progress:

- Developing real time switching level simulations.

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