Technical Appendix: Enhancing Local Energy Connectivity in Tribal Regional Communities, (ELECTRC)

GHG Reduction Estimate Method and Models/Tools Used:

Measure 1: Electric Transmission Intertie

An engineering feasibility study was completed by Electric Power Systems (EPS), an electrical engineering firm with extensive experience in the development of distribution and transmission systems in Alaska. The feasibility study identified that 100% of electricity requirements on the Tok Microgrid can be carried by the proposed project. The feasibility study is hundreds of pages and unable to fit within the space requirements of this technical appendix. TCC is more than happy to provide a fully copy of the feasibility study including typical design drawings, ROW analysis, environmental analysis and electrical engineering analysis if requested.

Measure 2: Solar PV and Battery Energy Storage

TCC completed analysis of production of solar production and storage using two software tools. Helioscope modeling was completed using specific equipment and site-specific data to determine estimated solar production. This solar production was then input into HOMER modeling software with a variety of sizes to determine the sizing required to maximize use of solar PV produced.

Measure Implementation Assumptions:

Measure 1: Electric Transmission Intertie

The feasibility study produced by EPS provided a proposed schedule with the expected completion of construction activities in 2029. This schedule established the anticipated implementation timeline for the measures. The engineering feasibility study also suggested a minimum 40-year design life. A capital cost estimate for the development of the project was provided along with Operations and Maintenance cost assessments. The capital cost estimate from the feasibility study is provided as an attachment.

Measure 2: Solar PV and Battery Energy Storage

A detailed third-party cost estimate was developed for the proposed solar PV and BESS project to establish the basis of the capital cost estimate. TCC has developed multiple solar/battery systems in rural Alaska over the last three years. The average project implementation timeline has been two years – the proposed schedule provides for three years as a conservative timeline for implementation. Solar PV systems have a design life of 25 years ,though many systems last longer. The 25-year basis was used as a basis for the measure design life. Operations and Maintenance estimates were developed by TCC; the bottom-up estimate is based upon experience with other rural Alaska solar PV systems; the roughly $40/kW is roughly twice the national average for a solar/battery microgrid system due to the challenging application of operations and maintenance in rural Alaska.

GHG Reduction Estimate Assumptions:

Measure 1: Electric Transmission Intertie

Technical Appendix: Enhancing Local Energy Connectivity in Tribal Regional Communities, (ELECTRC)

Baseline emissions for the Tok Microgrid were estimated based upon actual diesel fuel use measured for 2023. This data was acquired from the Alaska Energy authority Power Cost Equalization 2023 Report. A copy of this report is provided as an attachment.

The following Emissions factors for diesel were utilized using numbers from the IPCC (2013). Climate Change 2013: The Physical Science Basis.

	Reduced Emissions - EPA Factors				
Units of Measure	**C02**	**NH4**	**N20**	**NOx**	**Total**
kg/gallon	10.21	0.41	0.08	0.00515	10.70515
MT/gallon	0.010191	0.000409	0.000080	0.000005	0.010685721

Emissions reductions for the Intertie were calculated assuming completion of Measure 2 first. The above factors were multiplied by the total numbers of gallons reduced as determined by the assumption of 100% reduction of electrical generation from the existing diesel power plant. Based upon the above emissions factors, the MT /kwh for the existing Tok microgrid was determined to be .0007227 MT/kwh.

Emissions from the Golden Valley Electric Association (GVEA) grid was based upon self-reporting carbon intensity of the utilities 2022 generation (2023 data was not finalized). The reported carbon intensity was .00061430 MT/kwh, roughly 15% less carbon intensive than the AP&T Tok Microgrid.

To determine the emissions reductions impact of the intertie, the emissions of each kwh transferred over the transmission line were calculated by the reduced emissions from avoided diesel fuel use and then adjusting for the emissions impacts of the source of the purchased electricity (the GVEA grid).

Measure 2: Solar PV and Battery Energy Storage

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kg/gallon	10.21	0.41	0.08	0.00515	10.70515
MT/gallon	0.010191	0.000409	0.000080	0.000005	0.010685721

Emissions reductions for the solar PV were determined by reducing the electric generation requirements from diesel and multiplying the total resulting diesel fuel use reductions by the above listed emissions factors.

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GHG Emissions Reduced:

The below table identifies emissions reductions totals by measure using the above stated methodology to establish estimated annual emissions reductions.

Emissions Reductions Calculations (Annual)					
	Electricity generated / purchased (kwh)	**Baseline Emissions**	**Emissions / kwh (MT)**	**Measure Emission (MT)**	**Net Emissions Reduction**
Measure 1: 69 kV Intertie	6,745,600	4,874	0.0006140	4,142	732
Measure 2: Solar PV and BESS	4,603,960	3,326	-	-	3,326
Total	**11,349,560**	**8,200**		**4,142**	**4,058**

The below table identifies emissions reductions totals by measure using the above stated methodology to establish estimated emissions reductions over the time period from 2025-2050.

	2025-2030	2030-2050	2025-2050		
	Short Term Emissions Reductions (MT)	**Long Term Emissions Reductions (MT)**	**Total Emissions Reduction (MT)**	**Capital Cost**	**Capital Cost / MT**
Measure 1: Intertie	2,195.62	14,637.46	16,833.08	$79,493,405	$ 4,722
Measure 2: Solar PV and BESS	13,305.38	66,526.89	79,832.27	$16,153,902	$202
Total	**15,501.00**	**81,164.35**	**96,665.35**	**$95,647,307**	**$989.47**

Additional attachments:

1. AEA 2023 PCE Report (1 Page)
2. Tok Intertie Engineers Estimate of Construction Costs (1 Page)
3. Tok Helioscope Solar PV Modeling Analysis (2 Pages)
4. Tok Solar PV and BESS HOMER Analysis (1 Page)
5. Tok Solar PV and BESS Construction Cost Estimate (2 Pages)

Tok; Tanacross PCE

Utility: ALASKA POWER COMPANY
Reporting Period: 07/01/22 to 06/30/23

Community Population	1,401
Last Reported Month	June
No. of Monthly Payments Made	12
Residential Customers	803
Community Facility Customers	34
Other Customers (Non-PCE)	199
Fiscal Year PCE Payments	**$1,465,955**

PCE Statistical Data			
PCE Eligible kWh - Residential Customers	3,477,626	Average Annual PCE Payment per Eligible Customer	$1,751
PCE Eligible kWh - Community Facility Customers	550,538	Average PCE Payment per Eligible kWh	$0.36
Total PCE Eligible kWh	4,028,164	Last Reported Residential Rate Charged (based on 500 kWh)	$0.48
Average Monthly PCE Eligible kWh per Residential Customer	361	Last Reported PCE Level (per kWh)	$0.28
Average Monthly PCE Eligible kWh per Community Facility Customer	1,349	Effective Residential Rate (per kWh)	$0.20
Average Monthly PCE Eligible Community Facility kWh per Person	33	PCE Eligible kWh vs Total kWh Sold	42.6%

Additional Statistical Data Reported by Community*

Generated and Purchased kWh		Generation Costs	
Diesel kWh Generated	11,349,560	Fuel Used (Gallons)	767,605
Non-Diesel kWh Generated	0	Fuel Cost	$2,976,140
Purchased kWh	0	Average Price of Fuel	$3.88
Total Purchased & Generated	11,349,560	Fuel Cost per kWh sold	$0.31
		Annual Non-Fuel Expenses	$2,351,747
		Non-Fuel Expense per kWh Sold	$0.25
		Total Expense per kWh Sold	$0.56

Consumed and Sold kWh		Efficiency and Line Loss	
Residential kWh Sold	4,062,724	Consumed vs Generated (kWh Sold vs Generated-Purchased)	83.3%
Community Facility kWh Sold	550,538	Line Loss (%)	14.9%
Other kWh Sold (Non-PCE)	4,836,430	Fuel Efficiency (kWh per Gallon of Diesel)	14.79
Total kWh Sold	9,449,692	PH Consumption as % of Generation	1.9%
Powerhouse (PH) Consumption kWh	212,397		
Total kWh Sold & PH Consumption	9,662,089		

Comments

Supplies power to Dot Lake/Dot Lake Village & Tetlin

*The data contained in this report is primarily based on information submitted by the utility with their monthly PCE reports. Changes to the reported data and/or significant anomalies have been noted in the comments.

Option D-3 For EPA Grant Application

69kV MP 1388 Sub - Tok w/ underbuild

Substations

New AP&T Substation (DOT MP 1388) (Includes contingency, ROW/permitting, Eng. / Proj. Mgt)	$1,042,500.00	new sub to tie into GVEA 25kV line
New AP&T Substation (Tok) (Includes contingency, ROW/permitting, Eng. / Proj. Mgt)	$990,000.00	69/12.5kV sub near Tok Generation
LiDAR Survey (74 miles @ $850/mile, $50k mobilization)	$112,900.00	

Transmission Line Segments

New AP&T Sub (DOT MP 1388) - Tok Sub 69kV w/ Underbuild	Segment Length (miles)
	73.34
Transmission Line Construction (includes 20% contingency)	$48,462,440.40
Transmission Line Engineering, ROW Coordination & Project Management	$7,753,990.46
ROW / Permitting Costs to DOT, Potential Easements	$50,000.00
subtotal	$56,266,430.86

Option D-3 Project total (2024 $$)	**$58,411,830.86**
Option D-3 Project Total (2028 $$)	**$74,549,942.76**

Design 1 Tok Solar Pump Station Rd, Tok, AK 99780

Project Details

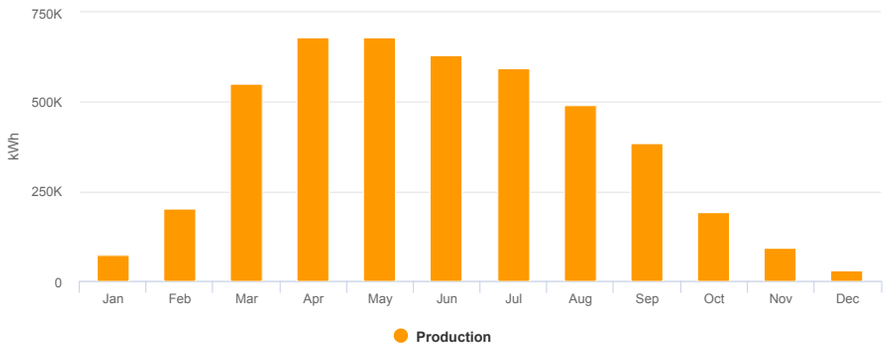
Address	Pump Station Rd, Tok, AK 99780
Owner	Ed Dellamary
Last Modified	Ed Dellamary 11 days ago
Location	(63.375485470185154, -143.35940998348653) (GMT -9)
Profile	Default Ground-mount

System Metrics

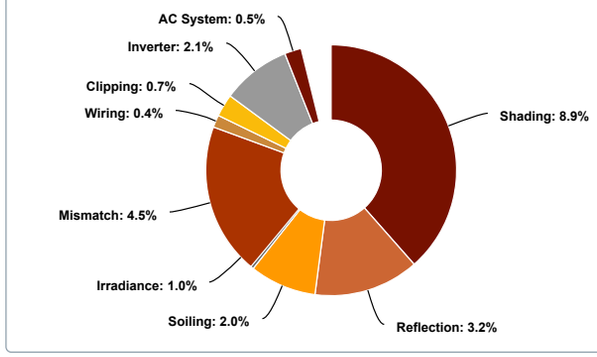
Design	Design 1
Module DC Nameplate	4.0 MW
Inverter AC Nameplate	3.3 MW Load Ratio: 1.23
Annual Production	4.6 GWh
Performance Ratio	79.5%
kWh/kWp	1,151.1
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Simulator Version	4c6441182e-e5d686d44a-b7181c5173-9942b3e8d3

Project Location

Production



System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,027.8	-
	Adjusted Global Horizontal Irradiance	1,027.8	0.0%
	POA Irradiance	1,448.1	40.9%
	Shaded Irradiance	1,318.8	-8.9%
	Irradiance After Reflection	1,277.2	-3.2%
	Irradiance After Soiling	1,251.7	-2.0%
	Total Collector Irradiance	**1,251.5**	**-0.0%**
Energy (kWh)	Nameplate	5,005,801.6	-
	Output at Irradiance Levels	4,956,911.5	-1.0%
	Output at Cell Temperature Derate	5,001,177.1	0.9%
	Output After Mismatch	4,774,216.3	-4.5%
	Optimal DC Output	4,756,535.8	-0.4%
	Constrained DC Output	4,724,647.9	-0.7%
	Inverter Output	4,627,096.0	-2.1%
	Energy to Grid	**4,603,960.3**	**-0.5%**

Temperature Metrics	
Avg. Operating Ambient Temp	2.3°C
Avg. Operating Cell Temp	9.9°C

Simulation Metrics	
Operating Hours	4,602
Solved Hours	4,602
Pending Hours	-
Error Hours	-

Condition Set

Description	Condition Set 1
Weather Dataset	TMY10km Gridmeteonorm(meteonorm)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.08	3.0°C
Flush Mount	-2.81	-0.05	0.0°C
East-West	-3.56	-0.08	3.0°C
Carport	-3.56	-0.08	3.0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5.0%
Cell Temperature Spread	4.0°C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Component Characterizations

Type	Component	Characterization
Module	SEG-550-BMA-BG (SEG)	Spec Sheet Characterization,PAN
Inverter	Sunny Highpower PEAK3 SHP125-US (480Vac) (SMA)	Default Characterization

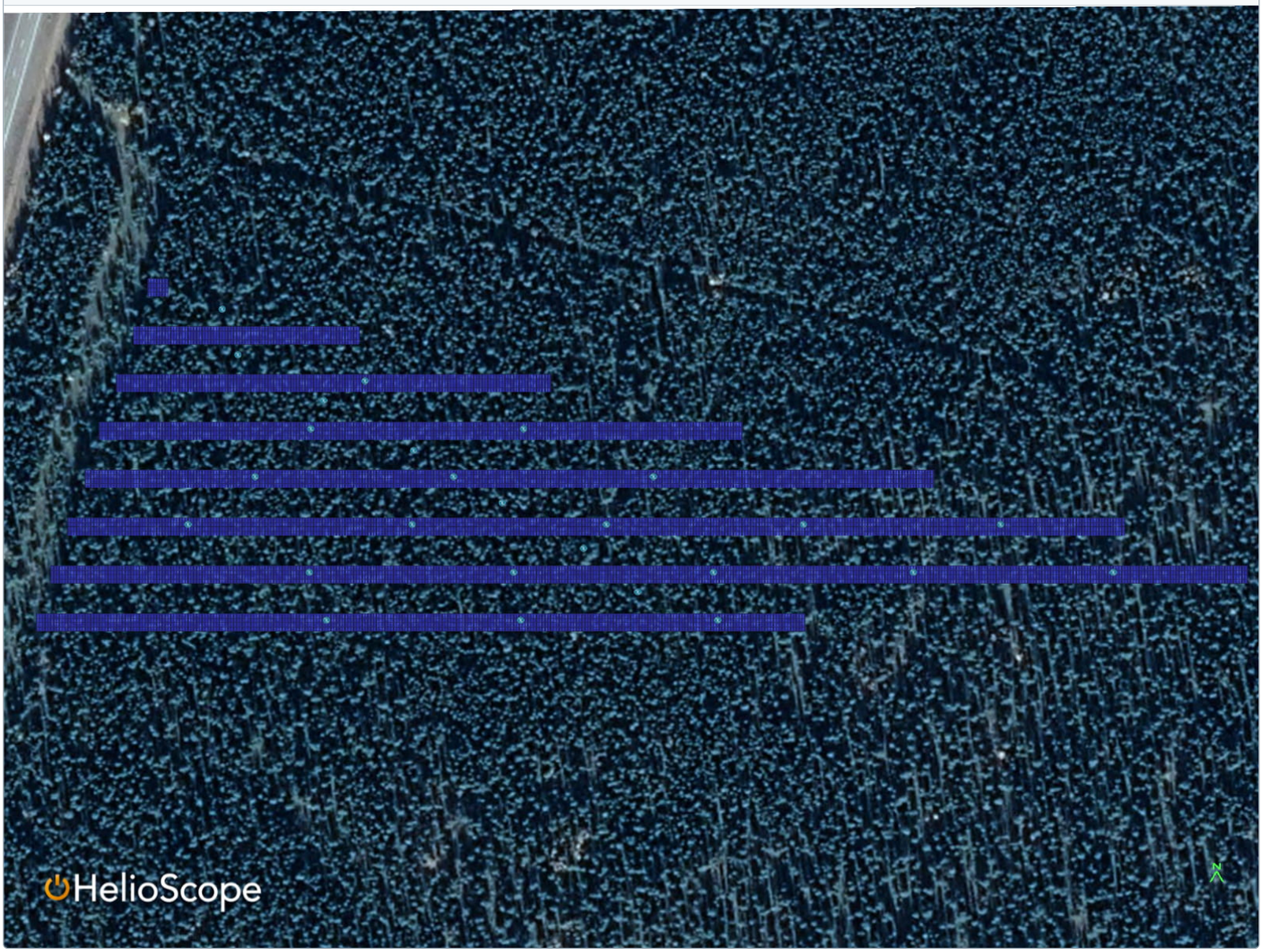
Design BOM

Component	Type	Quantity
Sunny Highpower PEAK3 SHP125-US (480Vac)	Inverters	26
SEG-550-BMA-BG	Modules	7,272
10 AWG (Copper)	Strings	320

Monthly Shading

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	8.8	40.7	20.4	77,616.9	74,658.7
February	28.1	81.7	55.2	210,248.0	203,108.6
March	83.3	164.5	149.7	571,165.7	551,112.5
April	135.5	193.7	191.2	726,544.5	678,956.5
May	177.0	201.1	197.6	749,512.5	680,187.3
June	182.8	190.2	186.7	707,428.1	629,191.8
July	167.5	179.6	175.6	665,627.6	593,140.3
August	122.4	147.2	143.9	544,262.7	492,118.3
September	73.2	113.7	109.6	415,923.1	384,101.1
October	33.0	70.3	54.8	208,262.8	193,681.3
November	12.0	46.6	25.7	97,783.4	93,405.6
December	4.3	18.8	8.3	31,426.5	30,298.5

Design Render



PREPARED FOR:
Tok and Tanacross Solar PV and BESS, Village of Tanacross
1314 Alaska Hwy, Tok, AK 99780, USA

Microgrid Proposal

PREPARED BY:
Jason Paskvan, Energy and Climate Planning Specialist
Your Company Name,
jason.paskvan@tananachiefs.org
907-452-8251 ext 2062

This proposal was generated using HOMER Pro, a dynamic software engine that runs complex simulations of your hybrid electrical system's energy data and system components to determine the least-cost solution and most effective risk-mitigation strategies. Originally developed at the US Department of Energy's National Renewable Energy Laboratory (NREL), HOMER software set the global standard for optimizing microgrid design. More than 200,000 HOMER Pro users worldwide have

Project Cost Estimate

Project	Tanacross Solar and Tok BESS
Location	Tanacross / Tok, Alaska
Prepared For	Tanana Chiefs Conference
Date	27-Feb-24

Cost Category		Units	Quantity	Rate	Total	Notes
Materials	Solar Panels	Each	7350	$300	$2,205,000	Assumes BiFacial 550W panels
	SMA Sunny Highpeak Inverters	Watt	27	$20,000	$540,000	Distributor Quote
	Wiring	Strings	325	$2,750	$893,750	Recent Pricing on similar projects
	Fencing	LF	3,349	$30.00	$100,470	Assumes Chain Link 6 ft
	3 Phase Power Line Extension	LF	300	$105	$31,500	
	Secondary Cables	LF	150	$32	$4,800	
	Transformers	Each	4	$10,000	$40,000	Quote - Vendor
	Solar Racking, ground screws	watt	4,000,000	$0.46	$1,840,000	Previous Recent Experience
	Battery Module - 4 MWh	LS	1	$2,183,090	$ 2,183,090	Tesla MegaPack - Quote
	Inverter - 3 MW	Each	1	$176,005	$176,005	Quote - Vendor
	Microgrid Controller	Each	1	$96,510	$96,510	Quote - Vendor
	Concrete Pad	Sq Ft.	2,400	$15	$36,000	
	Insulated Structure for Batteries	Sq Ft.	2,400	$177	$424,800	Pre-Engineered Metal Building
	Heating System - APC Power Plant	LS	1	$40,000	$40,000	Quote - Vendor
	Bi-Directional Meters	Each	2	$1,375	$2,750	
	Materials Total				**$8,614,675**	
Labor	Laborer	Hrs	10,080	$64.91	$654,293	Davis-Bacon, 6 crew, 28 weeks, adjusted for OT
	Plumber	hrs	240	$93.00	$22,320	Davis-Bacon, 2 crew, 2 weeks
	Electrician	Hrs	2400	$95.90	$230,160	Davis-Bacon, 20 weeks x 2 staff adjusted for OT
	Foreman / Operator	Hrs	5040	$75.77	$381,881	Davis-Bacon,28 weeks, three staff adjusted for overtime
	Labor Total				**$1,288,654**	

	Freight	Lb	1,079,052	$0.95	$1,025,099	Estimated Freight Costs, 95% of freight Anchorage to Tok
	Equipment	Weeks	84	$2,500	$210,000	Loader Rental 28 weeks, Skid Steer Rental 28 Weeks *2, D6 4 weeks, zoom boom 2 weeks, multiple rock trucks
	Supplies + Tools	Lump Sum			$172,294	2% of Materials
	Per Diem + Lodging	Man-Days	1260	$250	$315,000	Include lodging and per diem for non-local crew
General Conditions	Travel		20	$800	$16,000	Includes RT travel costs for non local crew; assumes four trips for 5 personnel
	General Conditions Subtotal				**$11,641,722**	
	Bonding and Insurance		1.50%		$174,626	
	Contractor OH and Profit		10.00%		$1,164,172	
	Escalation + Contingency		10.00%		$1,164,172	Assumes 5% Inflation, 5% Contingency
	Construction Total				**$14,144,692**	
Engineering	Design		3.00%		$424,341	3% of Construction total, assumes 35%, 65%, 95%, 100% Design Documents and all permitting
	Construction Admin		2.00%		$282,894	2% of Construction Total includes: Submittals, RFi's, Inspections, O+M, Training
	Engineering Subtotal				**$707,235**	
	Design and Construction				**$14,851,926**	
Admin	Project Management		2.75%		$408,353	2.75% of Design and Construction
	Indirect Rate	33.1% * direct expenses + .05% * flow through			$877,761	Federally Negotiated Indirect
					$16,138,041	

Prepared by	Gavin Dixon, Cumbre Consulting LLC

Notes:	Cost Estimate represents best information available at the time of the estimate, February 2024. Data is based upon recent actual construction costs on similar remote, high penetration solar PV and Battery Energy Storage projects completed in Alaska. Estimate assumes a two year project delivery schedule. This estimate is not a bid or a quote for services.