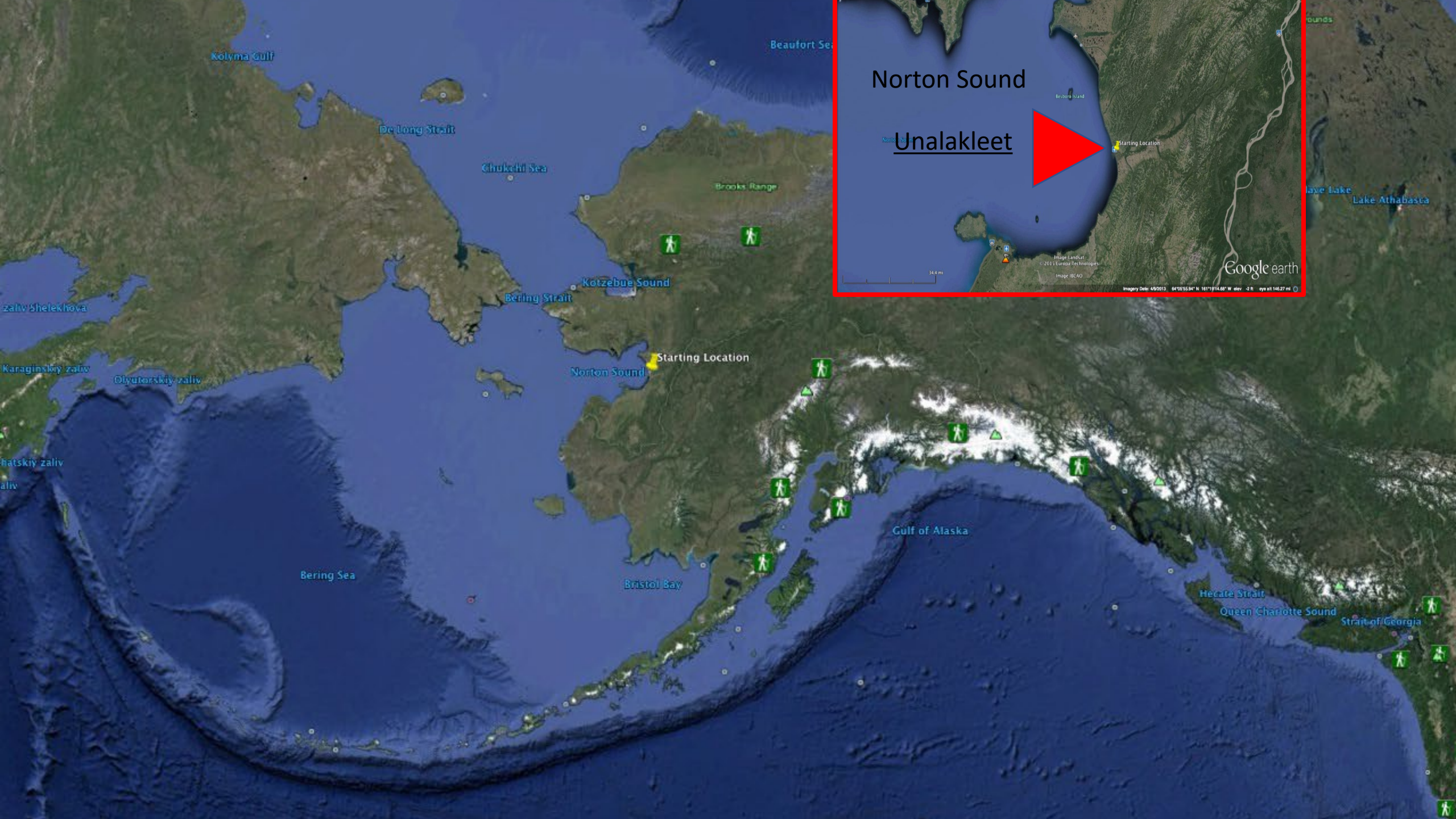
Unalakleet Microgrid Optimization & Typhoon Merbok Impacts

US Department of Energy –
Office of Indian Energy
Annual Program Review
Denver, CO
November 16, 2022

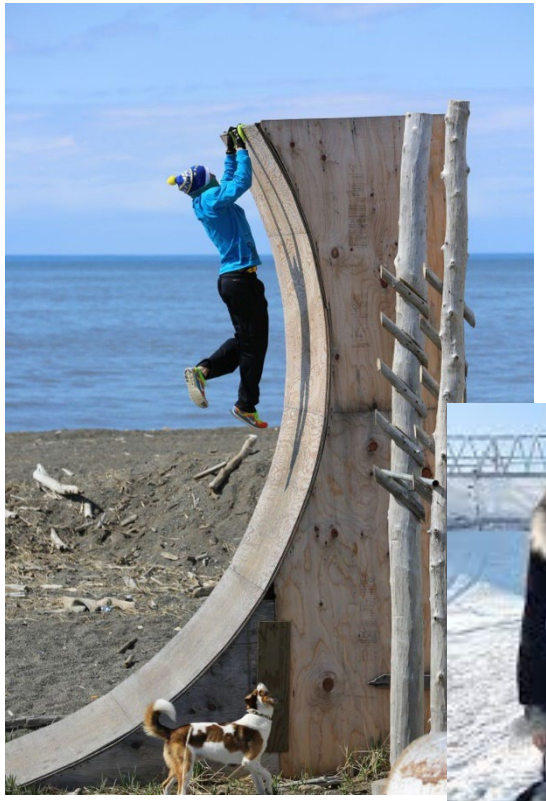
Unalakleet Native Corporation

"Where Southerly East Wind Blows"

UNALAKLEET VALLEY ELECTRIC COOPERATIVE
EST. 1961


Norton Sound
Unalakleet
Starting Location
Kolyma Gulf
Beaufort Sea
De Long Strait
Chukchi Sea
Brooks Range
Kotzebue Sound
Bering Strait
zaliv Shelekhova
Karaginskiy zaliv
Olyutorskiy zaliv
hatskiy zaliv
aliv
Starting Location
Norton Sound
Gulf of Alaska
Bering Sea
Bristol Bay
Hecate Strait
Queen Charlotte Sound
Strait of Georgia
Lake Athabasca
Google earth

Unalakleet Demographics



- ❑745 Residents
- ❑78% AK Native
- ❑400 miles from road system
- ❑150 miles southeast of Nome
- ❑Unalakleet Native Corporation: Land Owner
- ❑Unalakleet Valley Electric Cooperative: Electric Service Provider

Unalakleet Native Corporation

"Where Southerly East Wind Blows"

Unalakleet Native Corporation (UNC) operates a fuel station including a heating oil delivery, grocery store, burger restaurant, and a vehicle repair garage, all in Unalakleet, Alaska.

UNC leases land, residential and commercial buildings in Unalakleet, and an office building in Anchorage. Most of UNC's operating activities are concentrated in Western Alaska, but have recently expanded to government 8a Contracts in the Lower 48.

UNC as Land Owner, and UVEC as utility, and DOE-OIE joined forces to make powerplant/microgrid in Unalakleet more efficient & stable while maintaining safety & reliability.

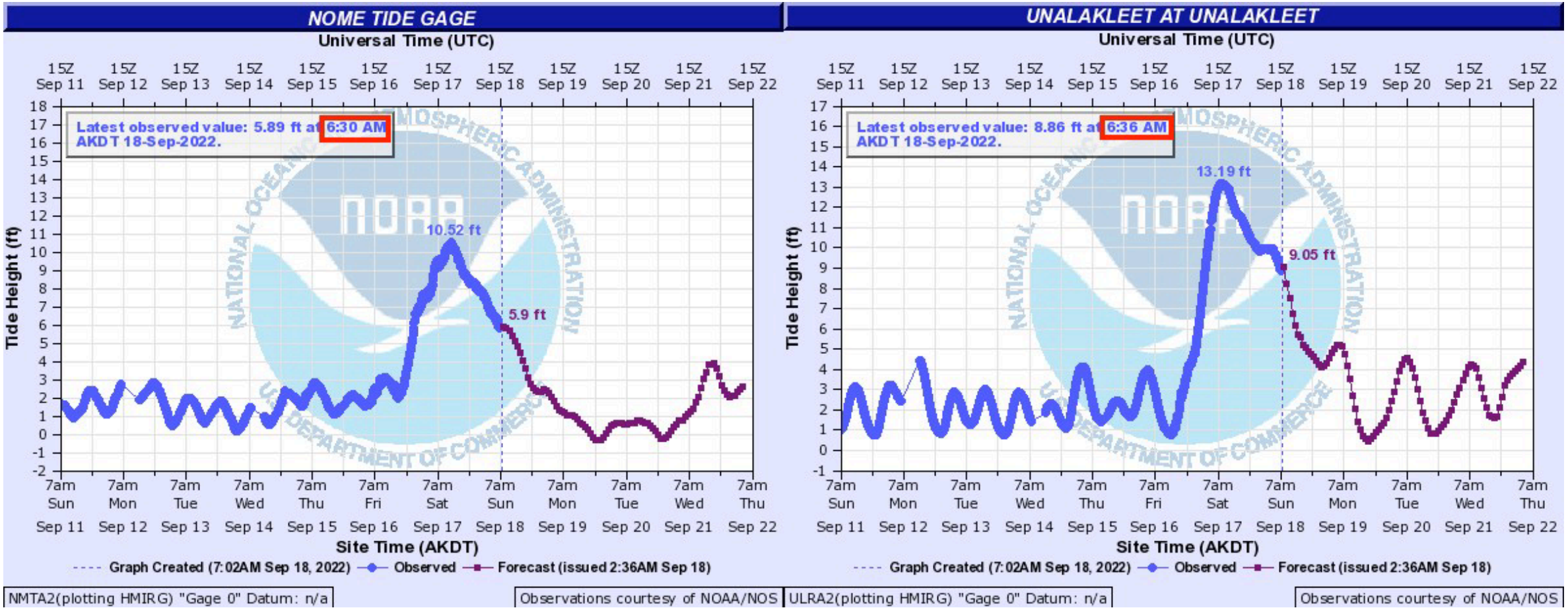
Covid Impacts: Loss of food & fuel sales, tourism, increased costs, transportation difficulties. – Main commercial airline shut from Covid.

Recent Impacts from Typhoon Merbok were significant and costly: inundation of airport infrastructure, power and water outages, and accelerated coastal erosion.

River Mouth – Normal & Typhoon

Fuel Delivery – Normal & with 13’ Typhoon

Water level observations during Typhoon



Effects on Airport

- Sectionalizers & Junction Boxes flooded
- Transformer battered by waves and debris
- Increase elevation of several key pieces of distribution infrastructure
- Preemptive shutdown impacted 57 services
  - FAA: AWOS, VORTAC, Satellite Building
    - Aircraft Navigation: VASI, ILS, NDB
  - DOT: Building, runway lights,
  - All airport hangars: WCAS,Ryan Air, BSSD
  - Includes Hillside residences
  - KNSA radio/emergency broadcasting
  - City Water Supply (Powers Creek Powerline goes through airport)

Sectionalizer

Flooded. Must be raised.

Overhead riser at East-West Runway.

THIS IS THE WORST LOCATION.

3-phase. Fed from Happy Valley/North Loop

Junction Box

Flooded. East side of North-South Runway.

Must be raised.

Junction Box

Not Flooded. At-risk.

East side of North-South Runway. Located north of windsock.

Sectionalizer and Transformer

Flooded. Must be raised.

Oceanside near DOT sand pile.

THIS IS THE SECOND WORST LOCATION.

Fed from West Loop or North Loop (under the north-south runway)

Sectionalizing Cabinet N1

Flooded. Raise/relocate.

Rocks on ocean side. Sand bagged prior to storms.

First j-box north of airport gate.

Contains bypass lines (under barge landing road.)

Junction Box N2

Flooded. WASHED OUT.

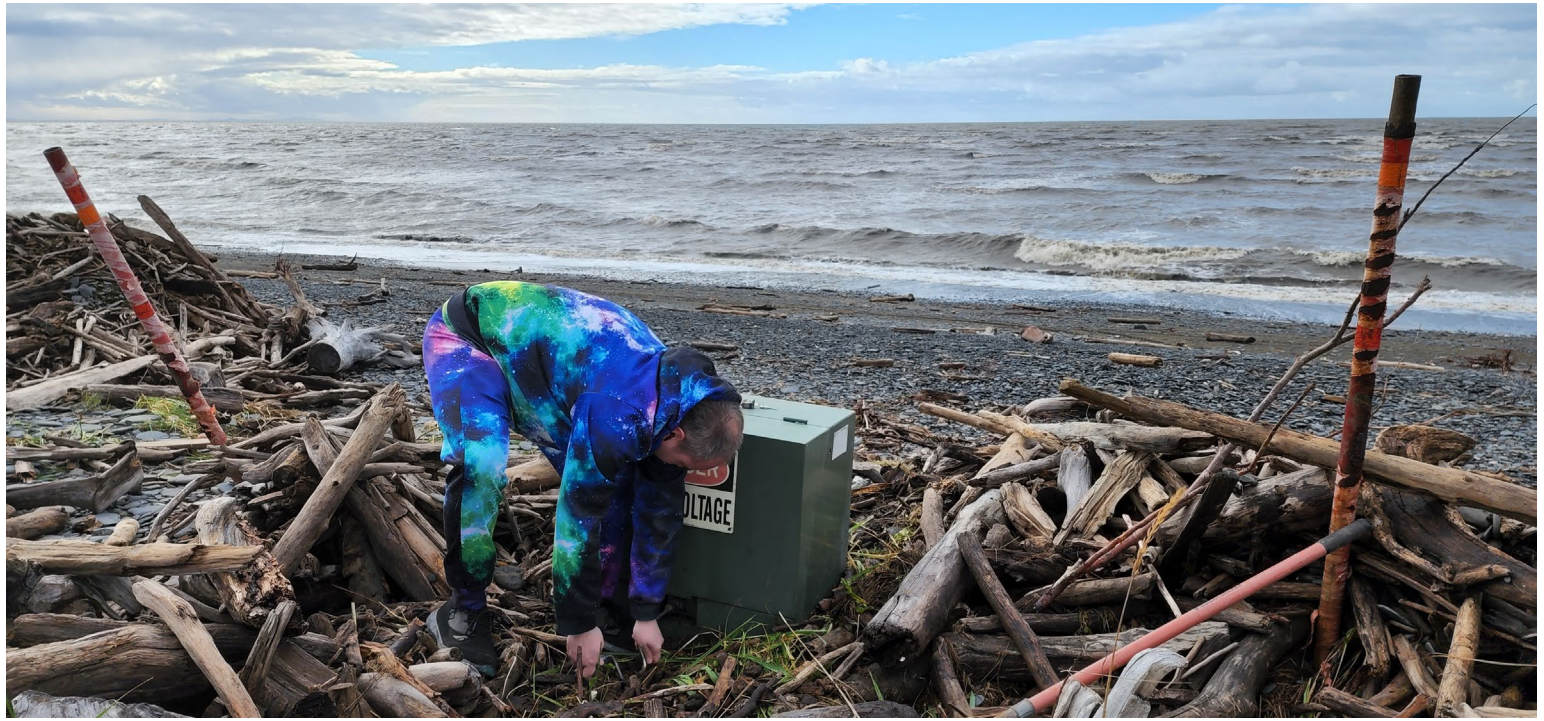
Destroyed by high surf.

Second junction box north of airport gate.

Junction Box N3

Buried by debris. Raise/relocate.

Third junction box north of airport gate.



Transformer N4

Heavy spray. Potential tipping hazard if struck by debris/waves. Raise/relocate.

Transformer located at R. Lockwood driveway and turn to Pumphouse.

Junction box N2

Replaced. **Still susceptible to storms.** Raise and protect with rock, or relocate. This is a temporary fix.

Analysis of flood on Airport

- UVEC equipment on Airport at risk of flooding
  - Three sectionalizing cabinets
  - Three transformers
  - Four J-cabinets

  - Raise and protect
  - 5 power poles leaning and to be straightened east of airport (Feeder to VORTAC, Windfarm, and 55 services)

Powers Creek Powerline

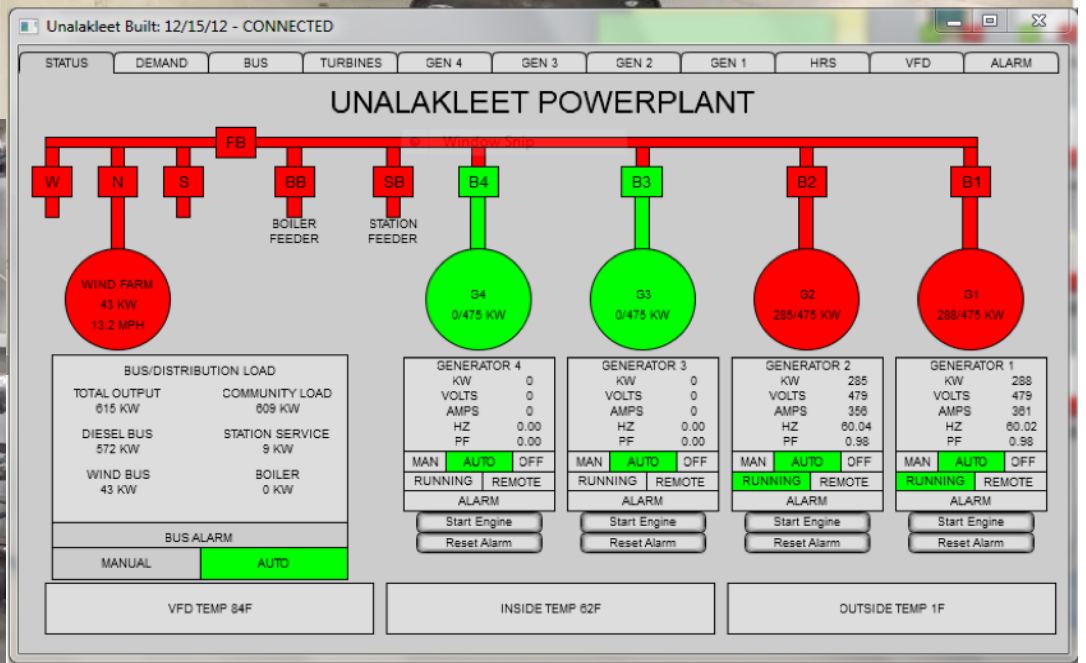
- One junction destroyed by surf during Merbok. One destroyed in previous fall storm.
- Must have spare elbows and 3000 feet of bypass stocked. Estimated cost: $30,000
- City water supply offline for over 24 hours (City backup generator failed but storm prohibited safe passage to facility)
- Hillside customers offline for 25 hours.

Analysis of flood/ Scope of work

- Move PCP inland (connect to BIA Road powerline): est. $375,000
  - 12,500 feet of conductor
    - Safely energize the City's water source and the R. Lockwood residence
    - Four junction boxes, one sectionalizing cabinet, and one transformer at-risk.
  - Short-term fix: est. $58,000
    - Place rock around existing infrastructure and increase elevations at 10 locations (4 PCP + 6 Airport)
    - Straighten 5 power poles
    - Replace 3,000 feet of PCP.

UVEC's System

- Electric loads: 400 – 1000 kW
- Four Cat 3456 475 kW gensets.
- Six 100 kW Northern Power Systems wind turbines.
- Recovered heat system.
- 300 kW Electric boiler – secondary load.



NorthWind 100 Turbines

*** 2009-Construction began with an agreement between UNC as land-owners and UVEC.**

*** 2010-SLC, 300 kW electric boiler, connected to Diesel Heat Recovery System: City Loop, School Loop, Baler Loop**

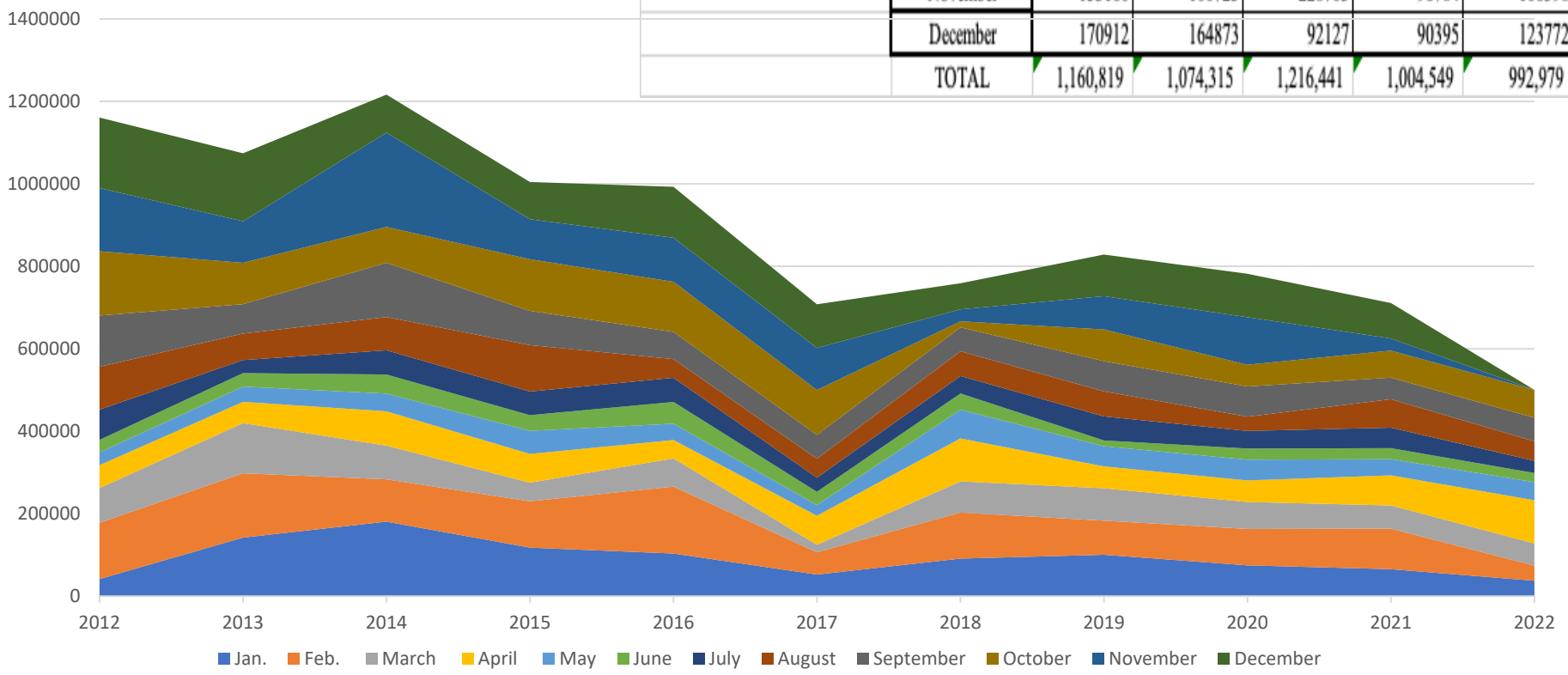
*** Rated 600 kW**

- **<u>Predicted</u> annual production: 1,500,000 kWh/year**
- **<u>Actuals</u> range from 750,0000 to 1,000,000 kWh**
- **<u>Predicted</u> annual fuel savings: 113,000 gal/year**
- **<u>Actuals</u> range from 50,0000 to 70,000 gals - improved integration = more fuel savings**

Wind Generation Over Time (2012-2022)

The Trend is Clear: More Curtailment, Less Wind Energy Production

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Wind Generation (kWh)	Jan.	41,739	142,298	180,776	117,933	103,510	52,499	91,176	100,543	75,013	65,557	37,745
	Feb.	136440	155802	102845	112152	162333	54256	111798	82551	88255	98526	36436
	March	84075	121640	81672	45575	68254	18121	75492	78855	65299	56233	53877
	April	55438	51846	83066	69516	44850	70389	104354	52800	52348	72858	104965
	May	31237	36813	43089	56039	39650	25823	69662	49117	50275	39387	43857
	June	30223	32539	46195	37850	52496	32168	39359	14034	26918	26762	21953
	July	73157	31699	58712	57270	58721	34321	42238	58168	42644	49658	29523
	August	104238	64357	80652	112629	45164	45889	60143	60722	34595	68724	47561
	September	124067	71323	131809	83188	66141	57575	57887	73286	73512	52236	57001
	October	156133	100400	86793	125218	121490	109167	14567	76899	52679	65909	67409
	November	153160	100725	228705	96784	106598	101795	29080	80743	115247	29240	0
	December	170912	164873	92127	90395	123772	106025	63332	100861	105075	85853	0
	TOTAL	1,160,819	1,074,315	1,216,441	1,004,549	992,979	708,028	759,088	828,579	781,860	710,943	500,327



What is the impact of wind energy on our rates?

- **UVEC would have imported 70,000 more gallons of fuel.**
- **Our overall system efficiency would drop without wind.**
- **The added fuel cost would add to our FUEL SURCHARGE**
  - **2014 Fuel Surcharge $0.2172 (Total Res. Rate $0.50)**
  - **2019 Fuel Surcharge $0.1699 (Total Res. Rate $0.45)**
  - **With out Wind our 2019 Surcharge would be $0.2188**
    - **That's 29% higher, or $0.0489 per kWh.**
  - **Expected higher fuel prices in future – would have even more impact**

Wind production is valuable; however, we can do better, much better!

Actual wind production is ~40% LESS than Predicted, AND
High winds require UVEC to turn on a second generator for grid stability.

Invest in proven technology to get us to "one-diesel" or "diesels off" mode.

DOE OIE to the rescue…

Assessment Focus Areas

- Power Line Capacity
- Capacitor Bank
- Secondary Load Controller/Electric Boiler
- SCADA – Data Collection and Analysis

Objective

Optimize integration and performance of existing equipment in order to achieve single genset operation and pave the way for the incorporation of additional renewables and energy storage.

Known Barriers and Concerns

- Electric boiler
- Wind curtailment
- Reactive power
- Data collection/access

Power Line Capacity

Transmission line capacity constraints have led to a demand for reactive power at the wind farm. Higher turbine production often requires a second genset come online.

Findings

At a typical level of wind production (300 kW),

- Paladin analysis indicates transmission line loss > 12%.
- Voltage drop at plant > 10%.
- Power loss over time = annual power output of an entire 100 kW turbine.

Unalakleet Power line Upgrade

There are two important issues considered in the line voltage upgrade:

1. Voltage Drop

The existing line voltage of 4,160 volts is constraining the efficient operation of the wind turbine output when the six (6) wind turbines are at the maximum output of 600 kW. At peak output, the voltage drop from the wind turbines to town is nearly 25%.

So, when we upgrade the line at 12,470 volts, at peak turbine output (of 600 kW), the voltage drop will be reduced to 2%.

2. Line Losses

Line losses are 28% for 4,160 volts during 500 kW of wind generation. When at 12,470 volts those line losses are only 3.73%.

RESULT: POWER LINE UPGRADE WILL ALLOW FOR MORE WIND IN THE SYSTEM, REDUCE DIESEL GEN-SET RUN TIME, SAVE FUEL

Priorities

1. <u>Upgrade power line & increase voltage</u>, starting with transformer replacement, then conductor and structural improvements as long-term solution to mitigate reactive power issues.

Increase system voltage from 4160 V to 12,470 V
* Reduces voltage drop from 25% to 2%.

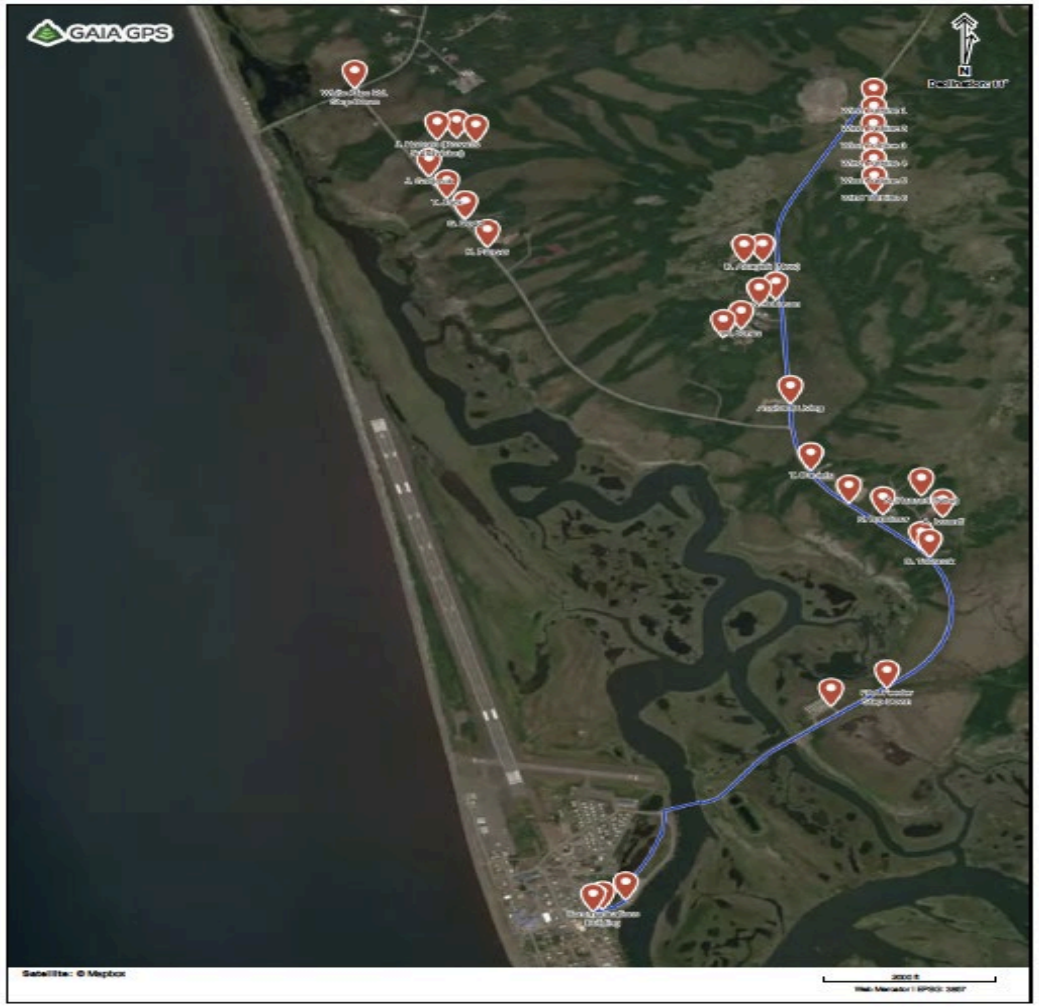
- Grid stability & Reactive load brought within reasonable parameters.

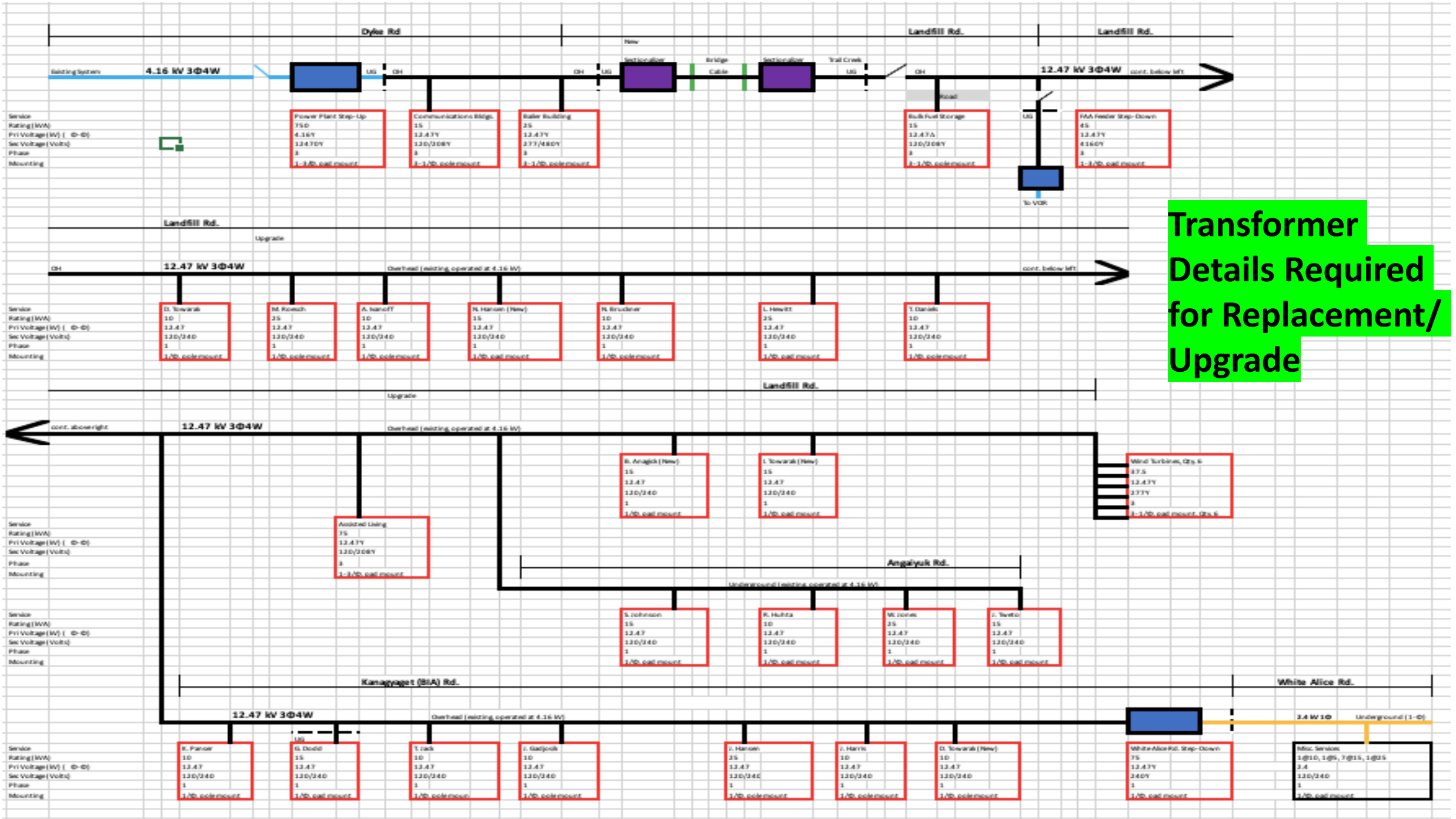
- Single gen-set operation

<u>Concerns, especially since Covid:</u>

- **<u>Price escalation of transformers & other materials</u>**
- **<u>Long lead time (supply chain)</u>**
- **<u>Lost consulting Electrical Engineer</u>**
- **<u>Lost airline service to community</u>**
- **<u>Ongoing system reliability</u>**

Transformer & Conductor Mapping




Dyke Rd
Landfill Rd.
Landfill Rd.
New
Existing System
4.16 kV 3Φ4W
UG
OH
OH
UG
Switchgear
Bridge Cable
Switchgear
Trail Creek
UG
OH
12.47 kV 3Φ4W
cont. below left
Road
Service
Rating (kVA)
Pri Voltage (kV) (Φ-Φ)
Sec Voltage (Volts)
Phase
Mounting
Power Plant Step-Up
750
4.16Y
12470Y
3
3-1/Φ pad mount
Communications Bldgs.
15
12.47Y
120/208Y
3
3-1/Φ pole mount
Boiler Building
25
12.47Y
277/480Y
3
3-1/Φ pole mount
Bulk Fuel Storage
15
12.47Δ
120/208Y
3
3-1/Φ pole mount
UG
FAA Feeder Step-Down
45
12.47Y
4160Y
3
3-1/Φ pad mount
To VOR
Landfill Rd.
Upgrade
OH
12.47 kV 3Φ4W
Overhead (existing, operated at 4.16 kV)
cont. below left
D. Towarak
10
12.47
120/240
1
1/Φ pole mount
M. Kowuch
25
12.47
120/240
1
1/Φ pole mount
A. Ivanoff
10
12.47
120/240
1
1/Φ pole mount
N. Hansen (New)
15
12.47
120/240
1
1/Φ pad mount
N. Brudaner
10
12.47
120/240
1
1/Φ pole mount
L. Hewitt
25
12.47
120/240
1
1/Φ pad mount
T. Daniels
10
12.47
120/240
1
1/Φ pole mount
Transformer Details Required for Replacement/ Upgrade
Landfill Rd.
Upgrade
cont. above right
12.47 kV 3Φ4W
Overhead (existing, operated at 4.16 kV)
B. Aragick (New)
15
12.47
120/240
1
1/Φ pad mount
I. Towarak (New)
15
12.47
120/240
1
1/Φ pad mount
Wind Turbines, Qty. 6
37.5
12.47Y
277Y
3
3-1/Φ pad mount, Qty. 6
Assisted Living
75
12.47Y
120/208Y
3
1-3/Φ pad mount
Angaiyuk Rd.
Underground (existing, operated at 4.16 kV)
S. Johnson
15
12.47
120/240
1
1/Φ pad mount
R. Huhta
10
12.47
120/240
1
1/Φ pad mount
W. Jones
25
12.47
120/240
1
1/Φ pad mount
J. Tuvito
15
12.47
120/240
1
1/Φ pad mount
Kanagyaget (BIA) Rd.
White Alice Rd.
12.47 kV 3Φ4W
Overhead (existing, operated at 4.16 kV)
2.4 kV 1Φ
Underground (1-Φ)
R. Panoe
10
12.47
120/240
1
1/Φ pole mount
UG
G. Dodd
15
12.47
120/240
1
1/Φ pad mount
T. Jack
10
12.47
120/240
1
1/Φ pole mount
J. Gadjosik
10
12.47
120/240
1
1/Φ pole mount
J. Hansen
25
12.47
120/240
1
1/Φ pole mount
J. Harris
10
12.47
120/240
1
1/Φ pole mount
D. Towarak (New)
10
12.47
120/240
1
1/Φ pole mount
White Alice Rd. Step-Down
75
12.47Y
240Y
1
1/Φ pad mount
Misc. Services
1@10, 1@5, 7@15, 1@25
2.4
120/240
1
1/Φ pad mount

Second-Level Priorities

2. <u>Improve SCADA and related data management systems</u>.

- New data server, extended memory.
- Re-establish data collection and visualization.
- Consolidate Wind & Diesel SCADAs.
- Update control and SCADA schematics.
- Collect data, use to conduct root cause analysis of outages.

A. Replace PLC

B. Replace generator controls

C. Expand functionality to incorporate BESS, increased renewables, electric thermal storage –> Post-DOE grant

These activities will occur after power line upgrade and first-level priorities are complete

Progress to-date & Future plans

1. Notice to Proceed. UNC to UVEC (contractor)
2. Project manager selected
3. Engineer was collecting baseline data (Gen & Dist)
4. Inventory of existing infrastrure completed
5. Financing secured
6. Engineering STOPPED in Q2 2020 – Covid & health
7. Lost Transportation outlets
8. Developed Materials & Supplies List
9. Created RFP to select new subcontractor based on new pricing and delivery challenges
10. Select new subcontractor to pick up where Engineer left off -- Board recently approved
11. Permitting needs better addressed, routing identified
12. Secure additional financing if needed

Contacts

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