

History of BESS (and IBRs) in Alaska



Some historical perspectives for
ESIG GFM BESS Project Team

Nick Miller

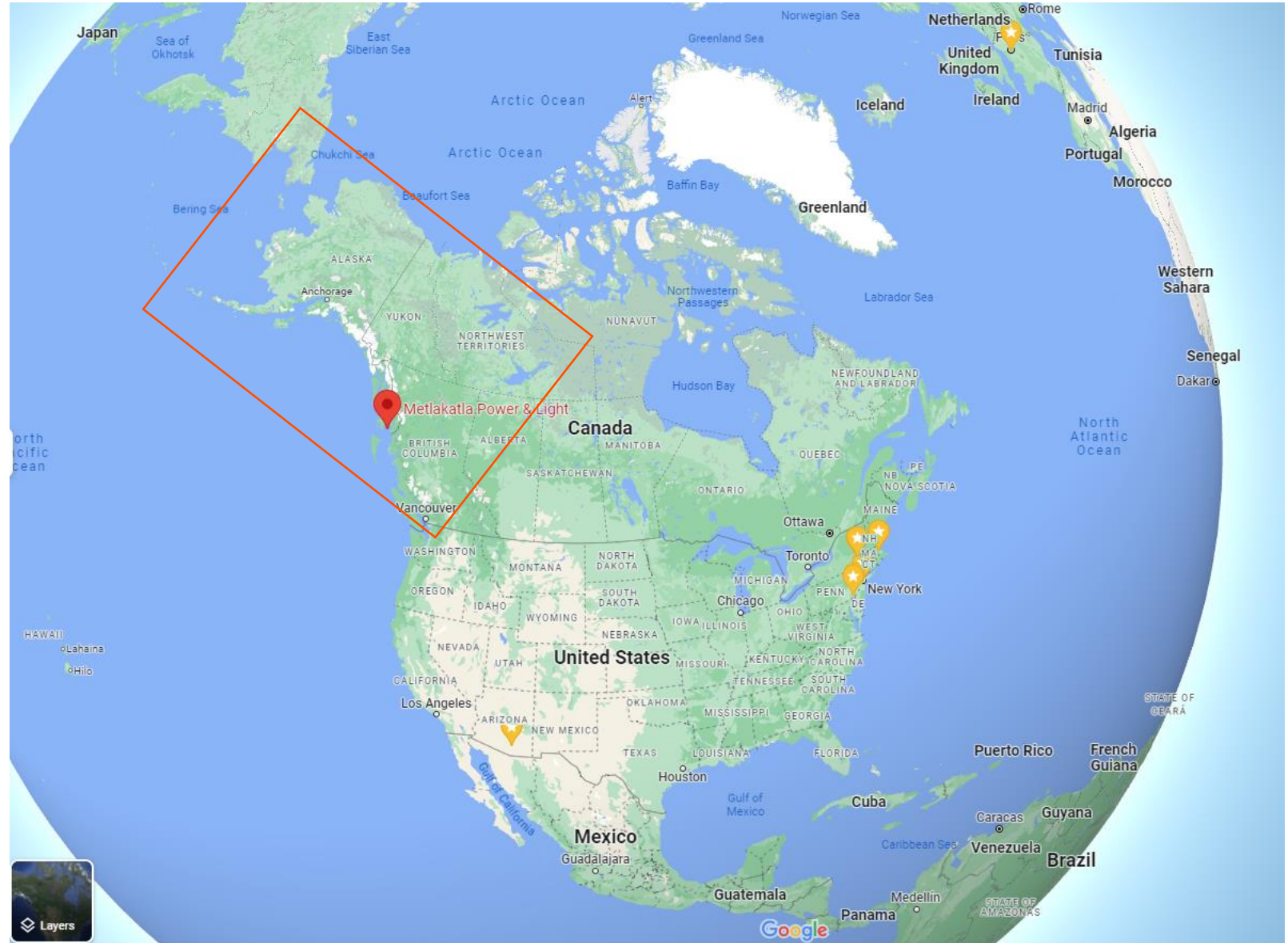
Sept 5 2024

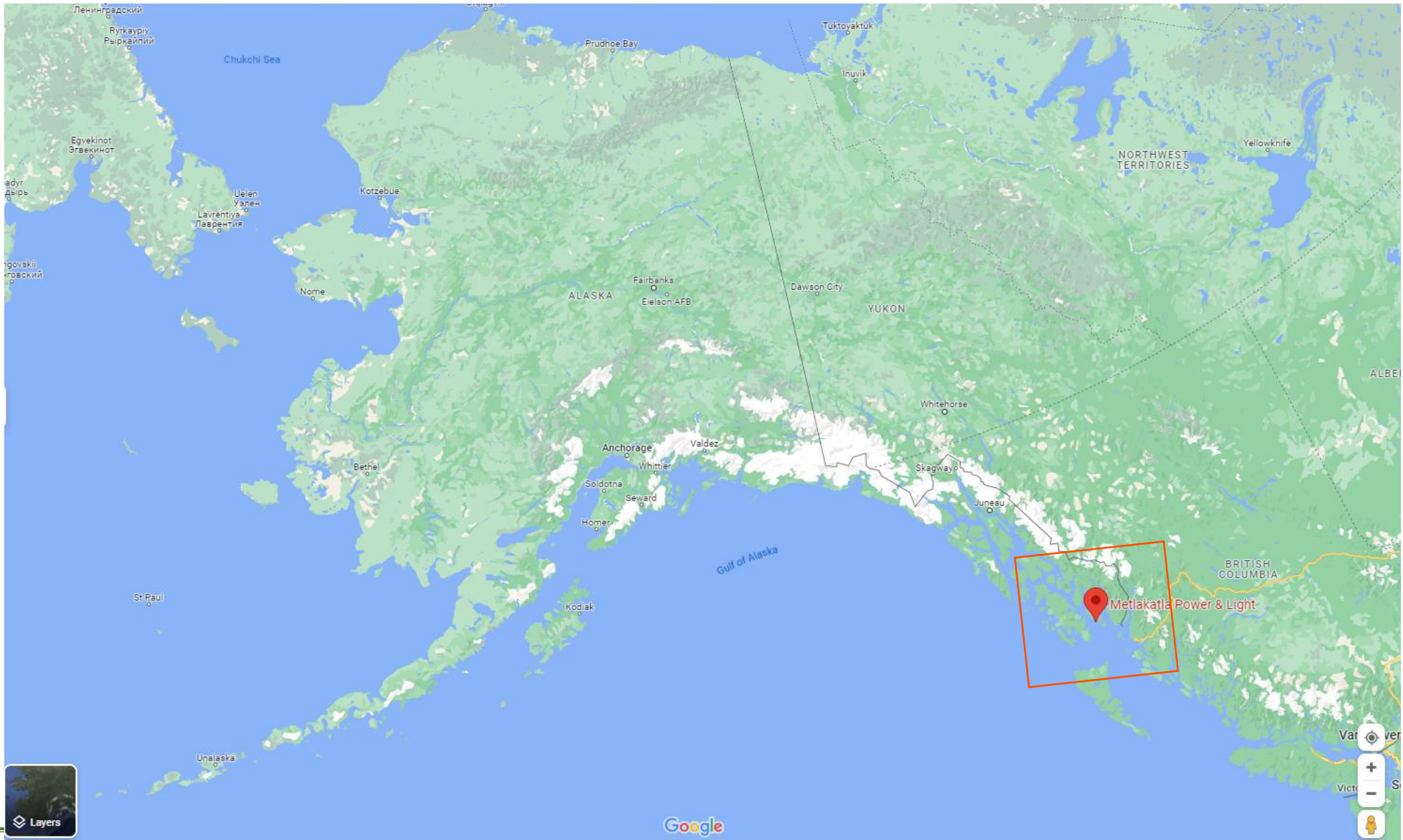
Alaska

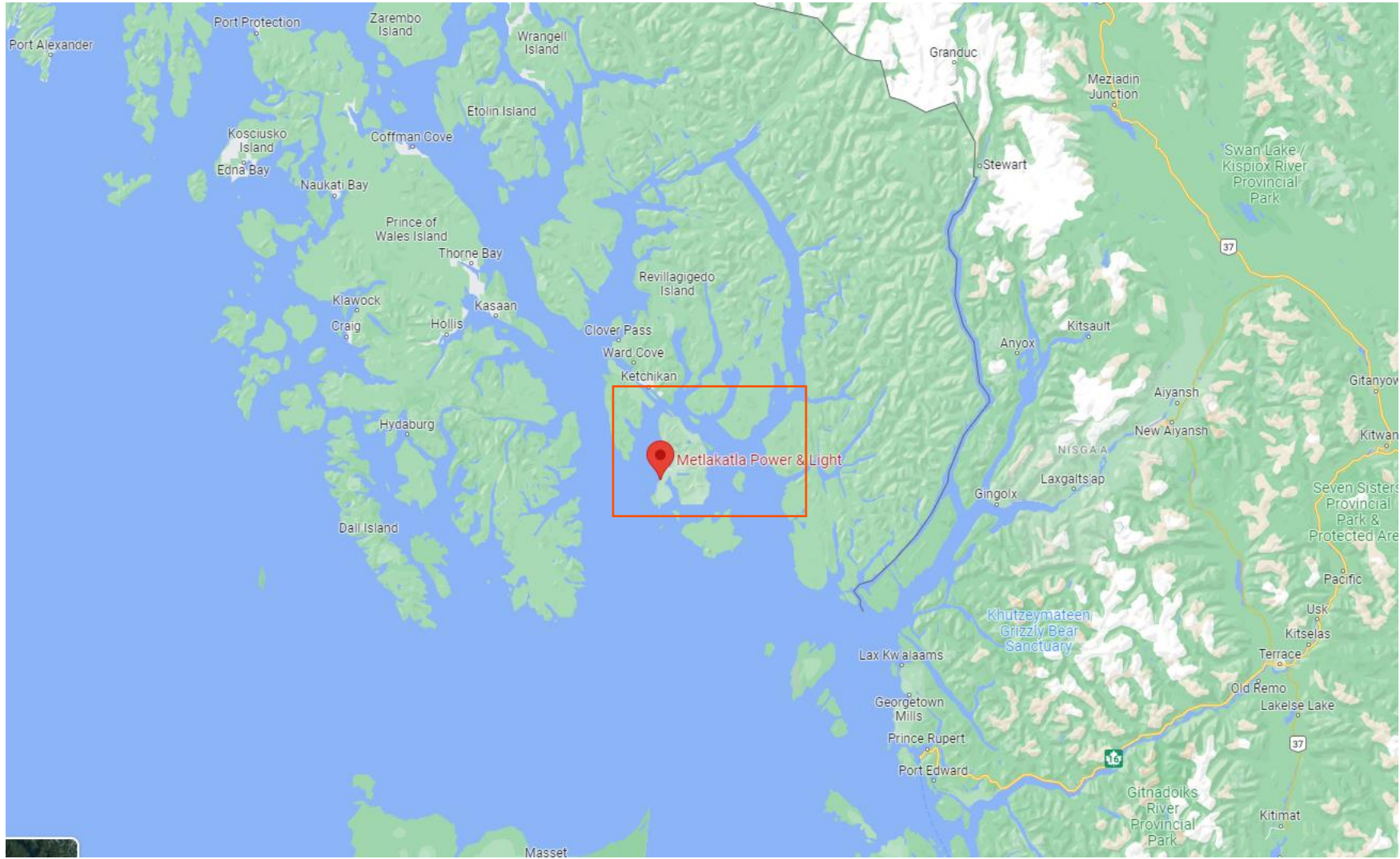
It's really big!

Metlakatla Power & Light

- Metlakatla is an island community on the Annette Island Reserve.
- The only federal reserve for indigenous people in the state.
- Governed by the Tshimshian Tribal Council
- ~1500 people









Grid-forming inverters are not new

Metlakatla BESS was a pioneering project, which included many requirements and features that strongly anticipated today's challenges with integration of wind and solar IBR resources

Pioneer Power Plant
Metlakatla Power & Light
1MW/1.4MWhr BESS.
Official Commissioning
August 7, 1997
“Founder’s Day”

The project was a joint effort of GE for inverters, controls, infrastructure, and GNB (later Exide) for batteries

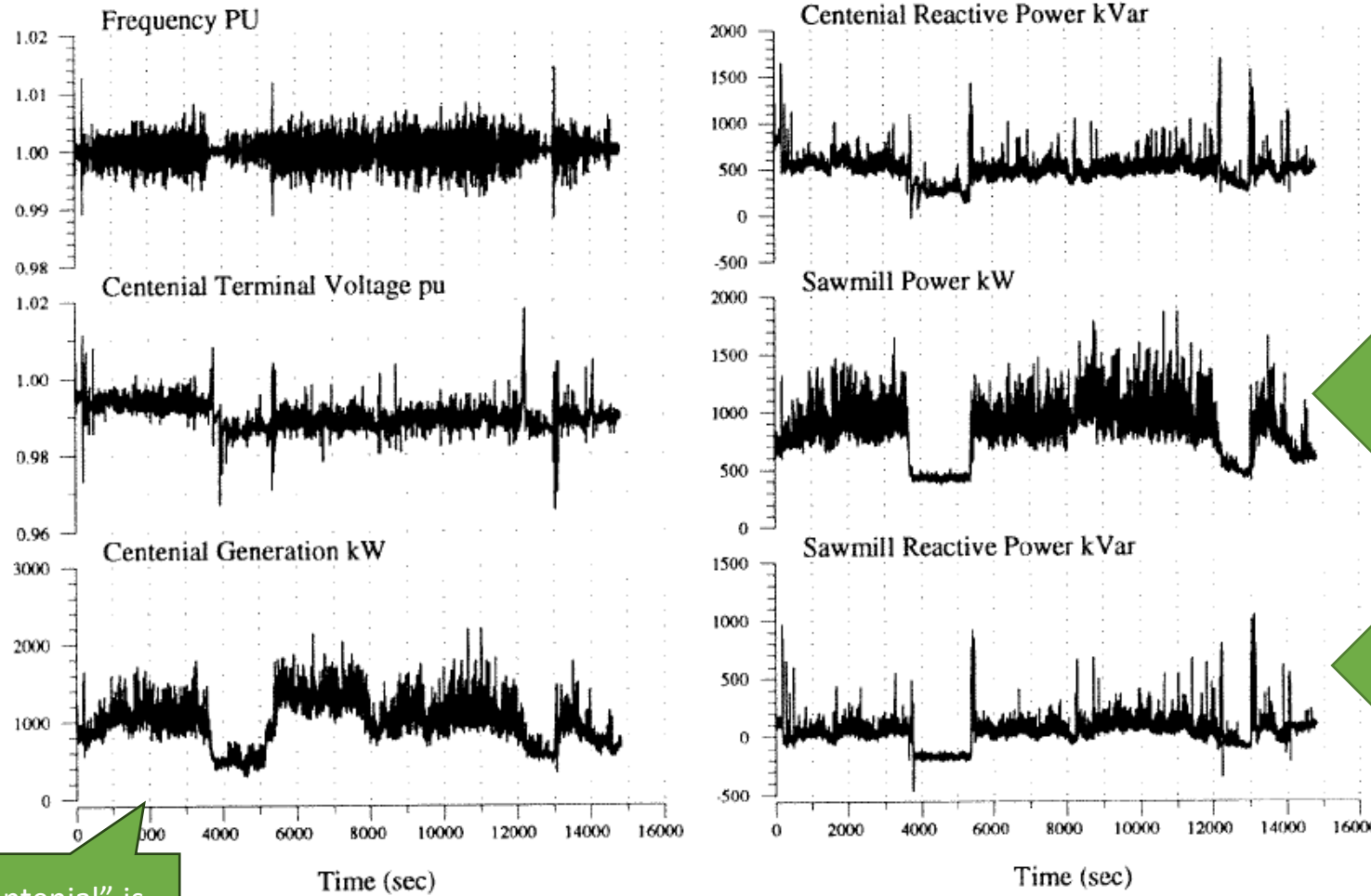
We (the industry) learned many lessons about grid forming, BESS control, charge management, system restoration, and overall integration.

Is it well worth a retrospective.



I still have my commemorative tee shirt, with a traditional painting specifically created by an artist of the community for the occasion. Cool, eh?

A difficult environment: foreshadowing solar and wind variability



This oscillography was effectively GE's product functional specification

Load Power

Load VARs

Note the conference name & date: we've been at this for a while!

Reference:
Battery Energy Storage System for Metlakatla Power & Light, N.W. Miller, et.al. 5th Int'l Conference on Batteries for Utility energy Storage, Puerto Rico, 1995

"Centennial" is the diesel genset

Figure 2.2. Typical Metlakatla System Load Profile.

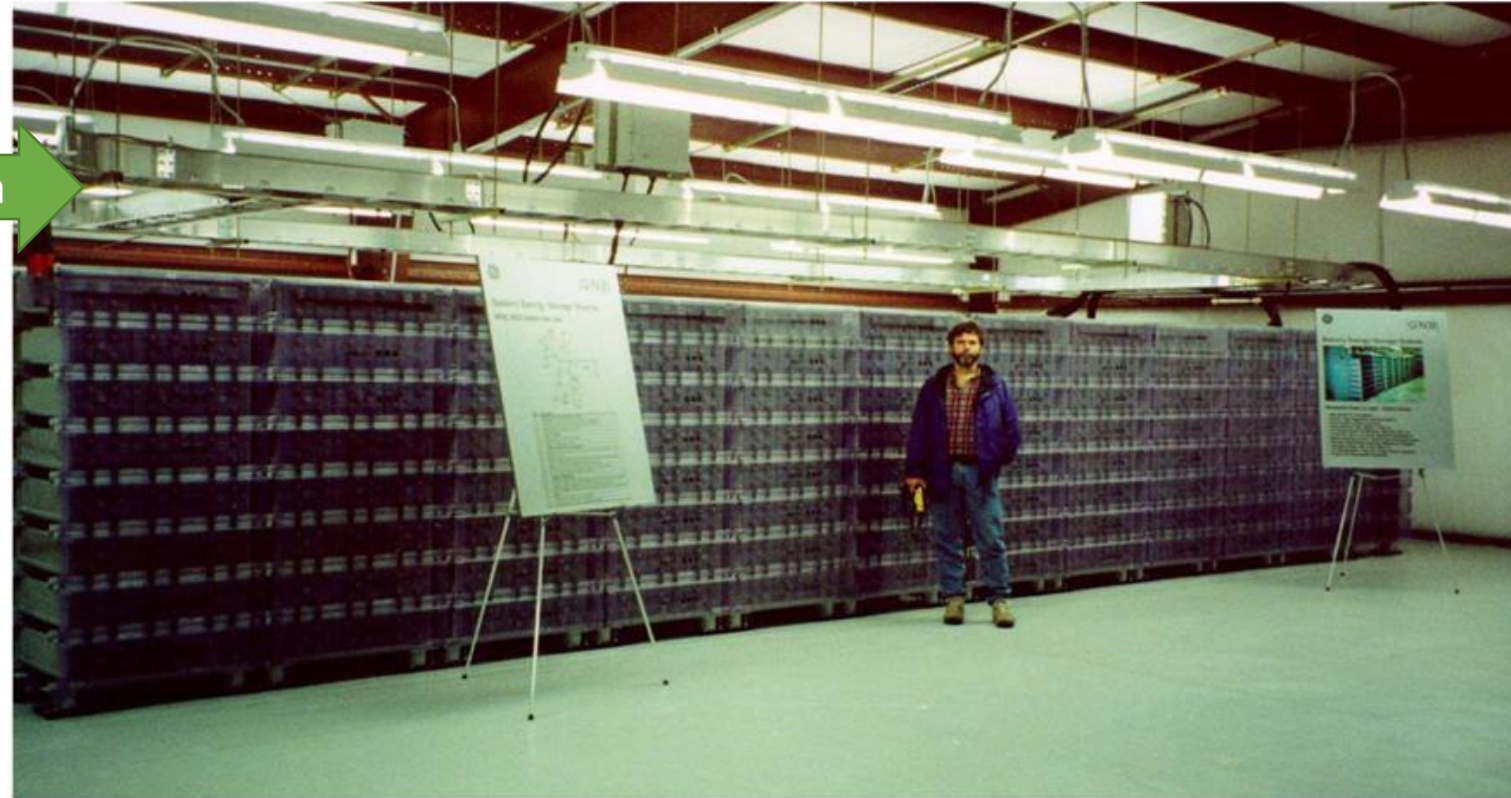
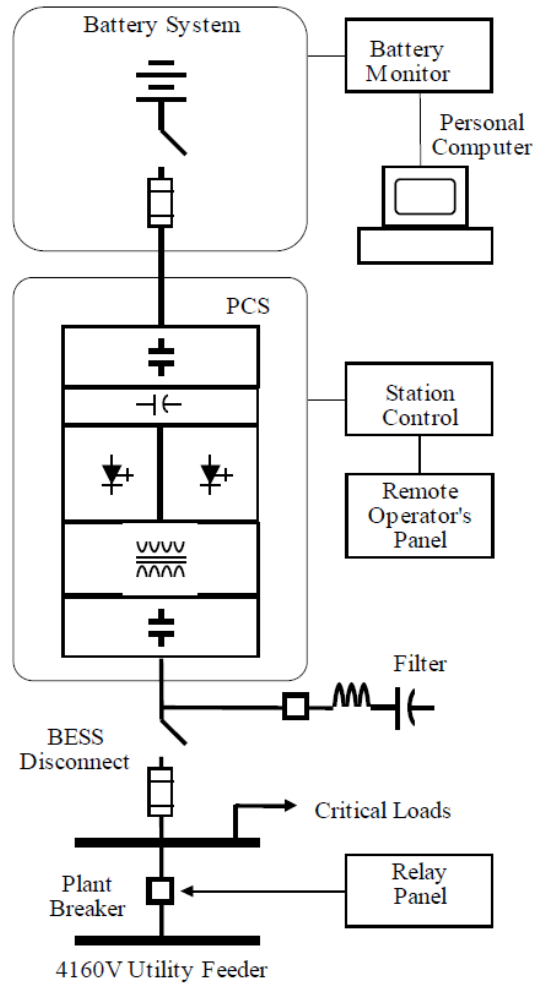
Grid Forming Batteries

Metlakatla Power & Light 1MW/1.4MWh-1995-7

Other Key GE Grid Forming BESS Projects:

- Vernon CA 5MW/2.5MWh- 1996
- Battery Energy Storage System of 30MW/22MWh- IID 2017

Even today, BESS projects are usually **not Grid Forming**



Grid Forming Batteries

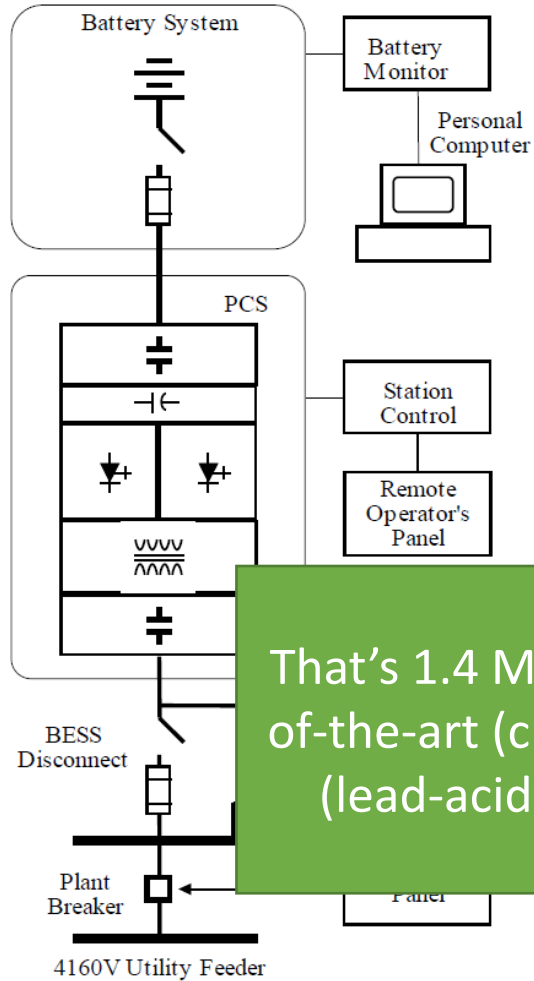
Metlakatla Power & Light 1MW/1.4MWh-1995

Other Key GE Grid Forming BESS Projects:

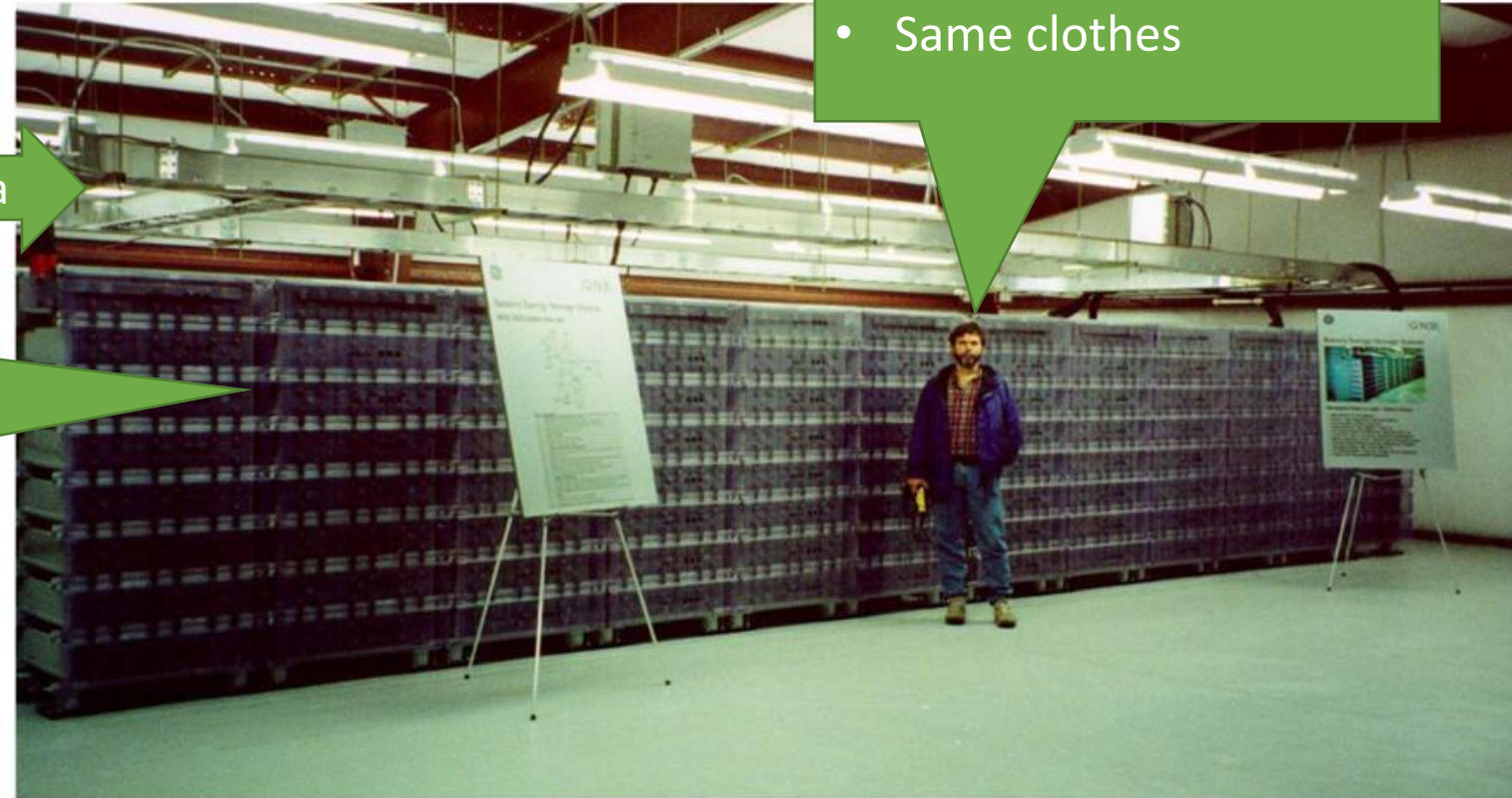
- Vernon CA 5MW/2.5MWh- 1996
- Battery Energy Storage System of 3

Even today, BESS projects are usually

- That's me:
- Dark hair and beard
 - A few pounds thinner
 - Same clothes

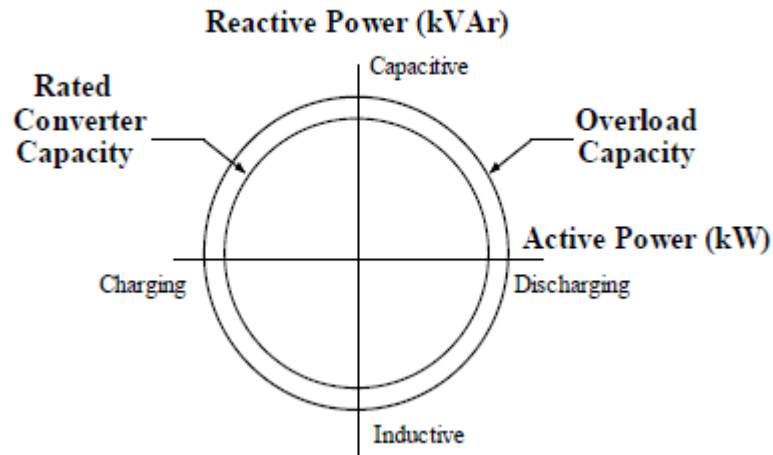


That's 1.4 MWh of state-of-the-art (c. 1995) VRLA (lead-acid) batteries



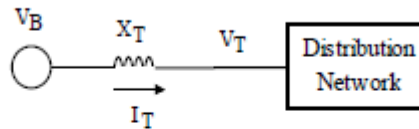
Virtual Synchronous Machine - VSM

Note the date: before we had the language “grid-forming”...

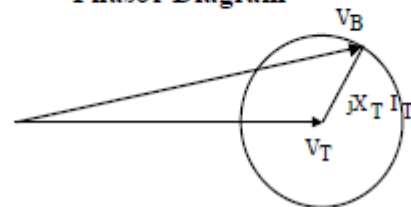


... “Since the BESS may be required to support an isolated electrical load, the PCS is designed with self-commutating.... **Pulse-width modulation (PWM) to generate a controllable AC voltage waveform**”
..... “... the generated voltage is completely controllable...”

Equivalent Circuit



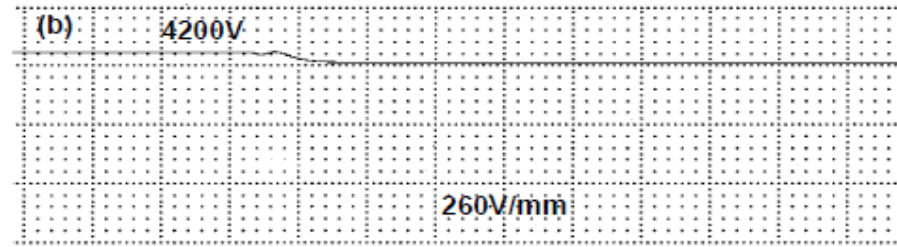
Phasor Diagram



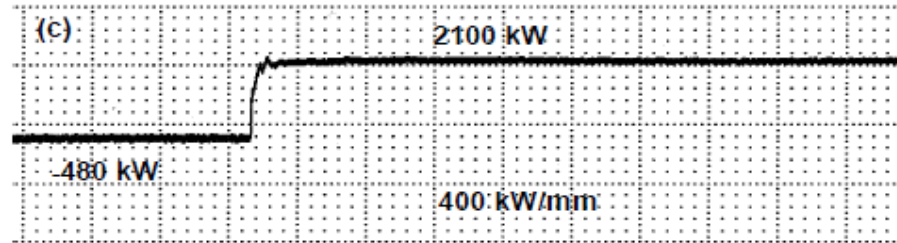
Reference: Design and Commission of a 5 MVA, 2.5MWH Battery Energy Storage System, N.W. Miller, et.al. IEEE SPM 1996

Trip to “zero” inertia microgrid

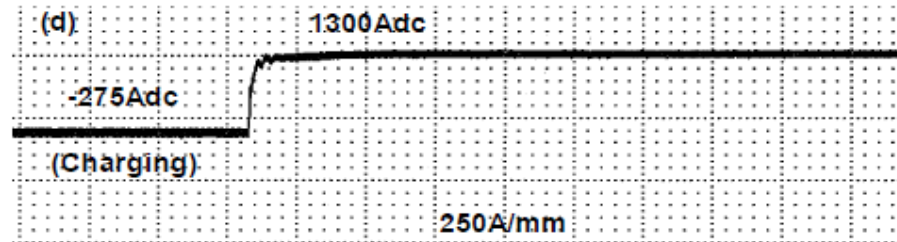
- This is an actual trip of a microgrid (an industrial facility) from the California grid.
- The BESS “instantly” picks up and sustains voltage and frequency
- This capability will be critical in future, when controlled breakup becomes a standard part of grid “resilience”



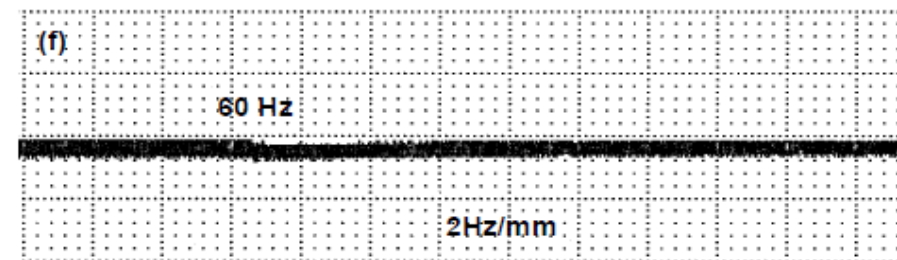
Voltage



Power



DC Current



Frequency

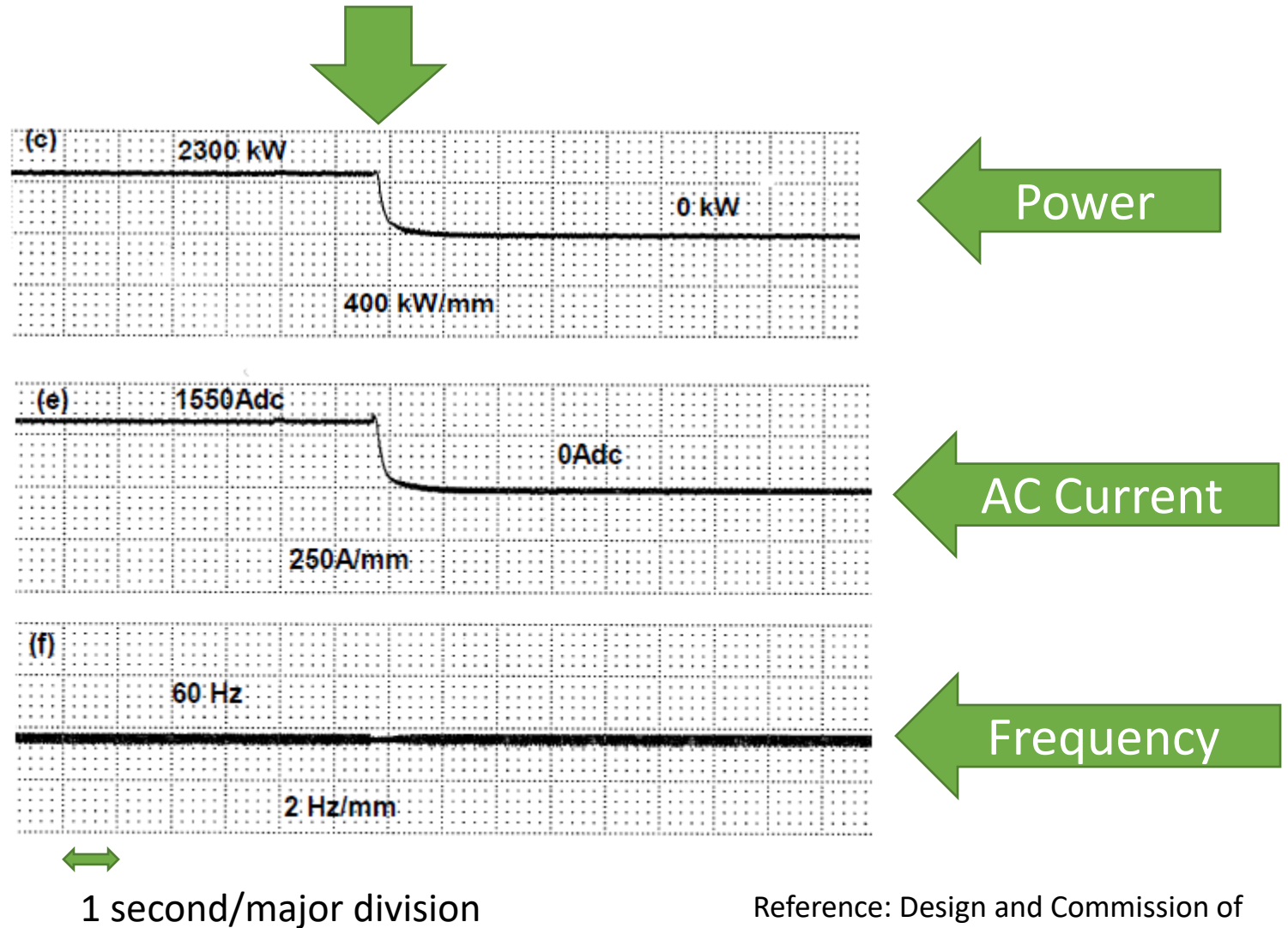
1 second/major division

GE & GNB did this project in California during about the same time period. Controls and inverters are very similar to Metlakatla. We published these tests in '96

Reference: Design and Commission of a 5 MVA, 2.5MWH Battery Energy Storage System, N.W. Miller, et.al. IEEE SPM 1996

Resync “zero” inertia microgrid to main grid

- This is the other side of the coin: resynchronization of the same microgrid back to the SCE grid.
- The BESS pulls the microgrid into synchronism across the breaker, allowing a “bumpless” reconnection
- Lots of industry awareness and practice issues need to be resolved before such behavior is widespread practice.



Reference: Design and Commission of a 5 MVA, 2.5MWH Battery Energy Storage System, N.W. Miller, et.al. IEEE SPM 1996

Blackstart and other features

- The synchronizing controls we just showed were integrated to an HMI at Metlakatla that facilitated system restoration and parallel operation with their main synchronous hydro generators.
- The HMI provided with the BESS was what the industry would call a microgrid controller today, coordinating the BESS power & SOC with the other generation and load in the isolated system
- System restoration times were reported to have been greatly reduced

How did it all work out?*

In 2008, the original batteries were decommissioned and replaced.

- Life: - warranty: 8 years
- - total actual operational life: 11 years, 7 months: 50% over projections
- Inverters and BOP were retained as originally designed and constructed (I think)
- Operating regime: online 24/7; maintained 50-80% SOC
- Fuel savings: 475,000 gallons/year (1.8M liters/year). 20M liters by battery replacement in 2009.
- 59kT of CO2 reduced.
- Reduced noise
- Reduced risk of environmental catastrophe from oil spills
- Estimated operational savings in 12 years: \$6.5M

* This data was presented by GNB Industrial Power division of Exide in 2009:
“The Metlakatla Battery Energy Storage System: Twelve years of Success”

- As of ~2023, the installation is out-of-service
- MP&L tells me (April 2024) they are actively planning on replacement BESS system for the immediate future. Details TBD (to me)

Perspectives on Today's Large Interconnected Systems

- Why GFM?
 - The magnitude and speed of variation required GFM.
 - The fundamental functional specification was to replace dynamic services (short circuit strength, inertia, voltage and frequency control) provided by synchronous generator specifically installed for these services.
 - In modern context, this was purely driven by the need to retire uneconomic, dirty synchronous generation.
- Essential reliability services were economically and reliably provided for more than 2 decades, including
 - Inertia, primary and secondary frequency control
 - Voltage control
 - Blackstart and system restoration
- Project was run by utility staff without requiring extensive training, new tools, or dedicated personnel. Project was custom built, but the power and battery components were commercial, industrially hardened, and mature.

Moving forward

- These are “real” utility experiences, not laboratory curiosities.
- 2+ decades of operation in the field, at extremely high reliability, *is* important context in the present trajectory towards widespread deployment in major interconnections.
- The current progress towards codification, standardized modeling, and systemically oriented performance requirements is supported by these experiences.
- Caution is warranted, Undue “go slow” approach is not.

Thanks

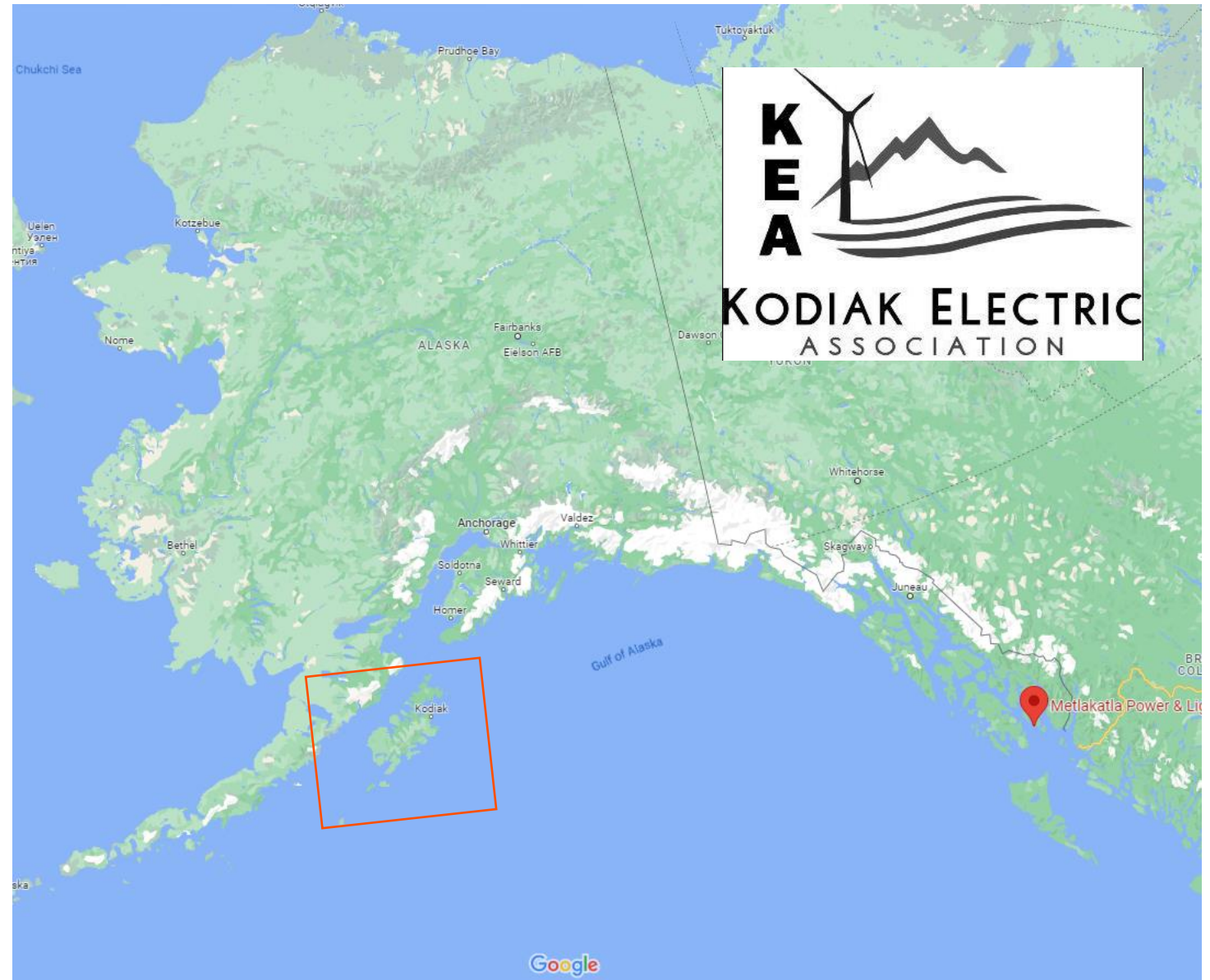
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Other tidbits about Alaska

Kodiak Island

- KEA – Kodiak Electric Association.
 - CEO Darren Scott
- Peak load 26MW (with new port loads)
- KEA targeted(2011) 100% renewables by 2020. Hit 99.7% in 2015
- Displaced 2.8M gallons (10.6M L) diesel ; \$7M/year



Innovative Pieces

Sequence:

1. Upgrade existing hydro. Existing 2x10MW plant left room for a 3rd (Wow!) added (2011)
2. Add 3x1.5 GE WTGs
3. Add 3MW BESS
4. Add 6x1.5 GE WTGs
5. Add 2x1MW Hitachi energy storage flywheels; support voltage and frequency.

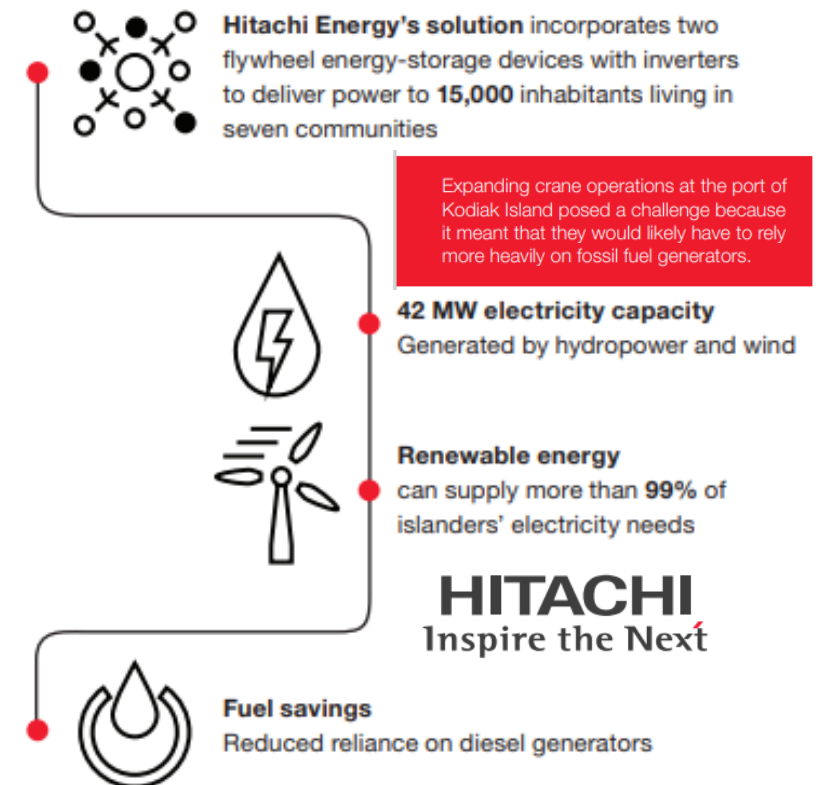
Stabilizes big swings from Port Cranes as well as wind variations

... And a lot of clever pondage and SOC management to avoid running diesels and minimize curtailment and spillage.

- All rates dropped and stabilized (no tracking diesel prices)
- New sustainable salmon fishing industry growth

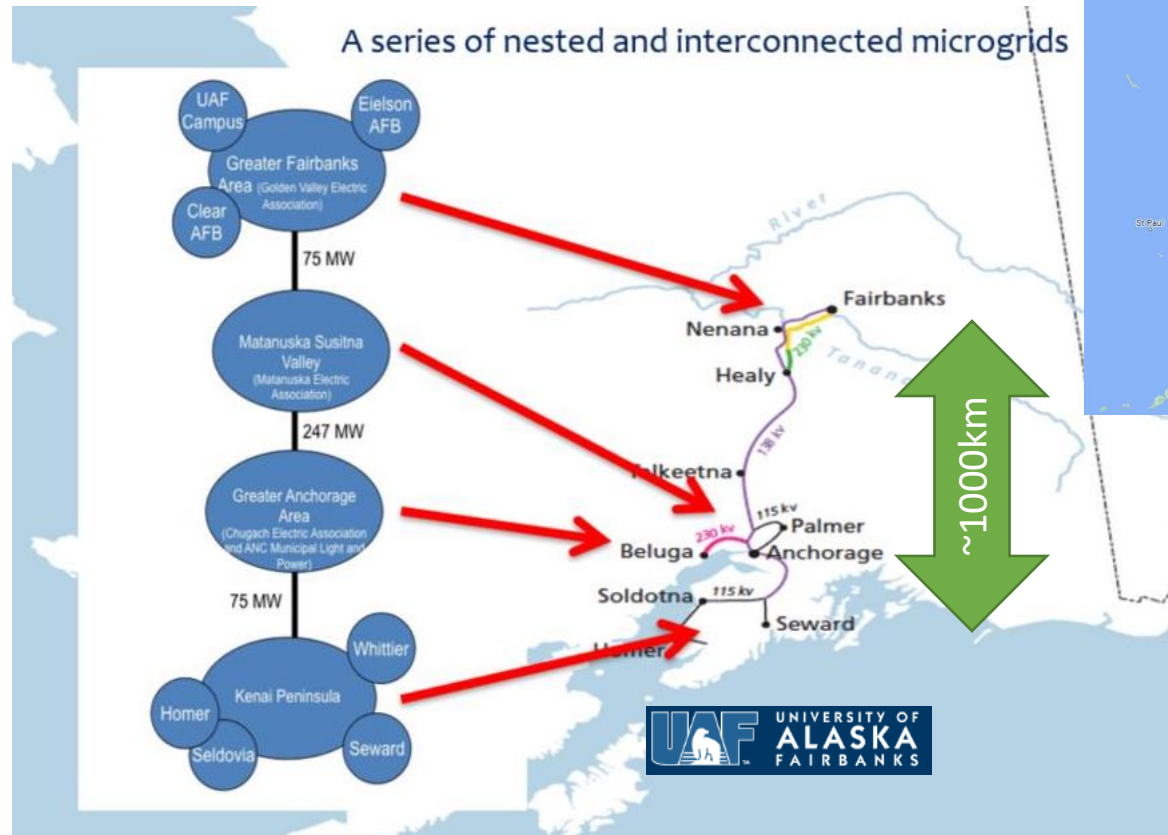


<https://aworldbridgesite.com/kodiak-electric-association/>

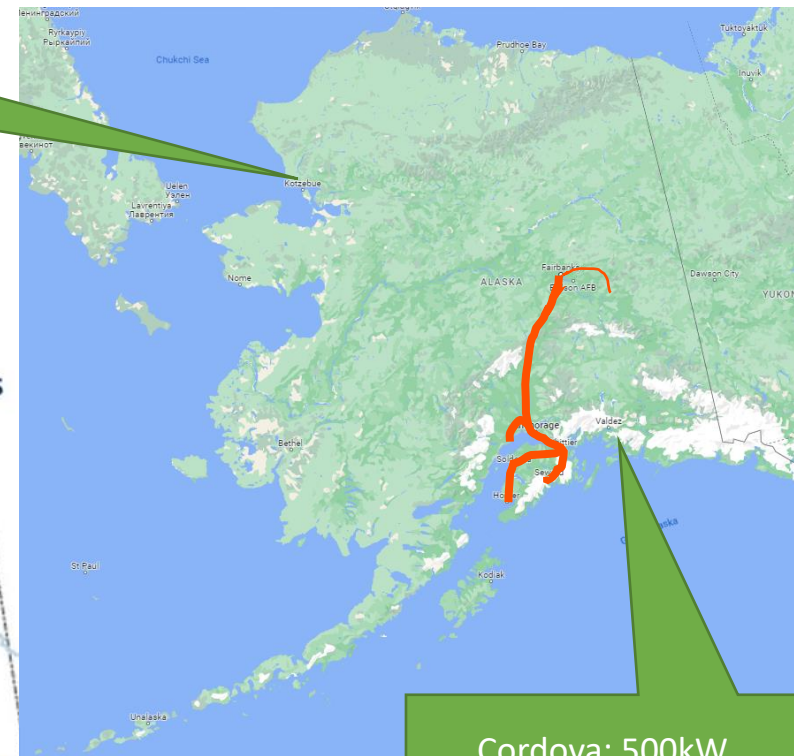


The “Railbelt”

- REALLY long: ~1000km
- Single circuit for much of that
- Mix of 115, 138, 230, 345kV lines
- About 75% of AK’s total load
- 5 Major LSE utilities; several other players
- 4400 GWh/year
- 20% renewable (2020), of which 2% wind
- Peak – winter evenings ~750MW



Kotzebue: 500kW,
2.8MWh Zinc-Bromine
Flow Battery c.2011



Cordova: 500kW,
(SAFT) Battery c.2019

“hundreds” of isolated systems in AK, from 200kW to 5MW (per US DOE).
Running microgrids before “microgrids was “thing”

The “Railbelt”. History & Future

- Many years of “interesting” stability issues.
 - Early BESS. C1998. 40MW in Fairbanks (Golden Valley EA). Huge for the time; many advanced controls (ABB)
 - SVCs (Healy,...)
 - Novel transient stability controls on Hydro (Bradley Lake – at the end of the whip)
 - Effectively multiple viable microgrids, normally interconnected
 - “only” 44MW wind today.
- Near future
 - **Several hundred MW of wind plus storage proposed**
 - 80% RPS considered
 - (Studied by NREL: “Renewable Portfolio Standard Assessment for Alaska’s Railbelt”, Denholm et al <https://www.nrel.gov/docs/fy22osti/81698.pdf>)

