Alaska Village Electric Cooperative
GRID BRIDGING SYSTEM

IPS Connect July 2022 Cordova Alaska

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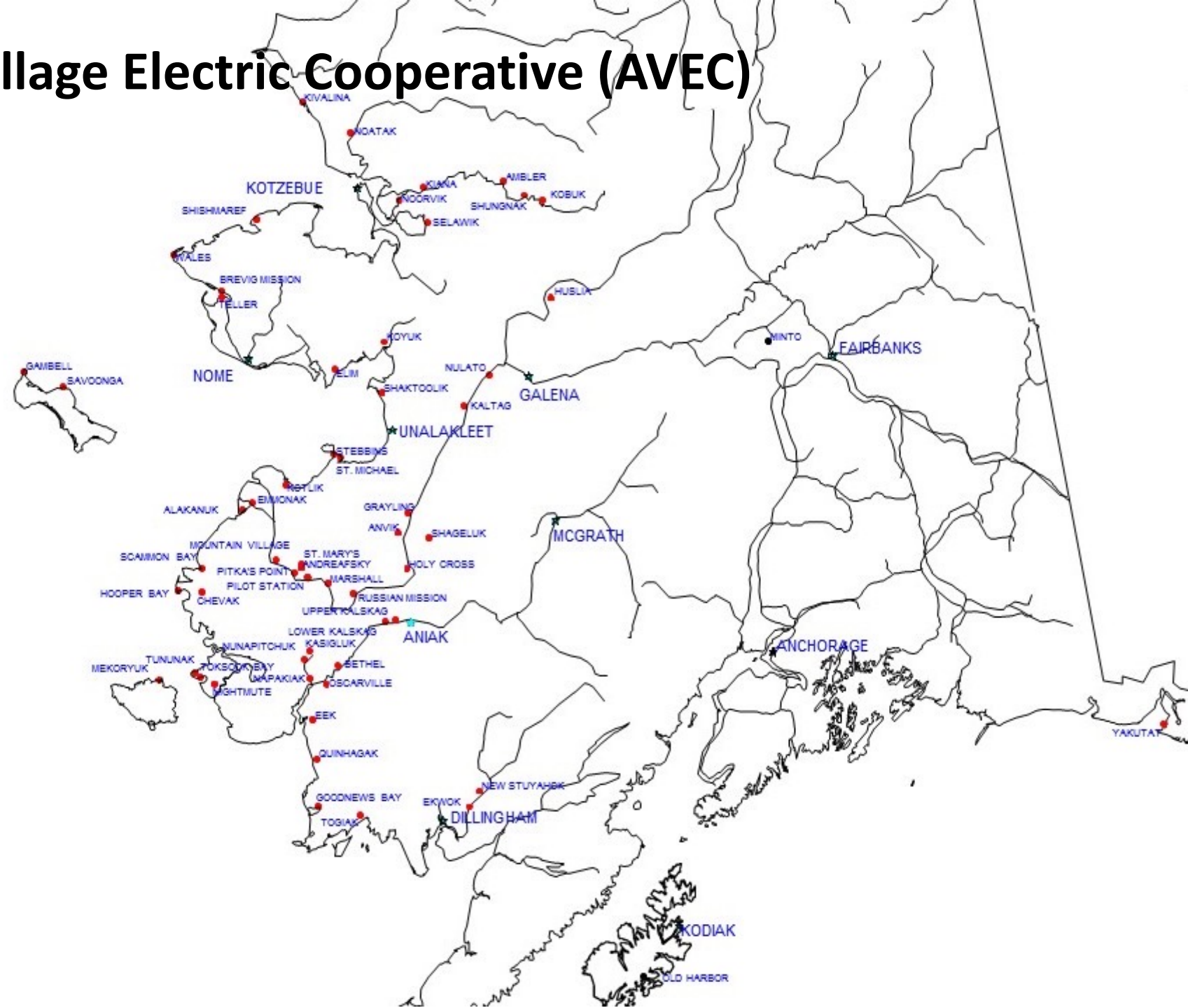
ACEP
Alaska Center for Energy and Power

A Typical western Alaska Village

Flat land:
No easy hydro opportunities
No gravity based energy storage
Few transmission lines

Who are we? Alaska Village Electric Cooperative (AVEC)

- Member-owned rural electric cooperative
- 58 microgrid communities across Alaska served
- 50 power plants
- 12 wind-diesel microgrids



What type of Power System is AVEC aiming at?

- Our only choice for reliable base generation is using diesels.
- We use a variety of different sizes so that we can pick the most efficient to run. This selection has to be automated.
- Our only current option for renewable energy is Wind.
- Our Renewable Grids hence tend to be Wind-Diesel hybrids and are usually in the size range of 100 kW up to 1000 kW.
- Wind is continually unpredictable and only partly controllable.
- Because wind is unpredictable, we have to run diesel capacity as back-up. Meaning that sometimes we run a 1000 kW loaded at 10% just to **maintain spinning reserve.** This is not only ironic, but inefficient.
- So our desire is to allow those diesels to be selected only by the need to supply actual power and not just spin to cover possible load increases.

Wind is AVEC's renewable opportunity

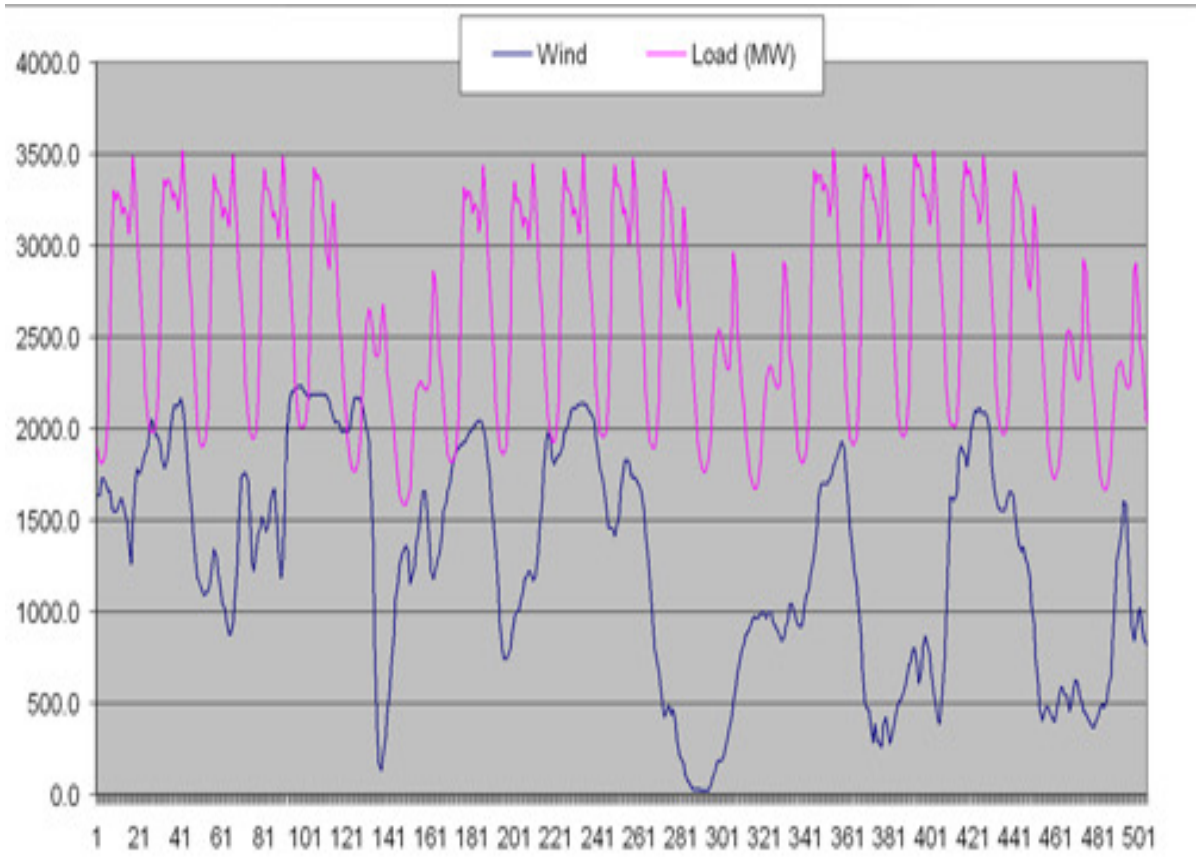
What is Spinning reserve?

Wind is unpredictable

And here is what unpredictable wind does to your power forecasting. At least the day/night load variations are somewhat predictable.

Here are 21 days of load, showing the daily variations in load (pink), and also what is typical variations in wind output.

Add the two variations together, and we have some serious operating and economic forecasting difficulties.



What is Spinning Reserve?

Spinning Reserve is the amount of immediately available (i.e. spinning) unused generation that has to be kept in reserve to provide power for short term future increases in load.

We need a synthetic way to provide that.

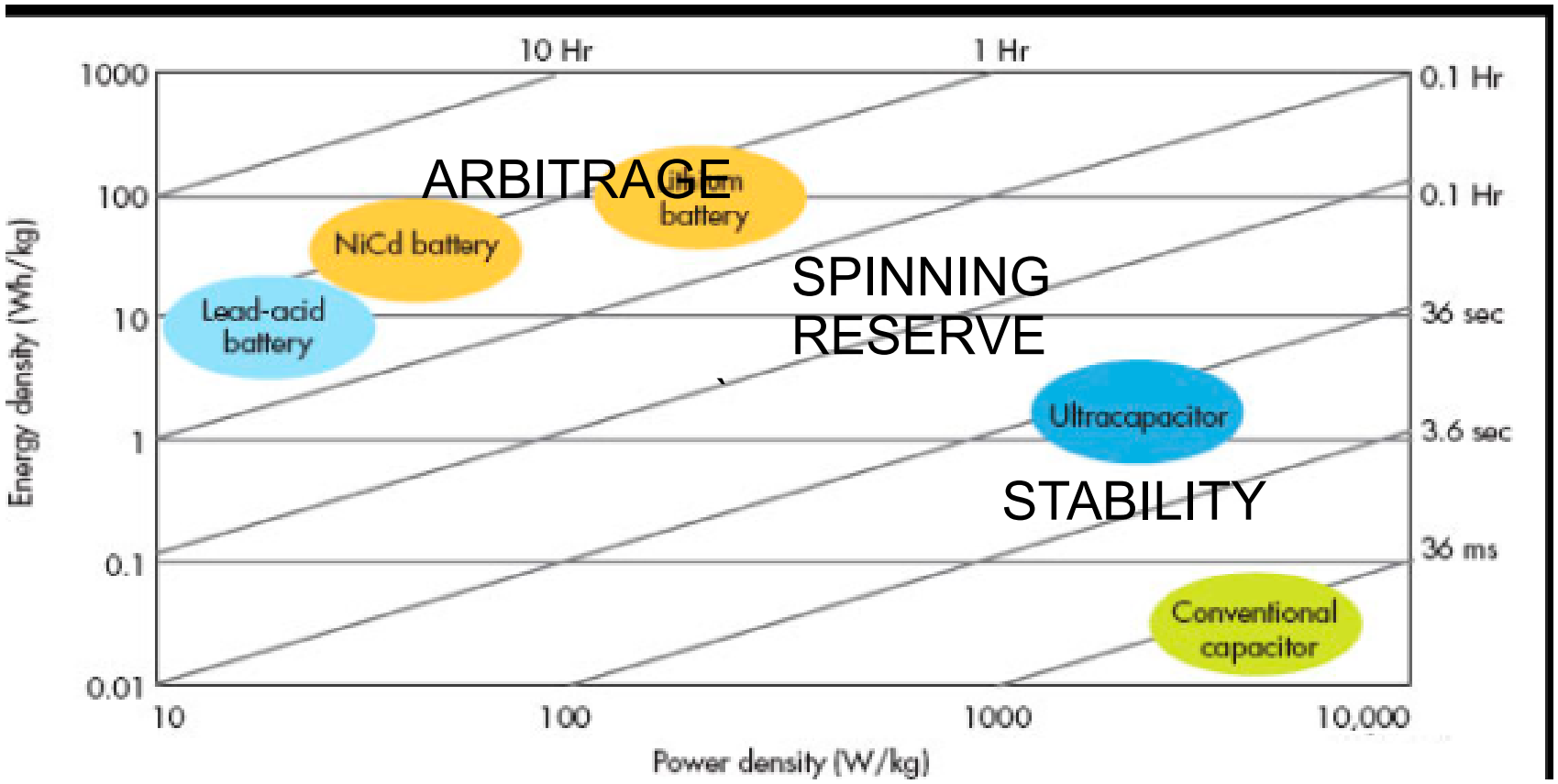
Our generators start quickly, so we can have additional generation on line in less than 2 minutes, hence we only need a small amount of energy storage to obtain this large operational advantage

A very big low hanging fruit.

Future Proofing AVEC Power Plants 1

- We will need synthetic spinning reserve in all our power plants some time soon. To make that happen, we need the following:
  - Inexpensive
  - Small footprint
  - Easy to install
  - Safe and easy to maintain
  - Replicable
- We do not need a lot of energy storage to pick this low hanging fruit. A 1 MW system could get by with only 30 kWhrs of energy storage
- That can be provided by Ultracapacitors
- Or we could have a slightly larger GBS using lithium titanate, which can be discharged as quickly as 10 minutes. Hence a 150 kWhr battery.
- Or we use a more traditional 1 hour lithium battery, like the one Cordova installed. There are some ancillary advantages if you have more storage.

So which approach meets these needs?



Ultracapacitor advantages and disadvantages

- Much Longer operational life than chemical storage such as Lithium.
- Rapid and high recharge rates. (90% in 6 minutes, 95% in 10 minutes)
- Extremely high-power densities.
- The capability to charge and discharge rapidly at very high and very low temperatures. (-50°C to +65°C)
- Fire safety – lower energy density eliminates fire risk almost entirely.
- Maintenance safety – Capacitors can be discharged for servicing.
- Easy state of charge calculation (by measuring voltage)

But…

- Low energy density compared to chemical storage
- Much greater cost.

1MW Ultracapacitor Modules installed in a rack

Lithium Titanate Advantages

- Possesses a greater full DOD cycle life (exceeding 16,000-25,000 cycles, depending on product)
- Rapid and high recharge rates. (90% in 6 minutes, 95% in 10 minutes)
- Extremely high-power densities.
- The capability to charge and discharge rapidly at very high and very low temperatures. (-50°C to +65°C)
- More Fire safety - eliminates the preponderance of safety failure modes present in typical lithium ion and other battery technologies (Altairnano is glad to share videos of standard FMEA testing where our modules have been shot, immersed in salt water, penetrated by nails, crushed and set on fire without going into thermal runaway, a catastrophic failure where batteries explode with great energy. Few other lithium ion technologies can make this claim).

Benefit Streams

- Removes the need to keep diesels running lightly loaded (this is the major benefit stream)

- By modulating battery charging and discharging, Engine switching can be greatly reduced.

- Power reliability is greatly increased, since the failure of any major generating resource is now backed-up with the GBS

- System frequency and voltage stability is improved.

- Diesels do not have to respond to very quick load changes, improving their efficiency further.

If the need for diesels capacity goes to zero, we can potentially go diesels – off.

Arbitrage is more difficult in wind-diesel systems and has hard to calculate benefits.

AVEC Grid Bridging Project

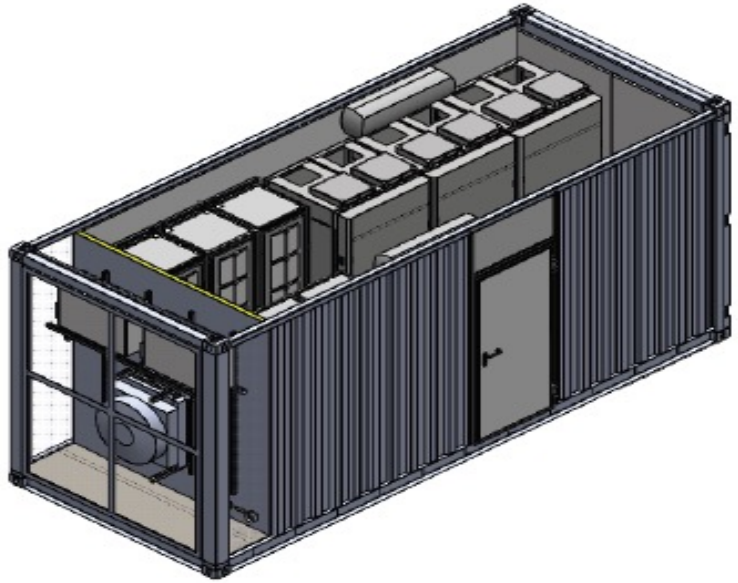
RFP and QUOTES

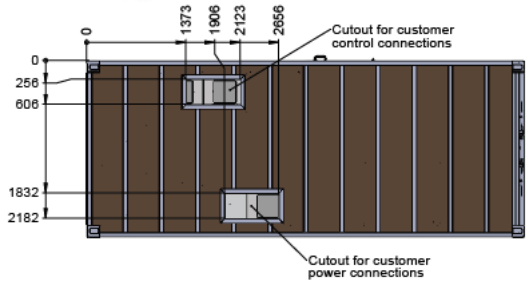
We received six acceptable bids. The two most expensive bidders were about twice the price of the two least expensive bidders.

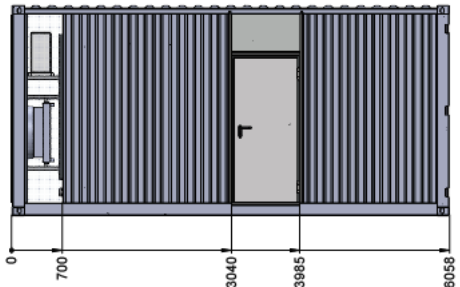
We had asked for three different battery capacities, but after reviewing prices, we decided to not purchase the short term 10-minute storage option nor the long term 4-hour option, but rather the mainstream 60-minute storage option.

We felt as a demonstration project, having 60-minutes of storage rather than 10-minutes would allow us to research a greater variety of operating paradigms.

The four-hour storage option could not be justified economically. The opportunities to shift energy from surplus times to diesel operating times did not justify the expense. We believe that is common for wind-diesel microgrids.







AVEC Grid Bridging Project

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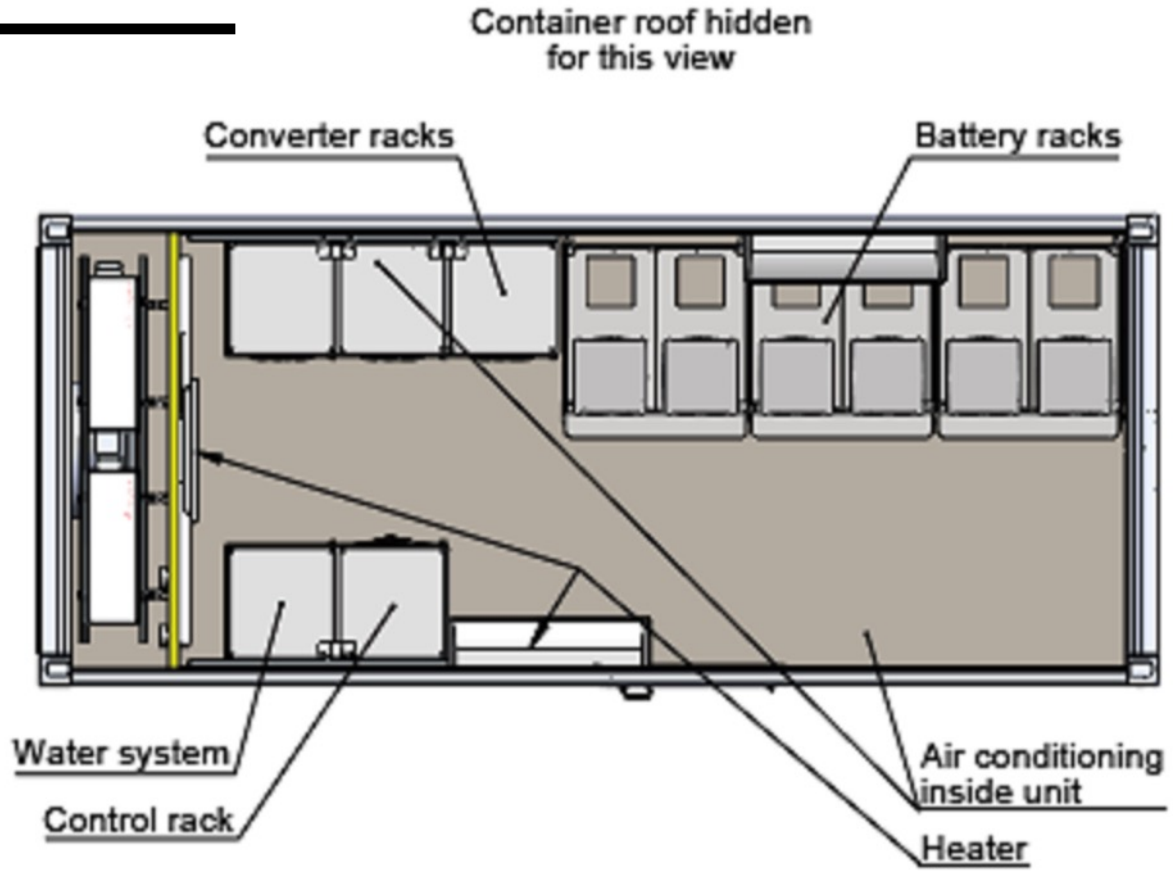
FREQCON

The final two bidders were similar in price, one was headquartered in Calgary, Canada (just down the Alcan highway from us) and the other was in Germany, so this advantage went to Eneon-ES.

We choose to go with the German vendor FREQCON, because their inverter design could connect to our 480V 4-wire powerplant without the need for an isolation transformer.

We simply did not have room at the site for a 1 MVA transformer, nor did we want the attendant operating loss.

FREQCON was able to supply as two ganged 500kW modules for increased flexibility.



FREQCON Module Layout (one of two 500kW units)

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Thank You

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Bill Stamm: President and CEO
Forest Button: Manager of Special Projects
Darren Westby: Manager of Engineering

This work is funded by the DOE OE Stationary Energy Storage program directed by Dr. Imre Gyuk.