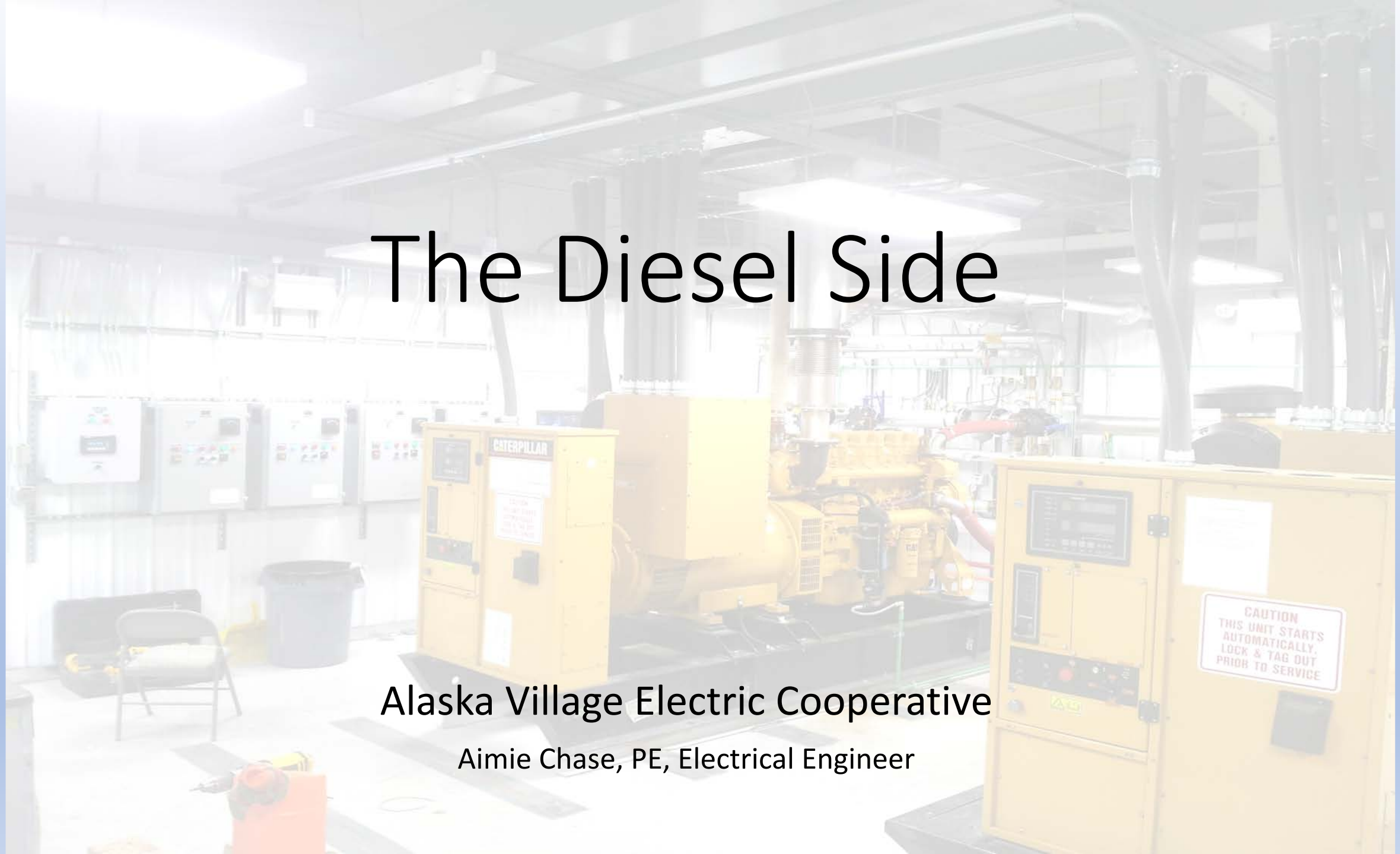


The Diesel Side

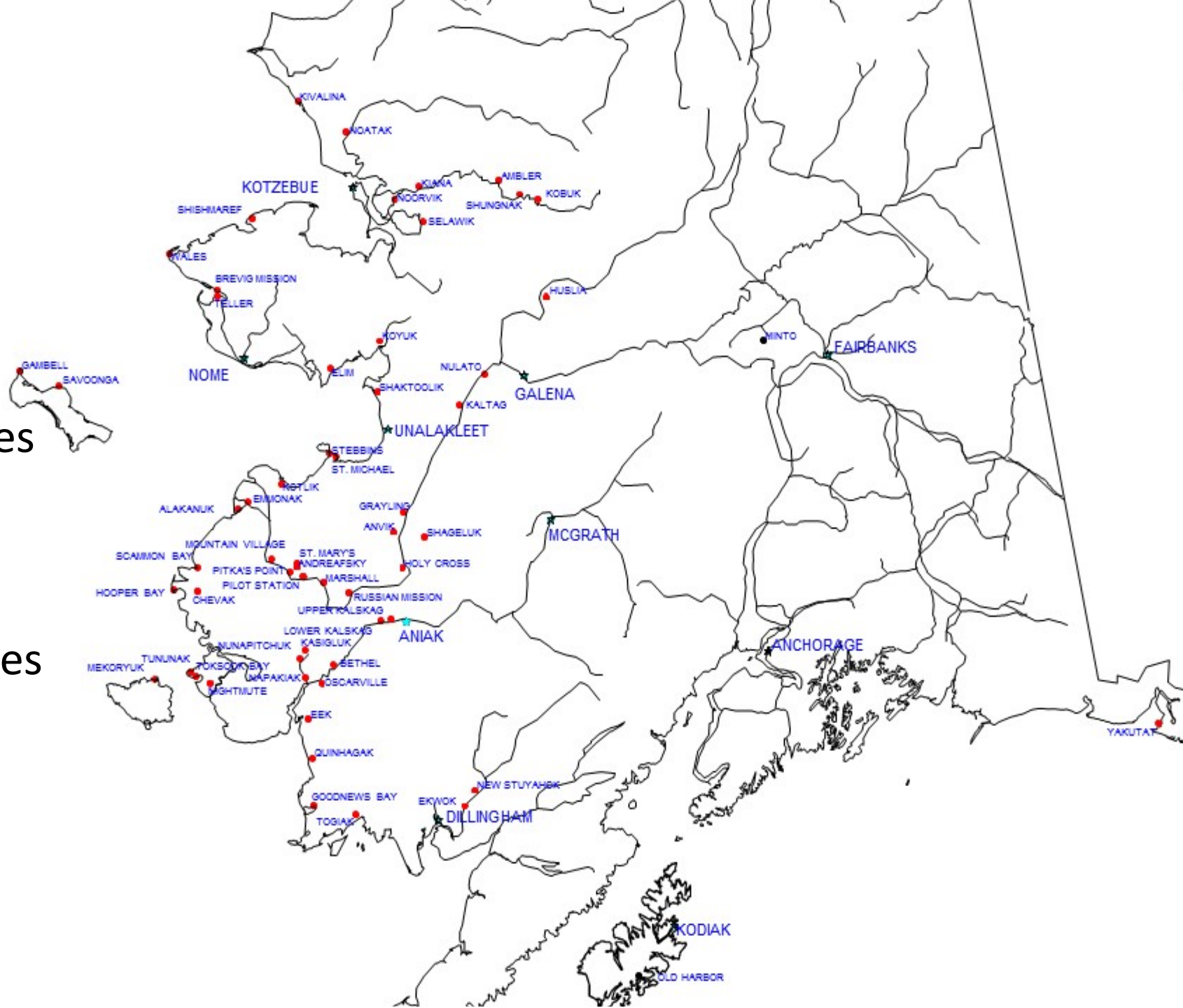
Alaska Village Electric Cooperative

Aimie Chase, PE, Electrical Engineer

AVEC

ALASKA VILLAGE ELECTRIC COOPERATIVE

- Member-owned rural electric cooperative
- 58 microgrid communities across Alaska served
- 49 power plants
- 12 wind-diesel hybrid systems serving 19 villages
- 170+ diesel generators 100kW to 2.2MW
- Average Village Loads 46kW to 4.8MW

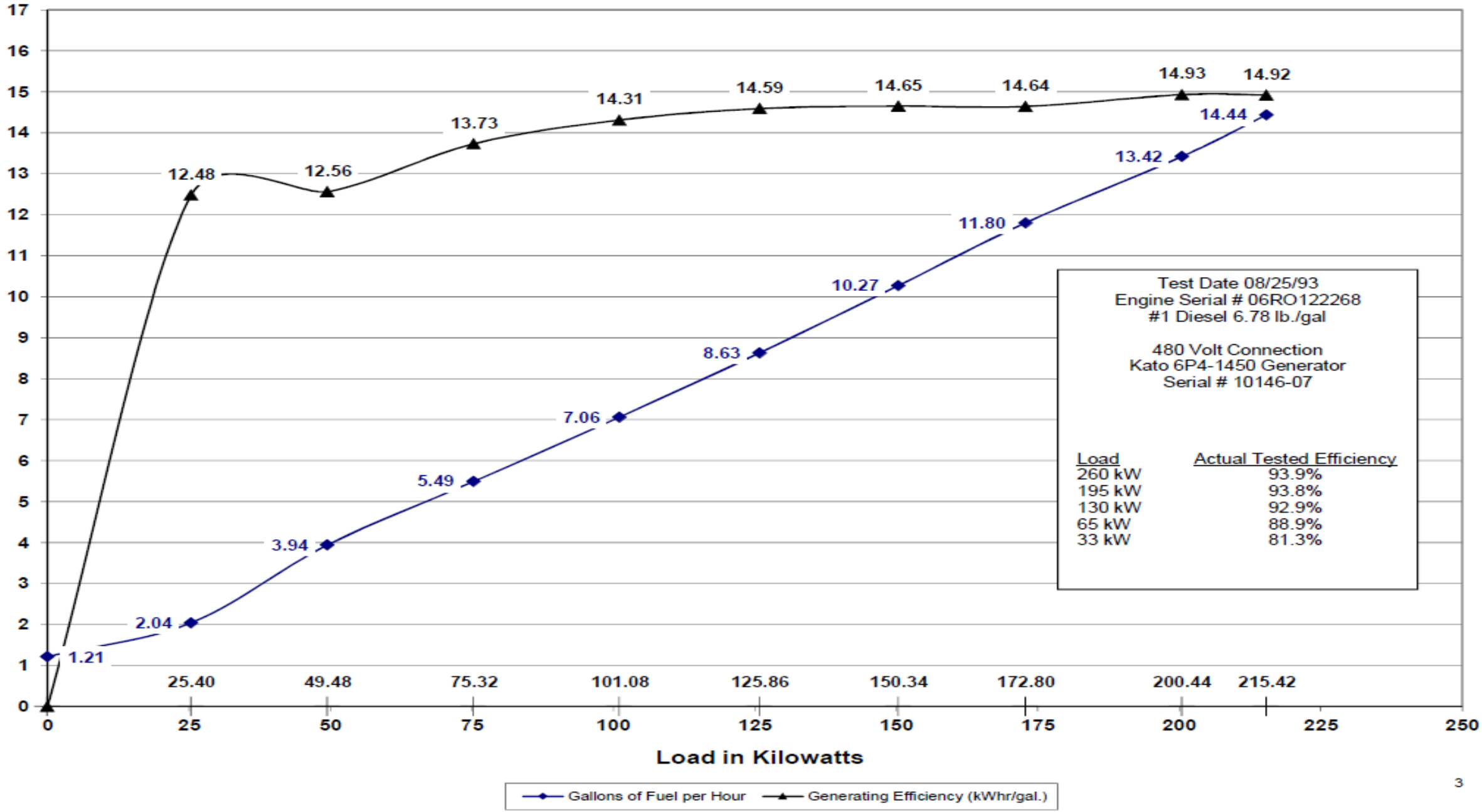


Objectives for Diesels in Wind Hybrid Systems

1) **Diesel engine must be neither overloaded nor too lightly loaded.**
2) Run most fuel efficient engine(s) for a given load and wind output.
3) Anticipate load changes in advance.
4) Don’t switch engines too often.
5) Maximize wind penetration without sacrificing reliability.

New 1200 RPM Detroit Diesel Series 60 12.7 Liter Engine with 12.7 Liter Turbo.

Generating Efficiency



Test Date 08/25/93
Engine Serial # 06RO122268
#1 Diesel 6.78 lb./gal

480 Volt Connection
Kato 6P4-1450 Generator
Serial # 10146-07

Load	Actual Tested Efficiency
260 kW	93.9%
195 kW	93.8%
130 kW	92.9%
65 kW	88.9%
33 kW	81.3%

How Low Can You Go?

- Peak efficiency is at 75-80% of engine rating.
- Above = over fueling
- Less load = less fuel efficiency
- A modern turbocharged, electronically injected engine is reasonably good down to ~25% minimum loading.
- No operational issues seen with running diesels lightly down to 15-20% minimal loading.
- Never seen wet-stacking problems due to level of variability in wind generation. May occur more as penetration level increases.

Hitting “the Floor”

- Caused by low loads or high wind output
- At diesel “floor,” Secondary Load Controller switches on heating elements in a boiler.
- Rapid SLC control creates frequency stability
  (but burns extra fuel if diesel is above its floor).
- If SLC is >50% load or over temperature, then wind is curtailed.

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Limits to Running at Best Fuel Efficiency

- Small engines with mechanical governing are prone to failure---
  Fuel pumps, linkages, & mechanical speed controllers have gone bad.
- Engines with electronic ECM's have no ill effects.
- Mechanically governed engines with larger flywheels have no ill effects also.
- 1800 RPM machines have more rotational energy for stabilization while 1200 RPM machines often have double the lifespan.
- Dispatch margins may inflate calculations into running a larger engine.

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Diesel Dispatch Calculations

- Total kW Request =
  Actual Diesel Load + Net Wind Generation
  + Reserve Margin (fixed limit to max engine load)
  + Stability Margin (limits engines from switching)
  + **Time of Day Anticipation (expects daily heavy loads)**
- Adjusted kW Request includes:
  Feeder pickup loads
  Estimated wind capacity
  Underfrequency Safety Margin, with increase and decrease rates

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Too Many Engine Starts and Stops

- Excessive engine transfers occur when “Stability Margin” in the dispatch calculations is too small.
- Causes battery bank issues
- Causes starter issues
- Ring gear teeth get chewed up
- Flywheel may need replacement
- Solution - See how the system behaves, then tune by increasing Stability Margin until optimum (2 transfers/day).

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Increasing Wind Penetration

- 900kW EWT installed St Mary's:
  Output is temporarily limited to 150 kW until Mountain Village tieline is connected (more load) and dispatch controller is integrated (more control).
- Spinning reserve is CRITICAL to reliability but eats at fuel displacement benefits.
- Grid Bridging System solution is in bid review.
- Continued partnership with Alaska Center for Energy and Power (ACEP) for GBS.


CATERPILLAR
CAUTION
THIS UNIT STARTS
AUTOMATICALLY.
LOCK & TAG OUT
PRIOR TO SERVICE

Thank You