# Load Following Wind at Golden Valley Electric Association

**October 31, 2018**

# GVEA is seeking to optimize:

- Efficiency ($ & footprint) when **regulating** or **load following** wind and solar.
- Or: cost of using power generation we can control to balance the output from power generation we cannot entirely control or predict.

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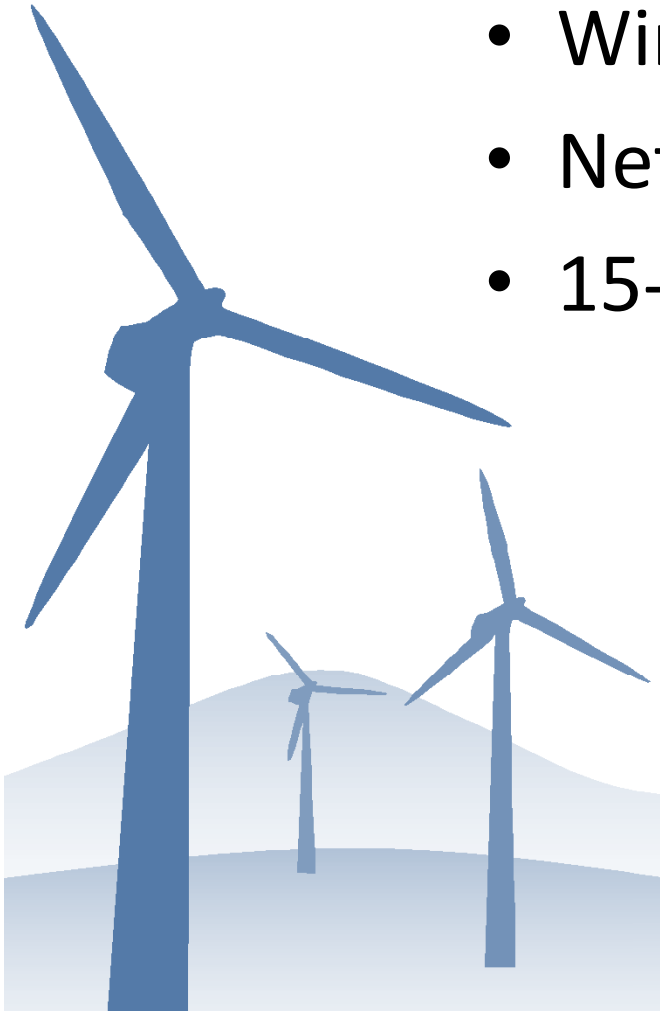
# Load Regulation Requirement

- Load only regulation:  ±5MW
- Wind: 0-25MW
- Net Load-Wind:  35MW?
- 15-minute variation:

$$\sigma_{NET} = \sqrt{\sigma_{Load}{}^2 + \sigma_{Wind}{}^2}$$

$$3\sigma_{NET} = 10.7 \ MW$$



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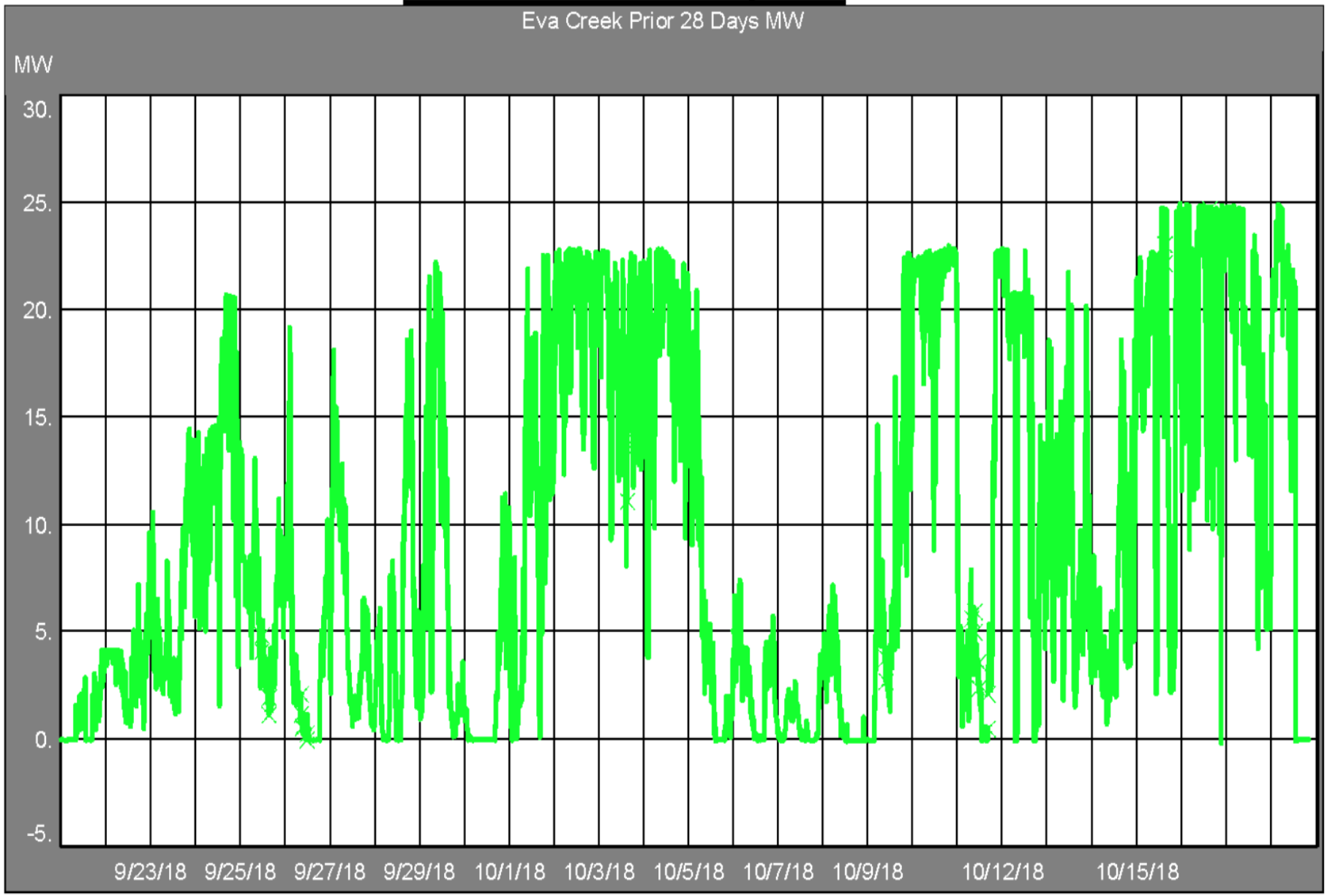
**Eva Creek Month-To-Date MWH (net):** 4735.9

9/20/2018 10/17/2018

## Eva Creek Prior 28 Days MW



# Generation Hierarchy – Least Cost First


- Delta Plant Frame 5 Gas Turbine
- Zehnder Plant Frame 5 Gas Turbines
- North Pole Frame 7 Gas Turbines
- Eva Creek Wind (requires load following)
- North Pole Combined Cycle Plant
- Purchased gas power over Intertie
- Healy Coal Plant
- Bradley Lake Hydro

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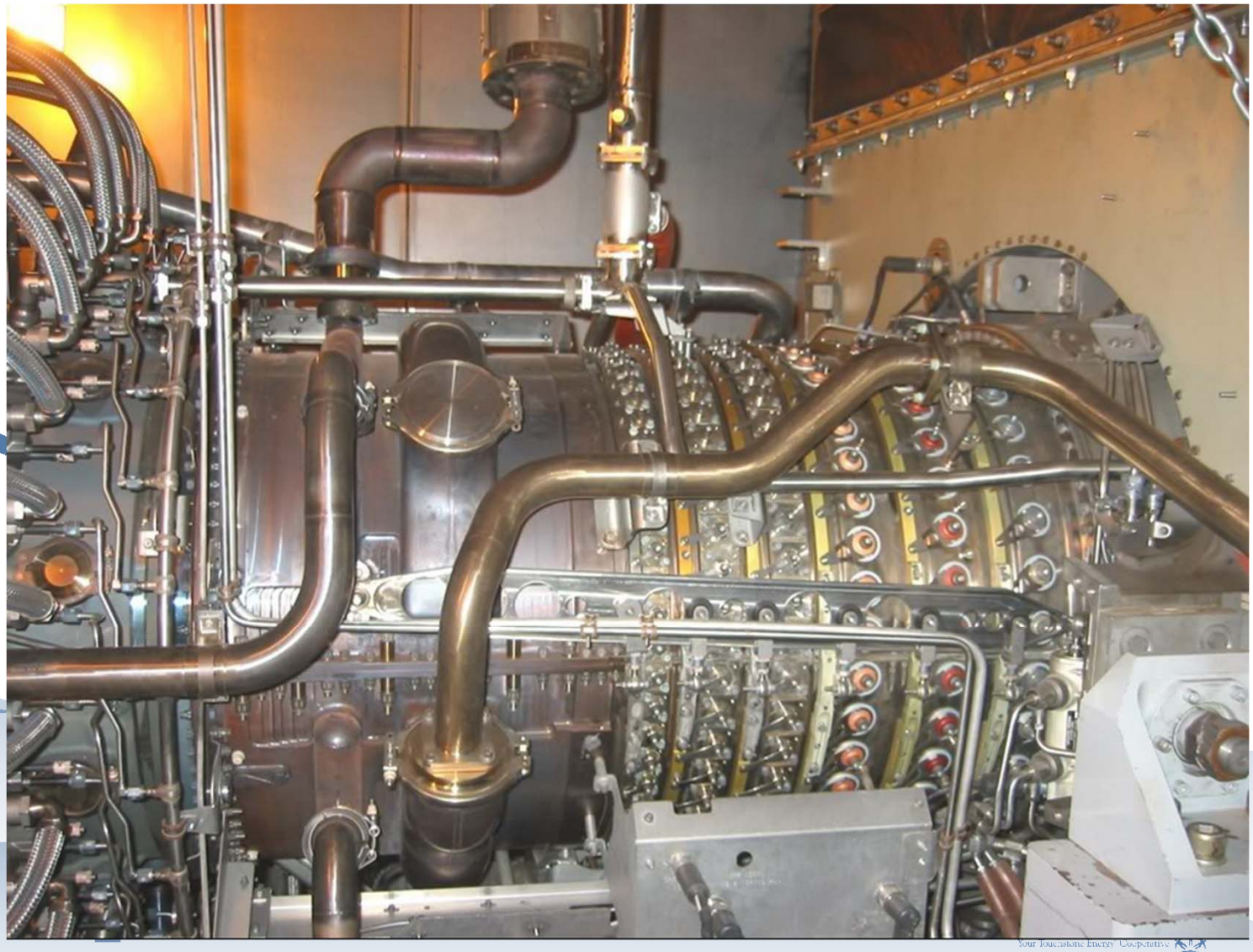
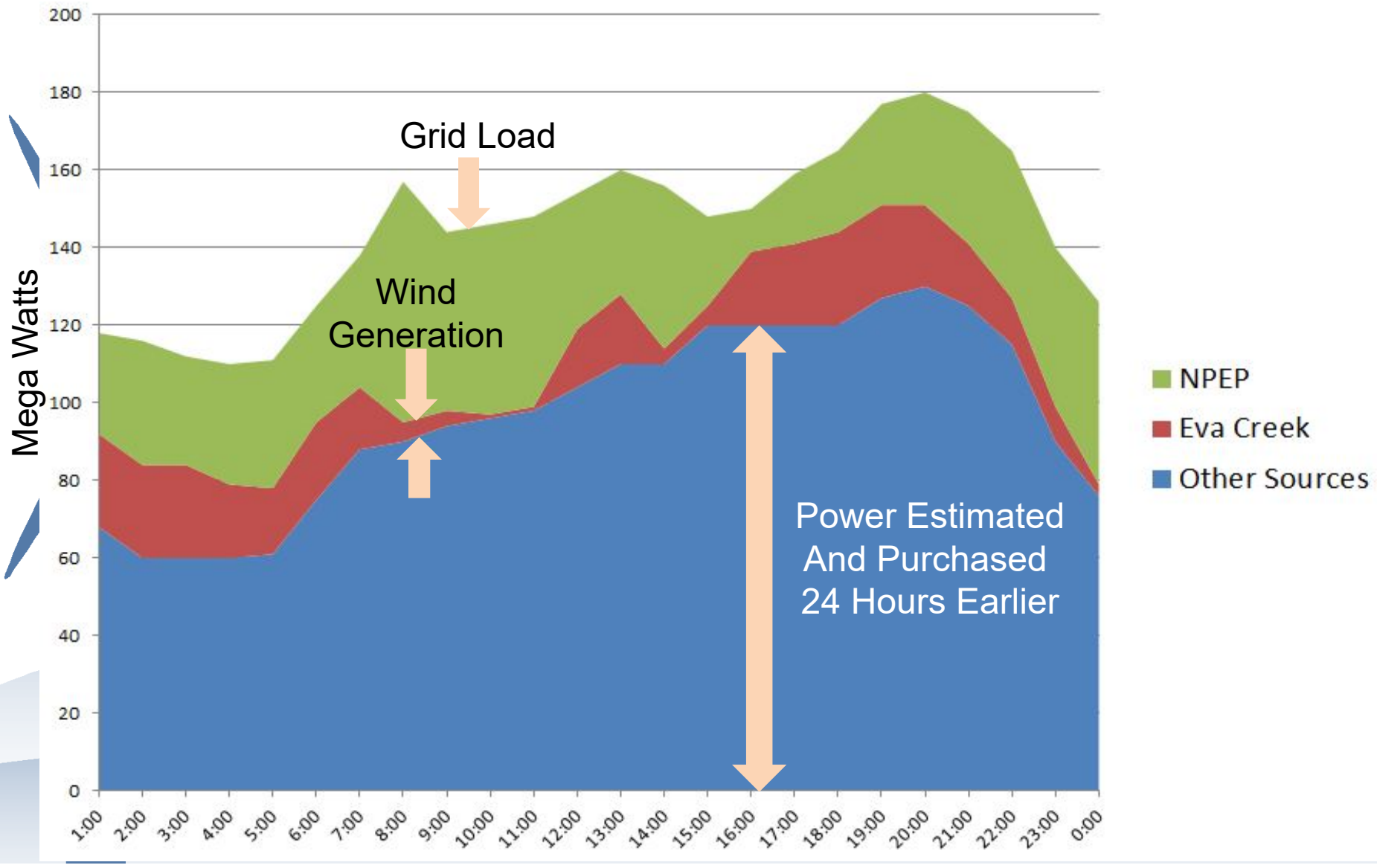
# LM6000 (747 engine) used for load following



# Conceptual Fairbanks 24 Hour Load Curve



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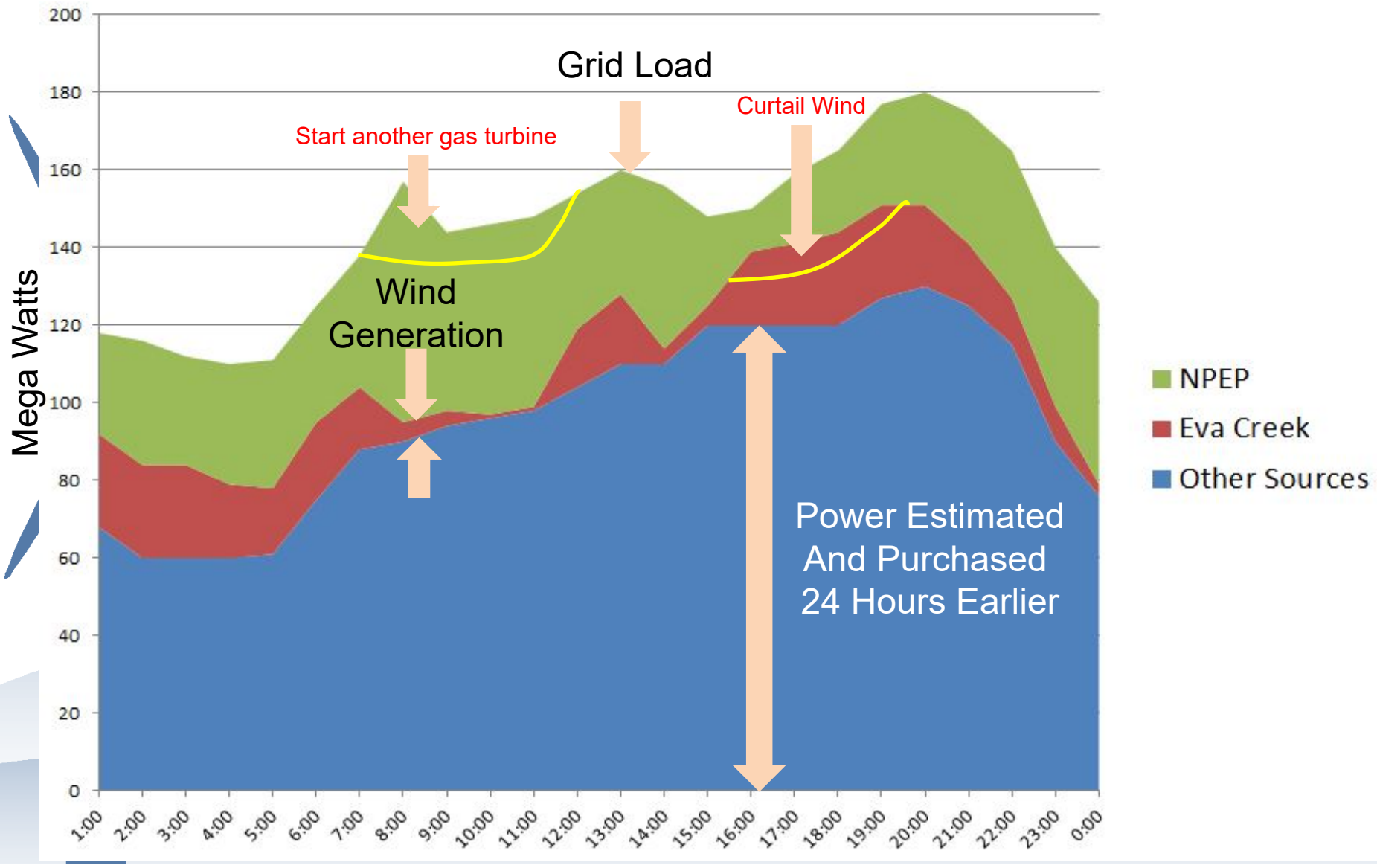

# Combined Cycle Plant (aka NPEP)

*Steam Turbine*

**BASE LOAD >**

-12 MW Nominal

-9 MW

-6 MW

-3 MW

4.2 MW steam

*Gas Turbine*
*(44% max efficiency in simple cycle)*

100% Fuel Flow

-50 MW Nominal Highest Efficiency

-40 MW

-30 MW

-25 MW, 50% load, 65% fuel

-20 MW

-10 MW

30% Fuel

-0 MW – Lowest Efficiency

Cost of Operation

0% Fuel

Efficiency

| GT | With ST |
|---|---|
| 44% | 52% |
| 33% | 39% |
| 22% | 24% |
| 11% | |
| 0% | |

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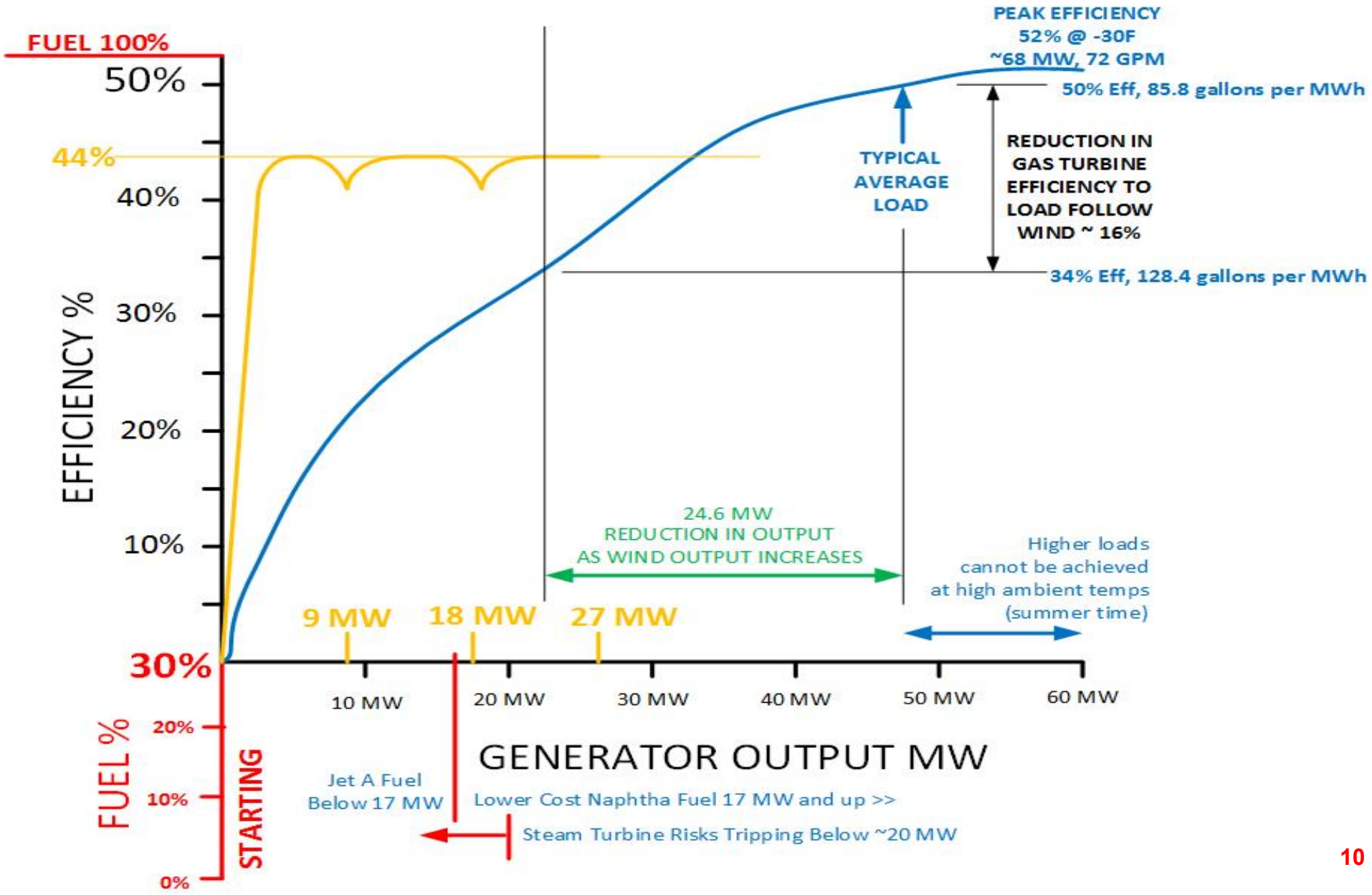
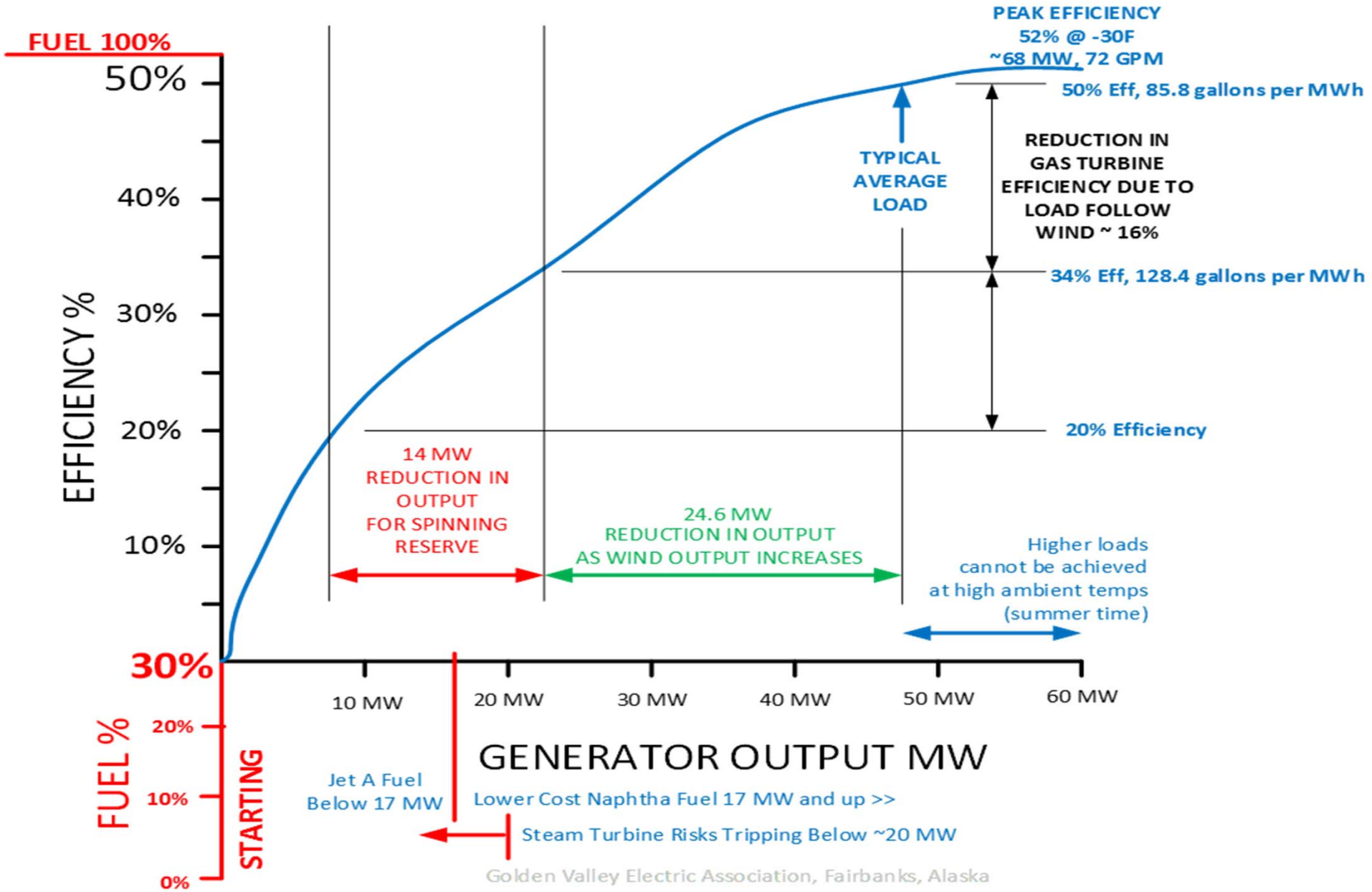
# COMBINED CYCLE LM6000 GAS TURBINE PLANT – NPEP EFFICIENCY CURVE – COMPARED TO DIESEL RECIP UNITS IN WIND LOAD FOLLOWING APPLICATION



# COMBINED CYCLE LM6000 GAS TURBINE PLANT – NPEP EFFICIENCY CURVE – WITH WIND LOAD FOLLOWING AND SPINNING RESERVE APPLICATION

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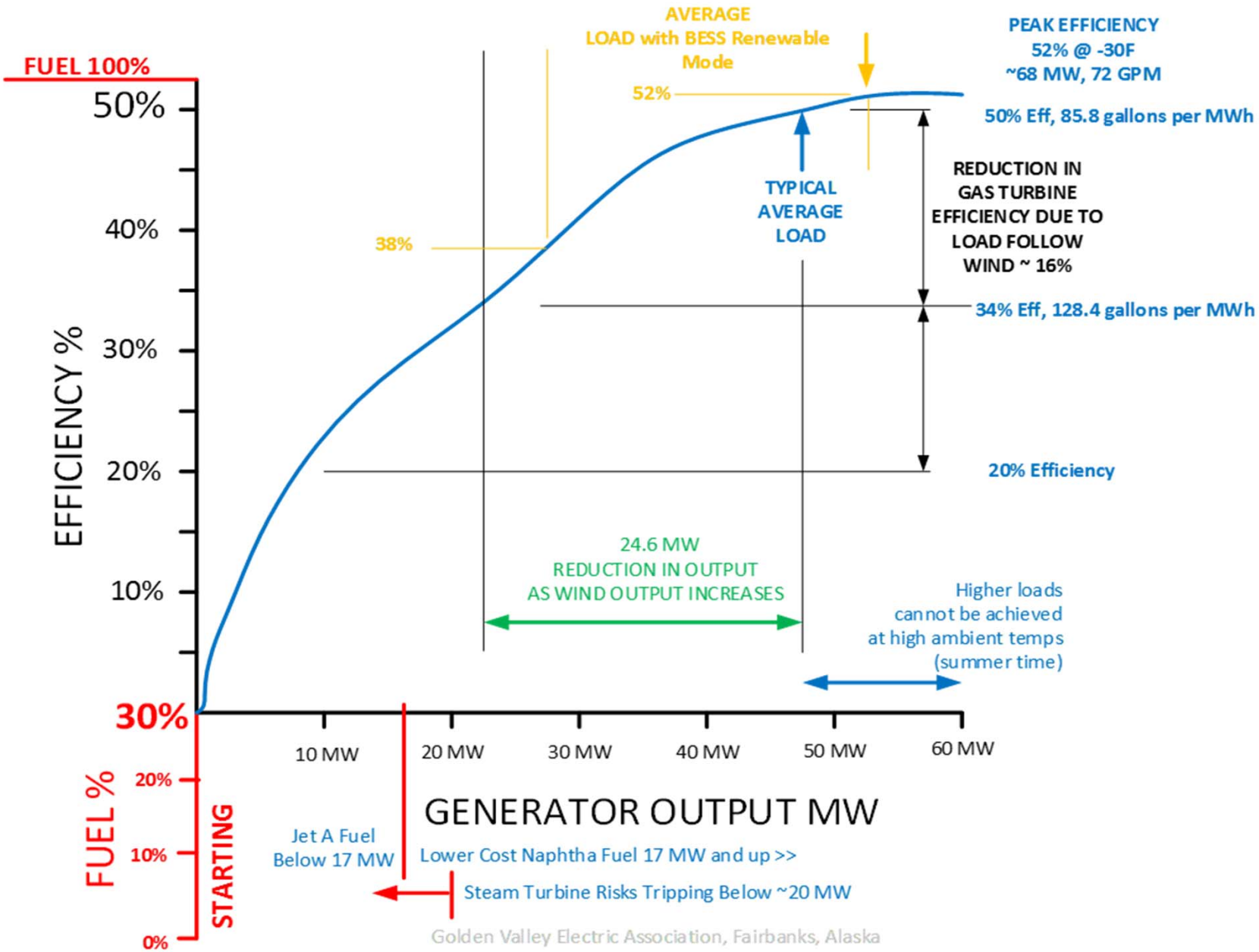
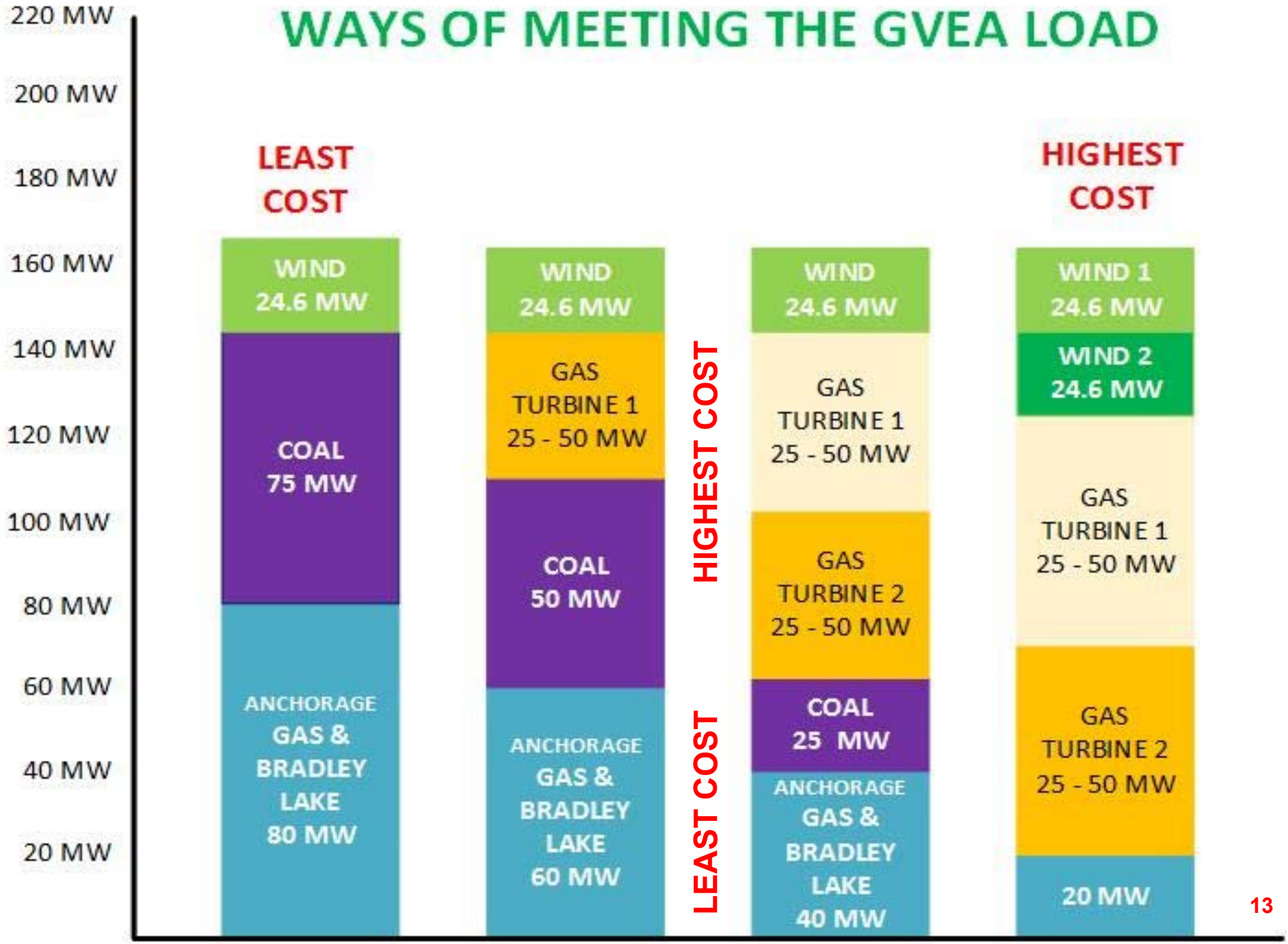
# COMBINED CYCLE LM6000 GAS TURBINE PLANT – NPEP
## EFFICIENCY CURVE – WITH BESS RENEWABLE MODE APPLICATION




Golden Valley Electric Association, Fairbanks, Alaska


WAYS OF MEETING THE GVEA LOAD
220 MW
200 MW
180 MW
160 MW
140 MW
120 MW
100 MW
80 MW
60 MW
40 MW
20 MW
LEAST COST
HIGHEST COST
WIND 24.6 MW
COAL 75 MW
ANCHORAGE GAS & BRADLEY LAKE 80 MW
WIND 24.6 MW
GAS TURBINE 1 25 - 50 MW
COAL 50 MW
ANCHORAGE GAS & BRADLEY LAKE 60 MW
HIGHEST COST
LEAST COST
WIND 24.6 MW
GAS TURBINE 1 25 - 50 MW
GAS TURBINE 2 25 - 50 MW
COAL 25 MW
ANCHORAGE GAS & BRADLEY LAKE 40 MW
WIND 1 24.6 MW
WIND 2 24.6 MW
GAS TURBINE 1 25 - 50 MW
GAS TURBINE 2 25 - 50 MW
20 MW

# Concepts for load following, basically 4 choices:

- 1: Store wind energy and dispatch it like any other resource
  - Stored hydro, compressed air, batteries
- 2: Sell wind power on the market at a loss.
- 3: Add generation that works much better for regulation
  - Diesel recip units 40+% efficient
  - Convert the NPEP to 2x1 combined cycle
- 4: Distributed load management
  - Demand Response to shut down hot water heaters and high loads at the member's premises
  - Store power in customers electric vehicle batteries

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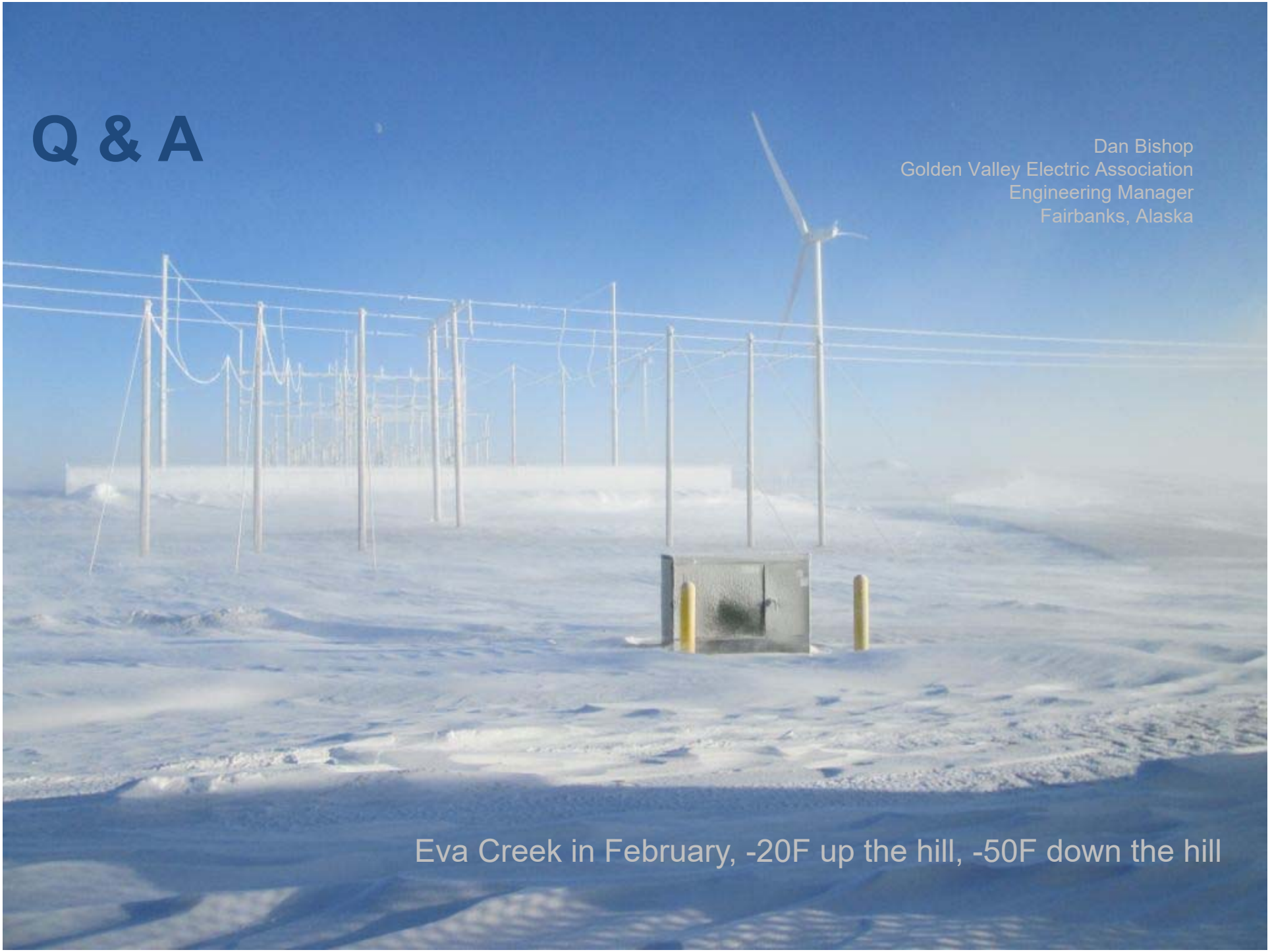
# Q & A

Dan Bishop
Golden Valley Electric Association
Engineering Manager
Fairbanks, Alaska



Eva Creek in February, -20F up the hill, -50F down the hill