Controls for Remote Microgrids with High Penetration Renewable Generation

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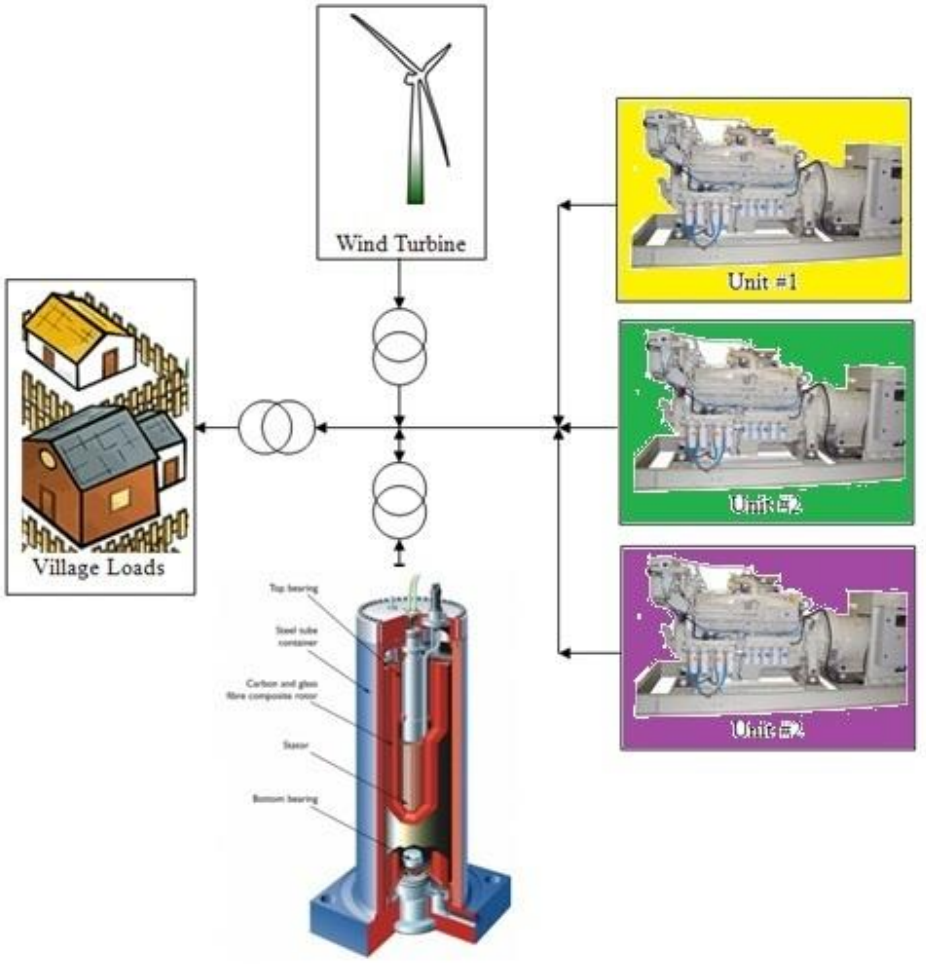
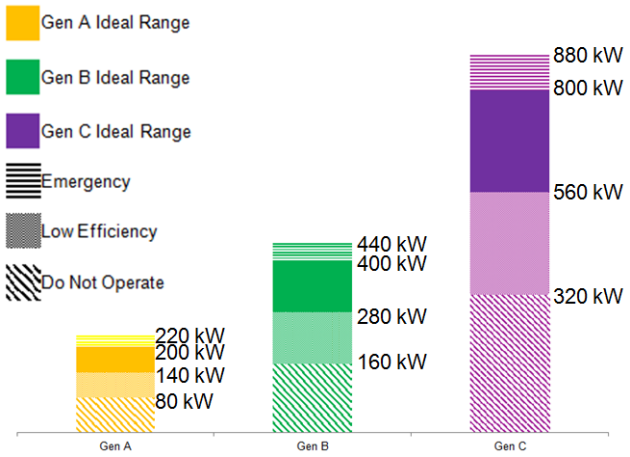
01/2012

Outline

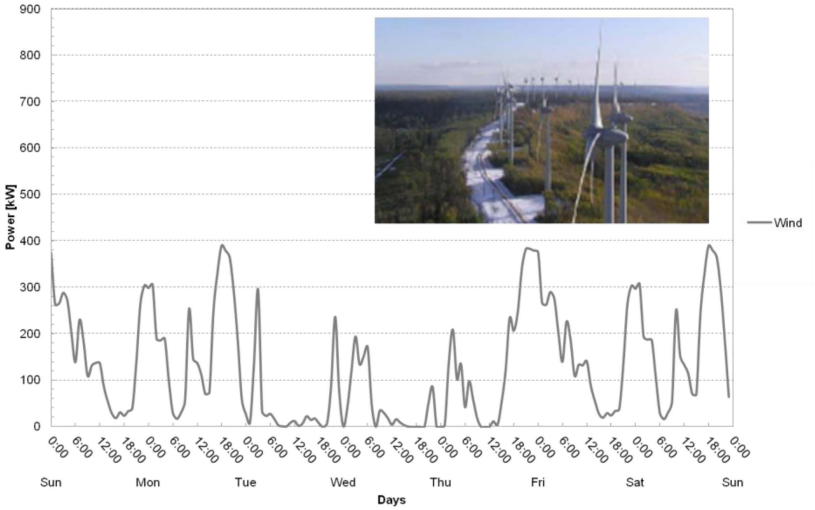
1. Remote Microgrid Overview
   - Load Patterns & Intermittent renewable generation
   - Renewable Penetration – definitions, illustrations and operating strategies
2. Problem events from High Penetration renewable generation
   - Problem 1: high speed variation causes power quality issues
   - Problem 2: combined ramp rates and increased diesel cycling
   - Problem 3: Forecasting is imperfect
3. Hatch approach to microgrid control design.

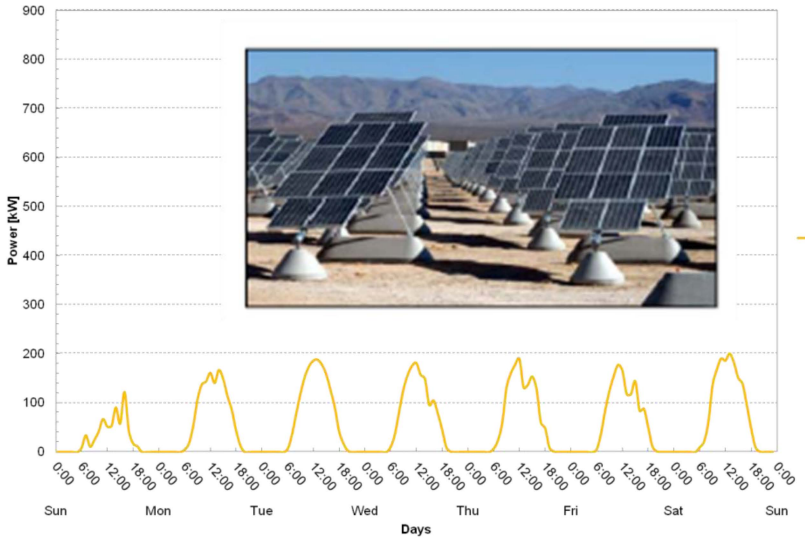
Remote Community Microgrid

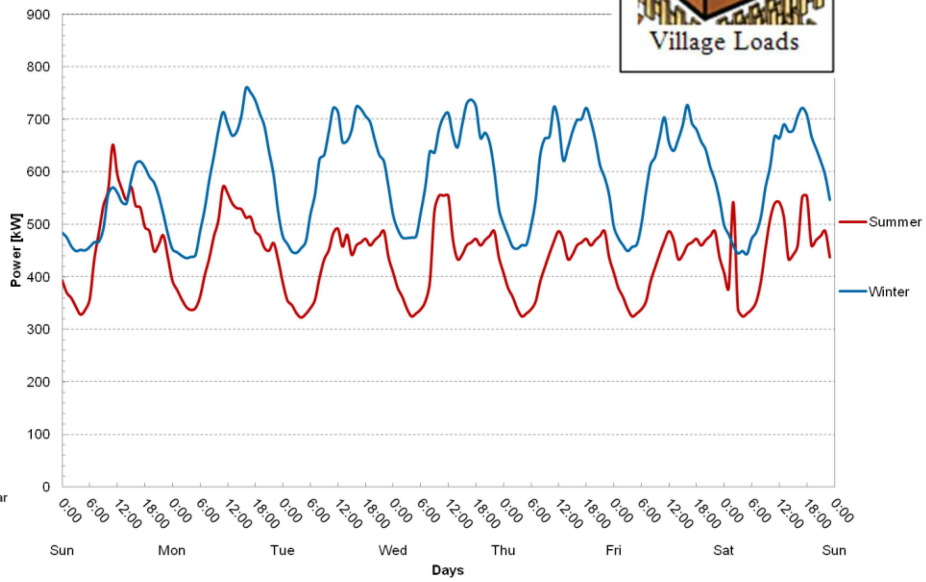




Intermittency – Renewable Generation & Load







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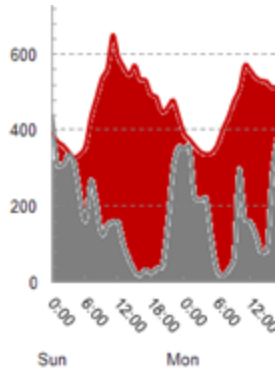
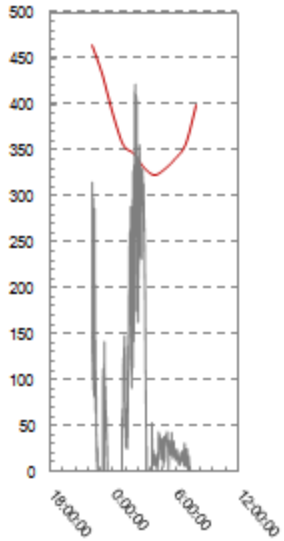
Renewable Penetration - Definitions

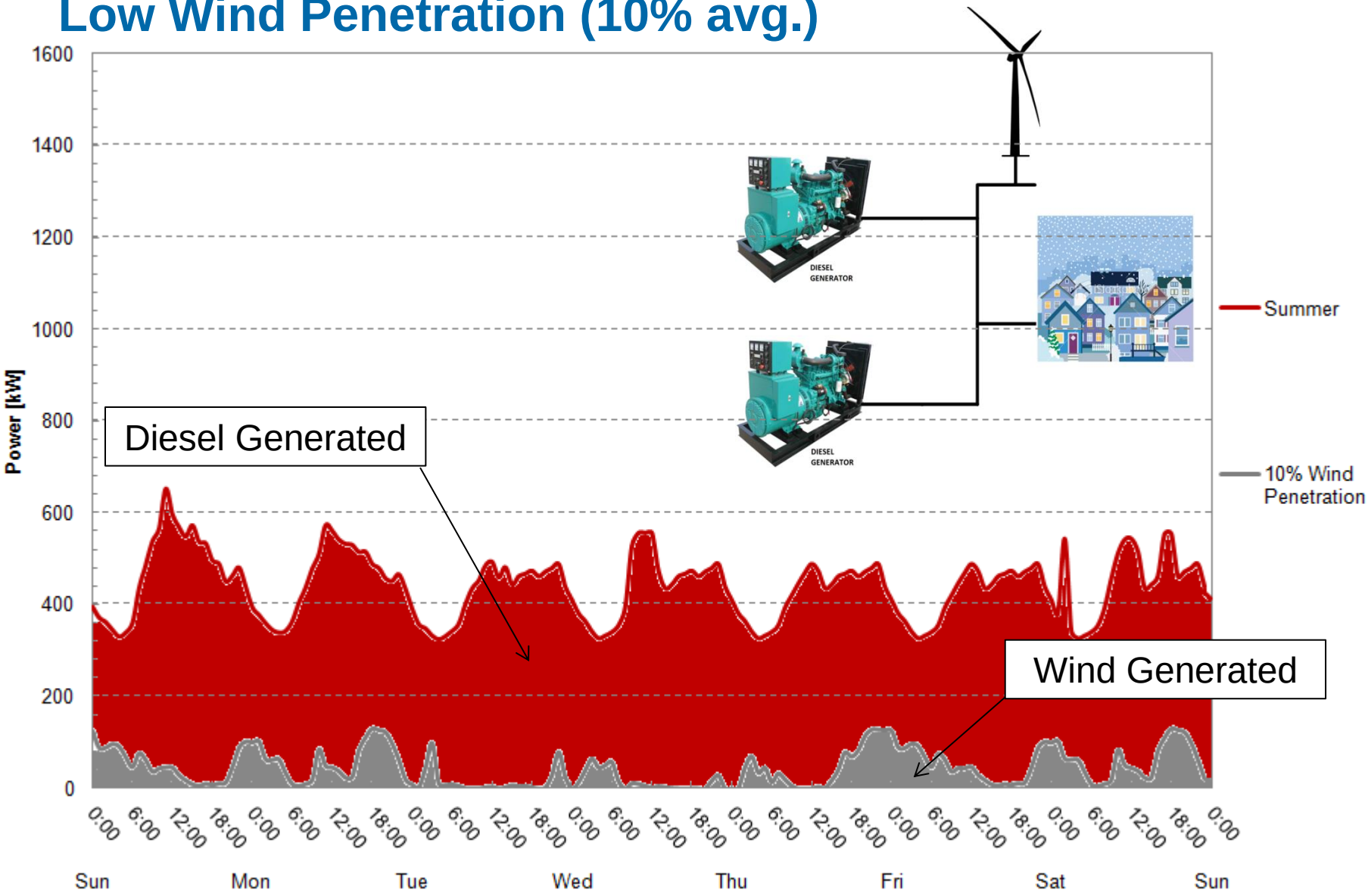


$$\text{Average Penetration} = \frac{\text{Total Renewable Energy (kWh)}}{\text{Total Energy Demand (kWh)}}$$



$$\text{Instantaneous Penetration} = \frac{\text{Renewable Power Output(kW)}}{\text{Electrical Load (kW)}}$$

Low Wind Penetration (10% avg.)



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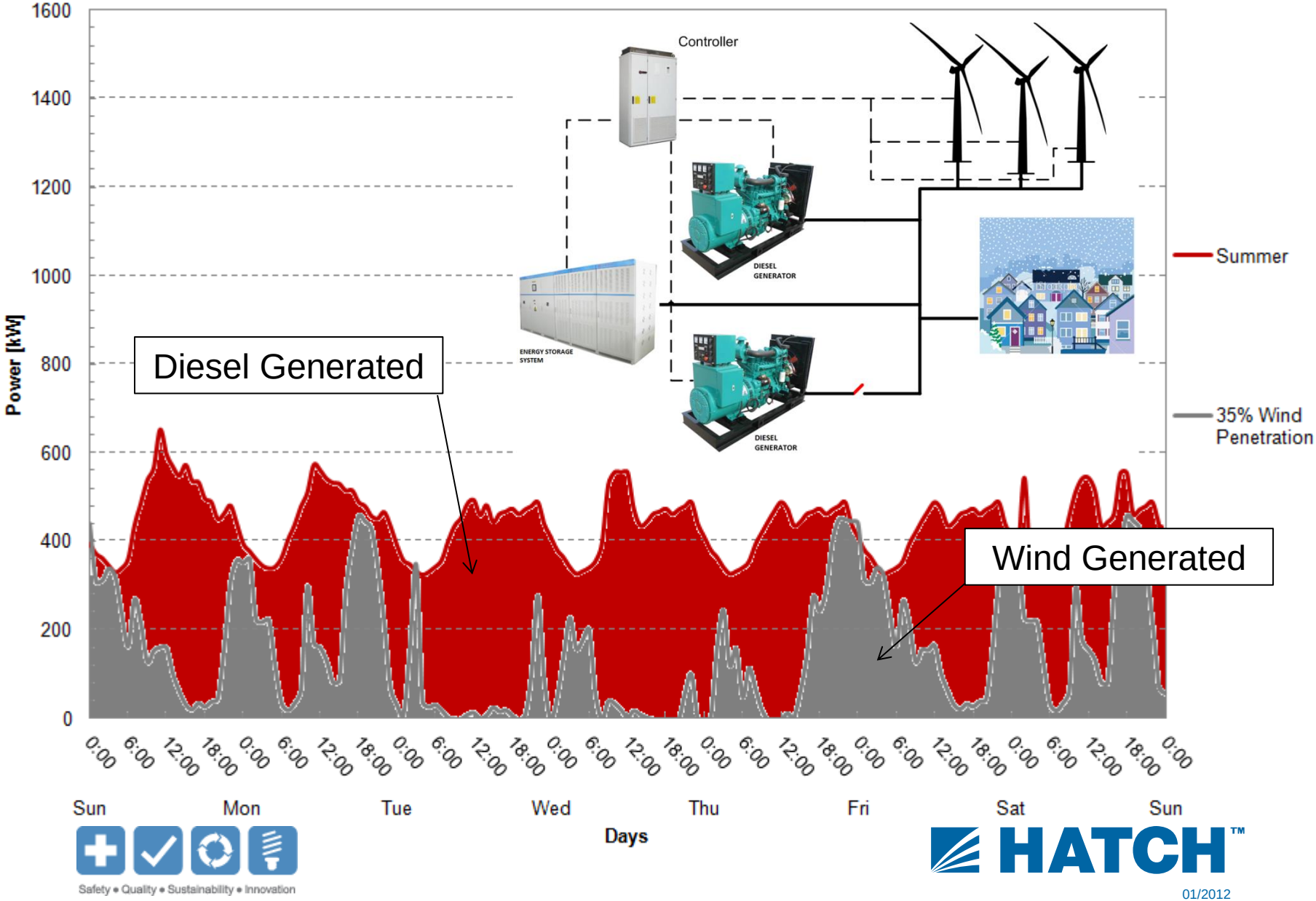
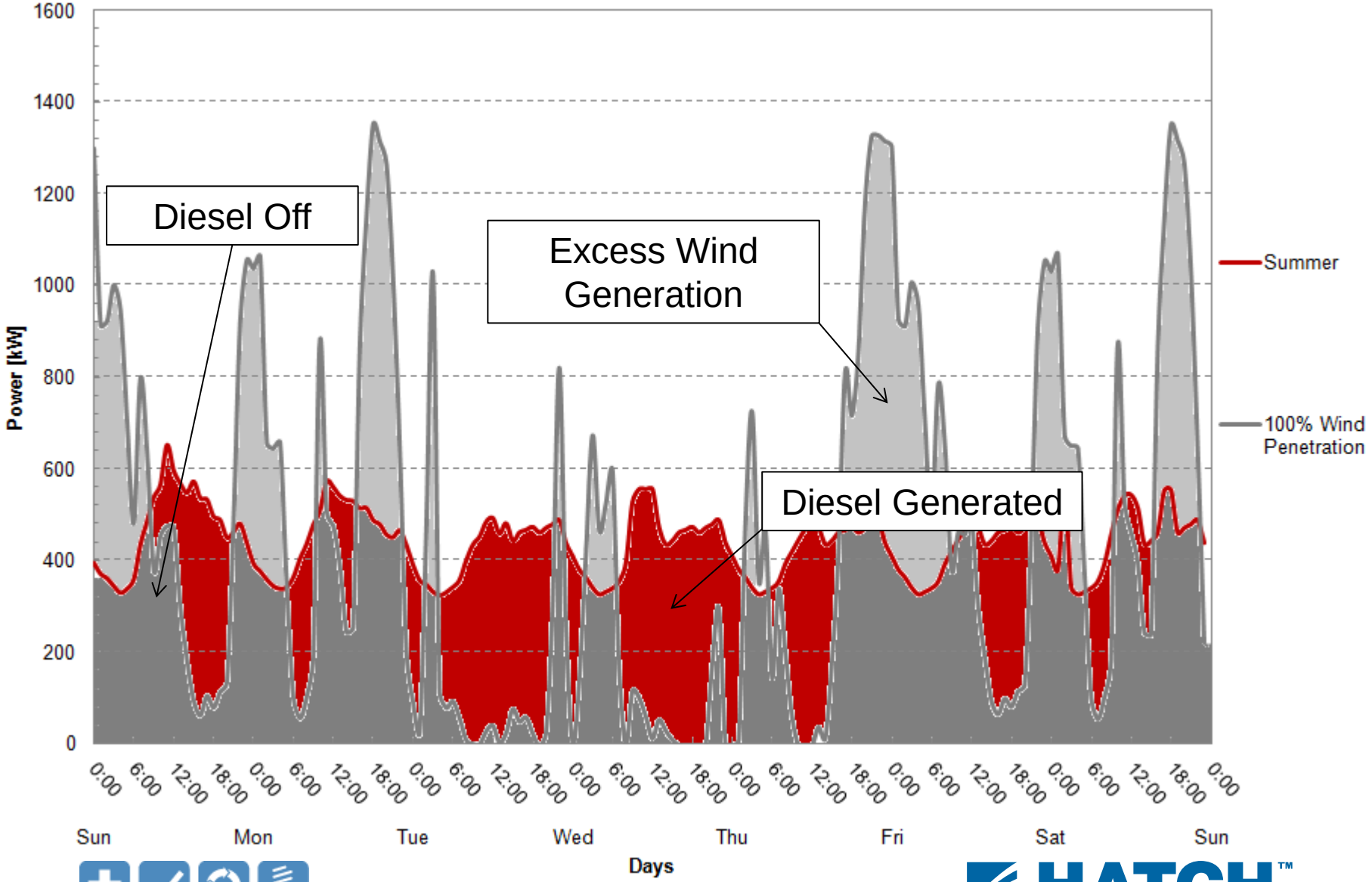
Medium Wind Penetration (35% avg.)



High Wind Penetration (100% avg.)



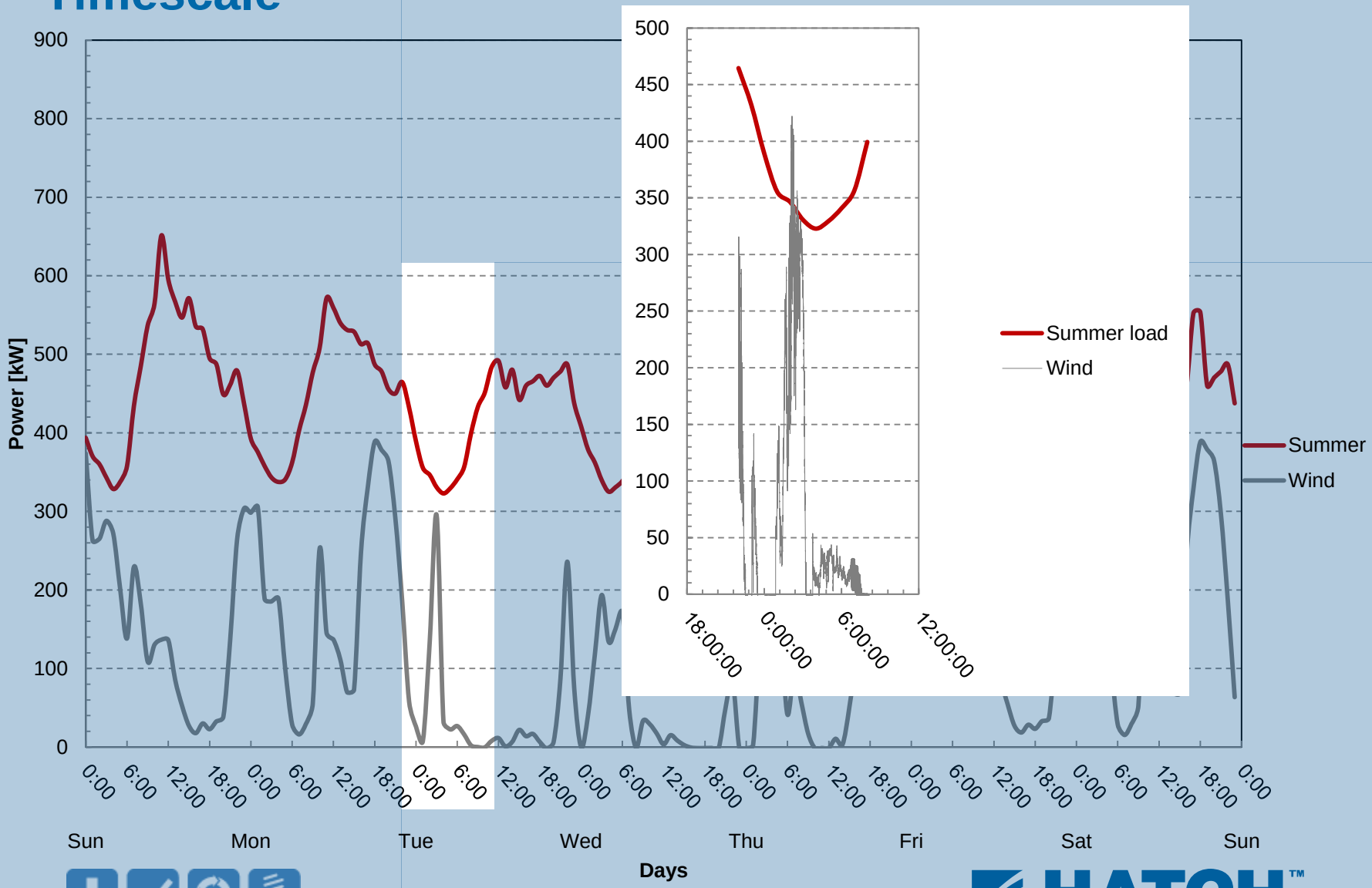
Outline

1. Remote Microgrid Overview
   - Intermittency Load & Intermittent renewable generation
   - Renewable Penetration – definitions and illustrations

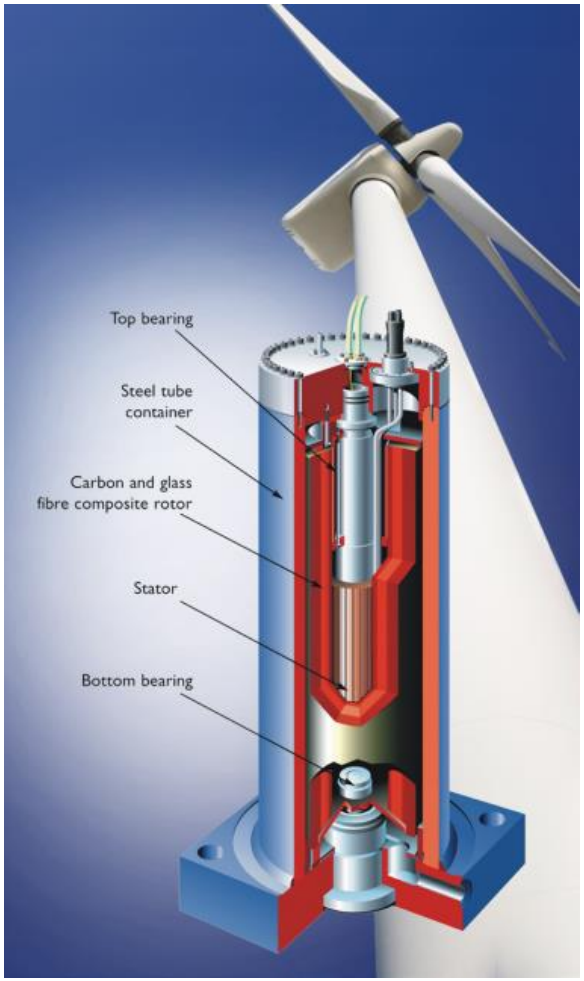
2. Problem events from High Penetration renewable
   - Problem 1: high speed variation causes power quality issues
   - Problem 2: combined ramp rates and increased diesel cycling
   - Problem 3: forecasting is imperfect

3. Hatch approach to microgrid control design.

Problem 1 - Frequency ~ High Resolution Timescale

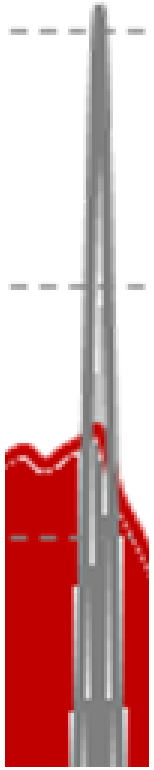


Fast Acting Energy Storage

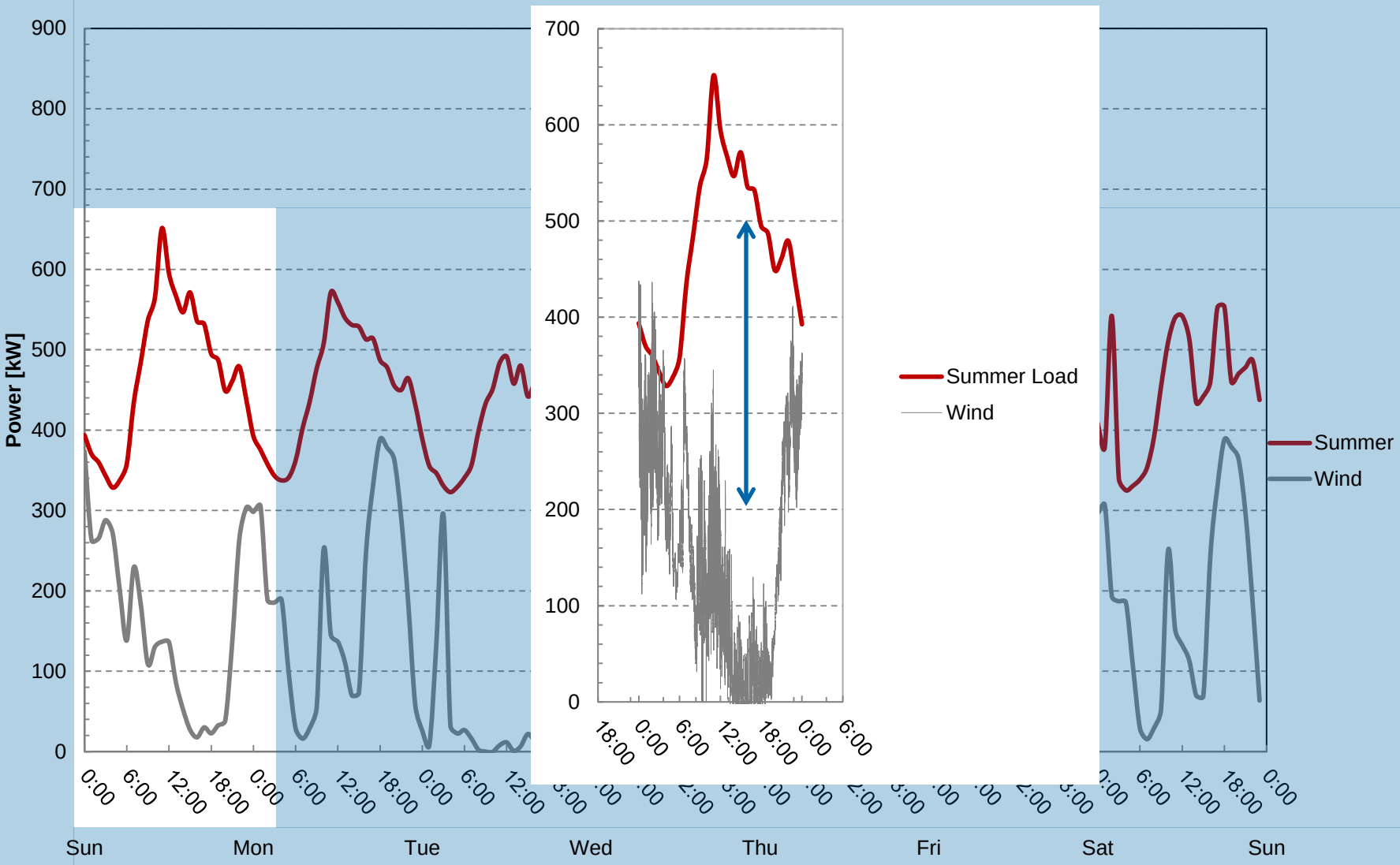


- Power conditioning
  - Voltage and frequency regulation

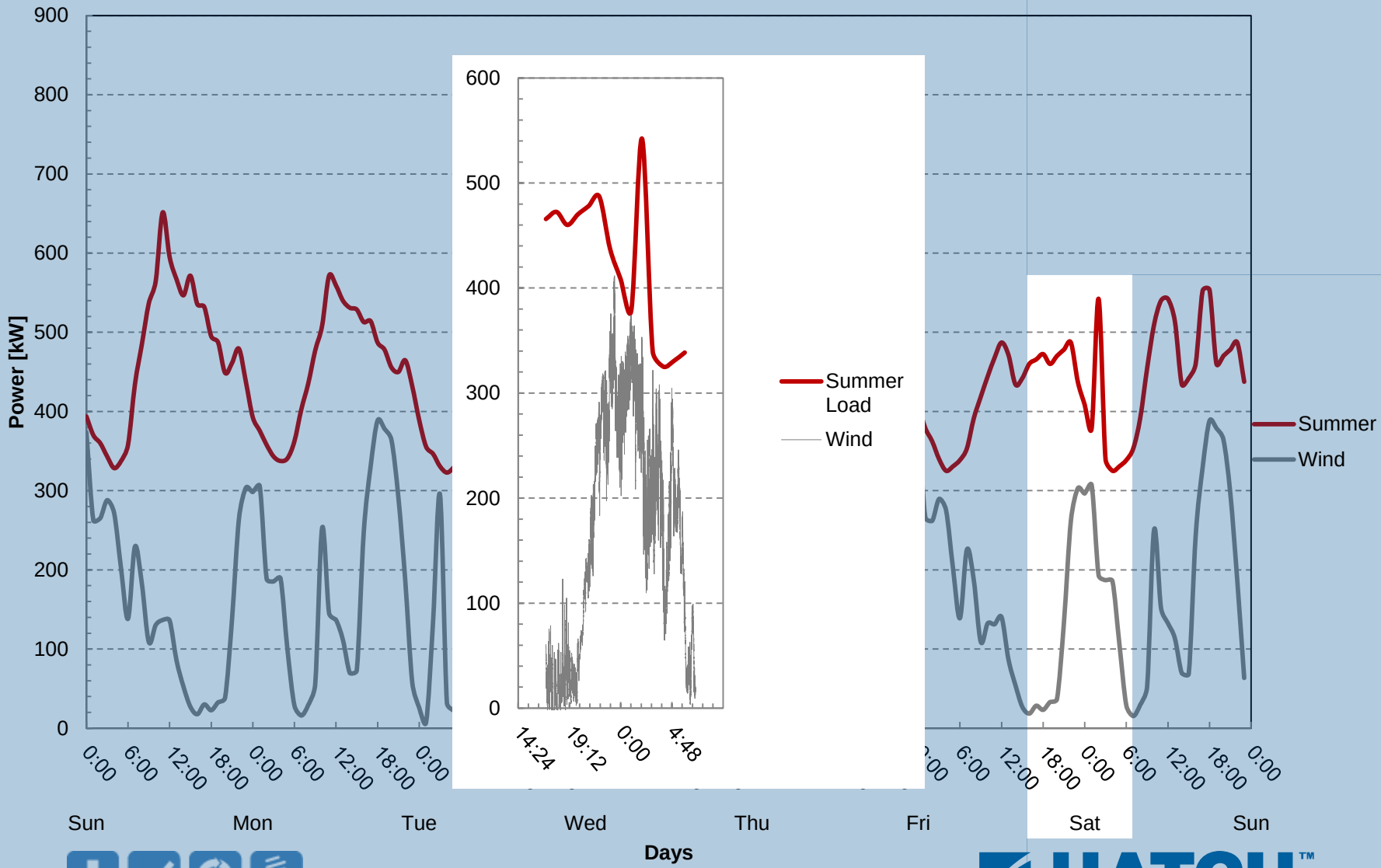
The flywheel can supply and absorb both real power to control frequency and reactive power to control voltage



Problem 2a: Combined ramp rates & Diesel Cycling



Problem 2b: combined ramp rates & diesel cycling



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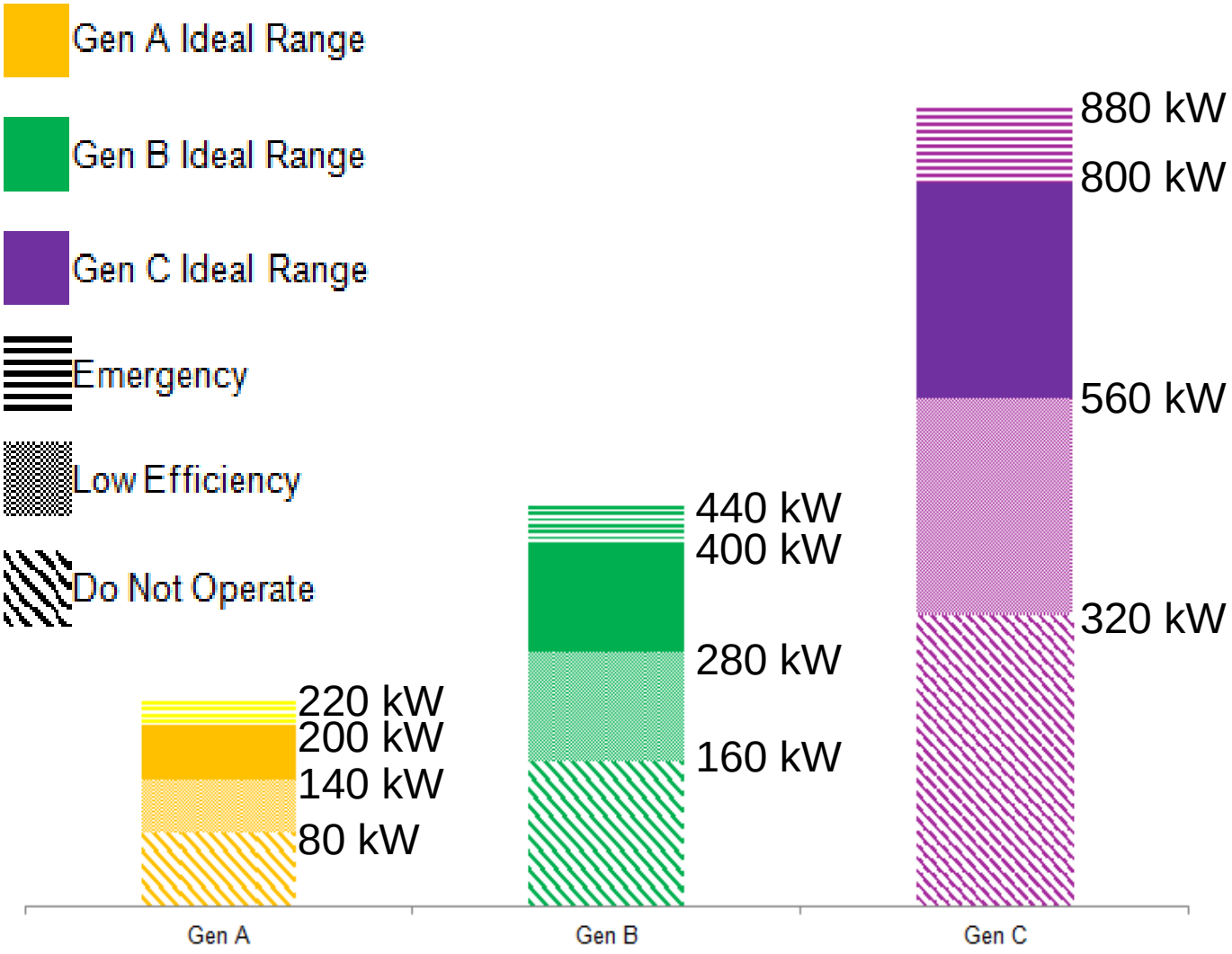
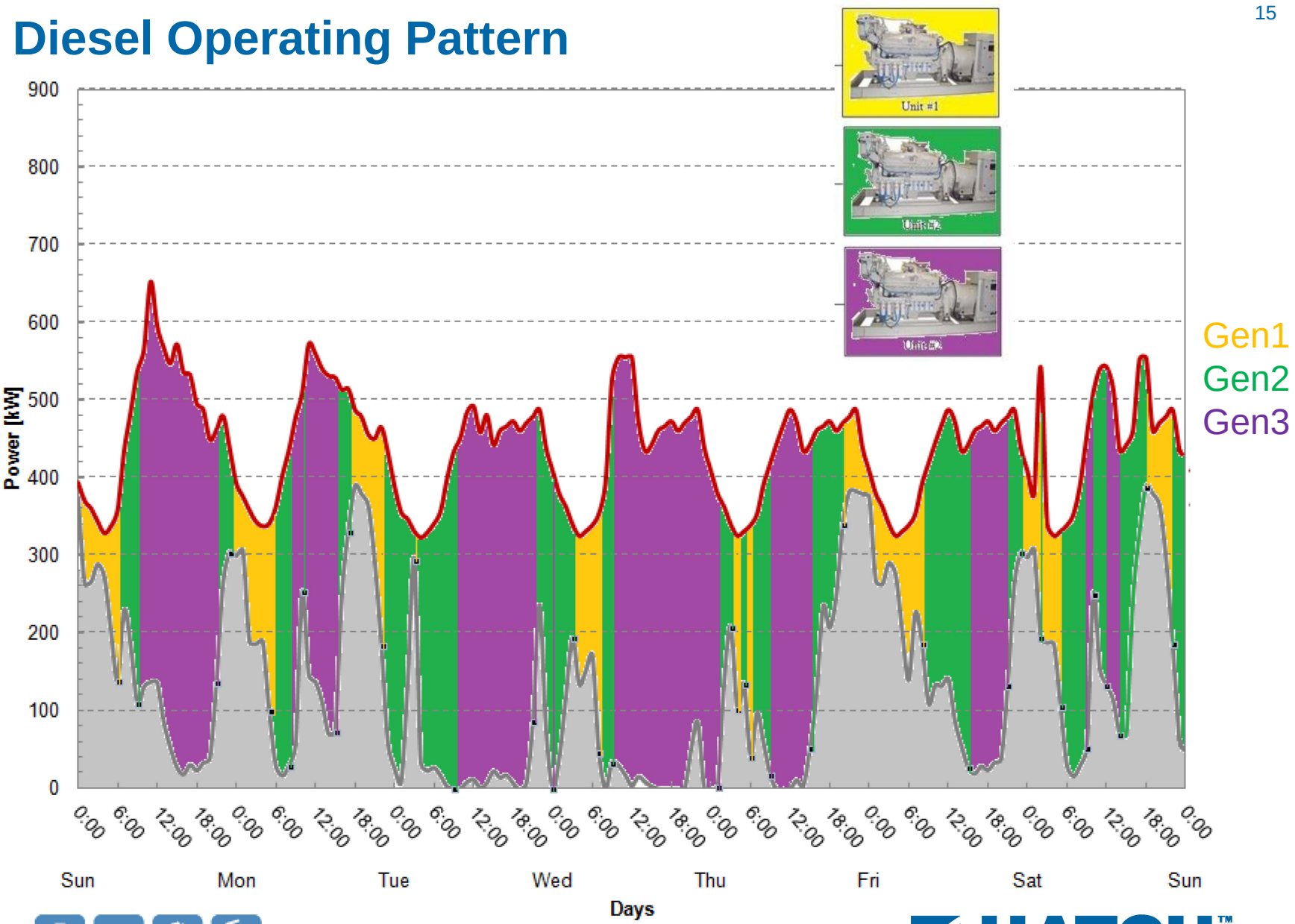
Diesel Fleet Operating Bands



Diesel Operating Pattern



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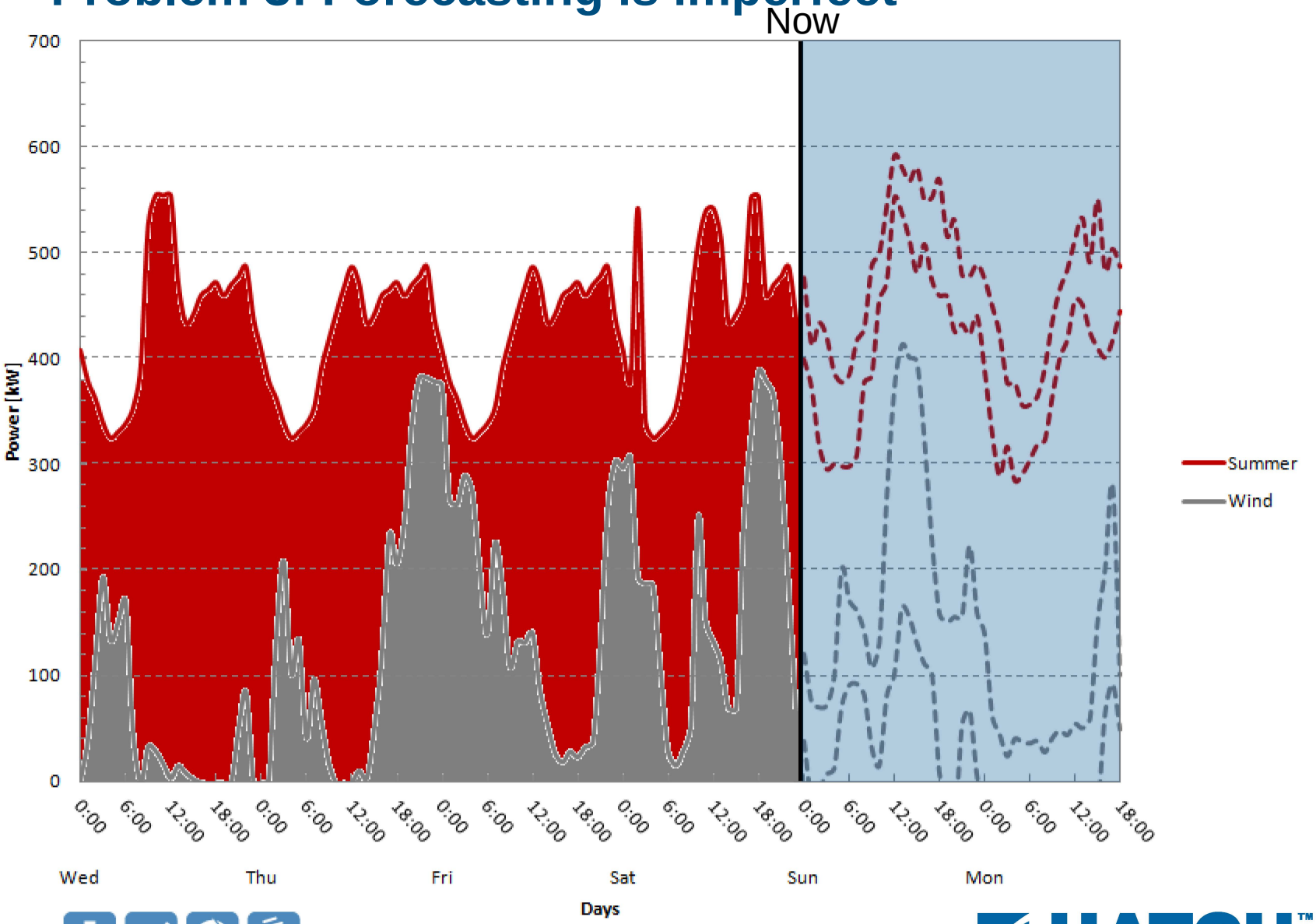
Problem 3: Forecasting is imperfect



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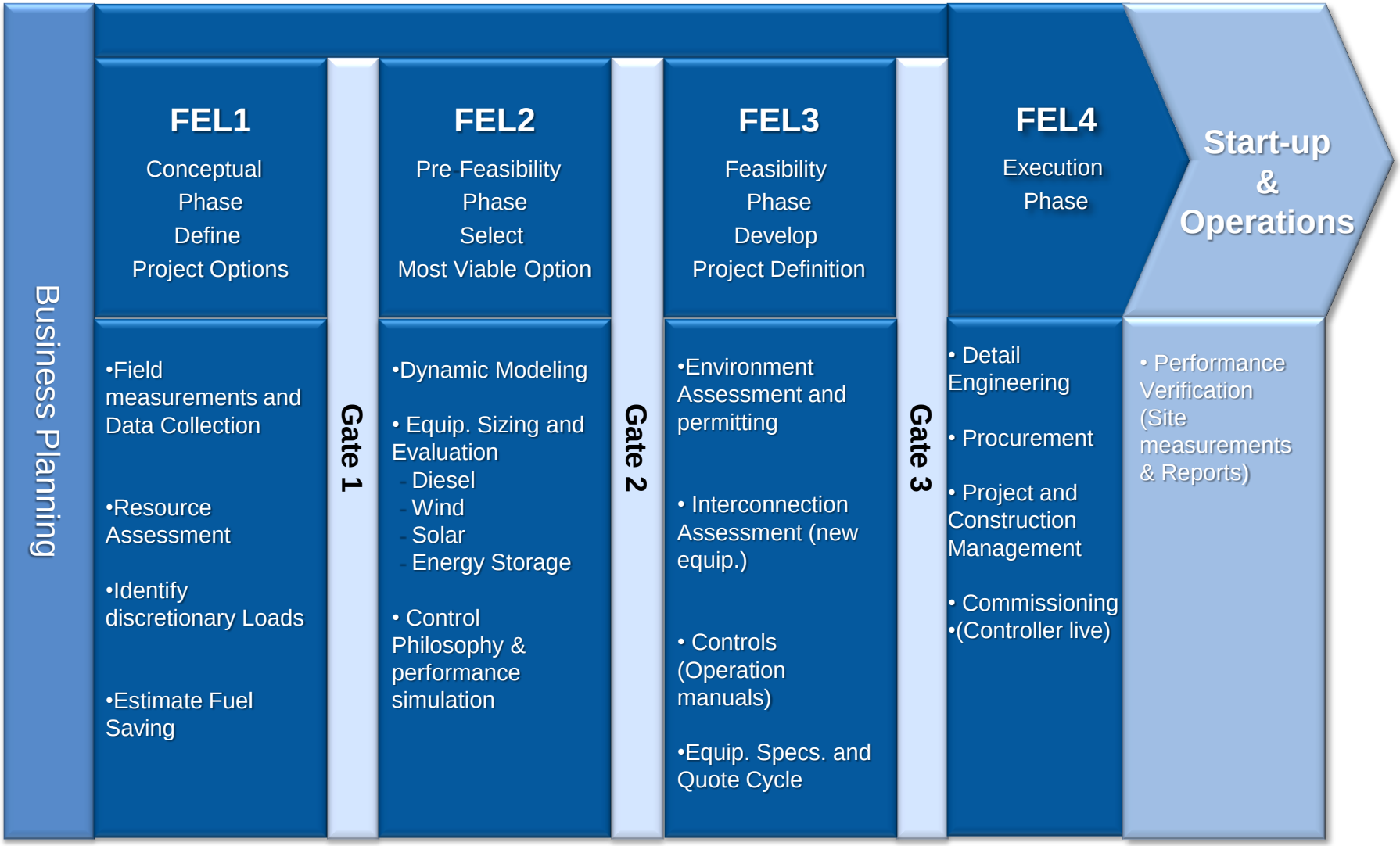
Hatch Microgrid implementation Process



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Closing:

1. Controls is a complex issue –

2. Proper inputs for planning and design
   - Site specific data - seasonality variation in load and resource
   - Potential discretionary load usage patterns.

3. Proper sizing/selection of equipment for each site.

4. Performance modeling to de-risk CAPEX investment in new assets.

5. Come see us at our booth.

Thank You

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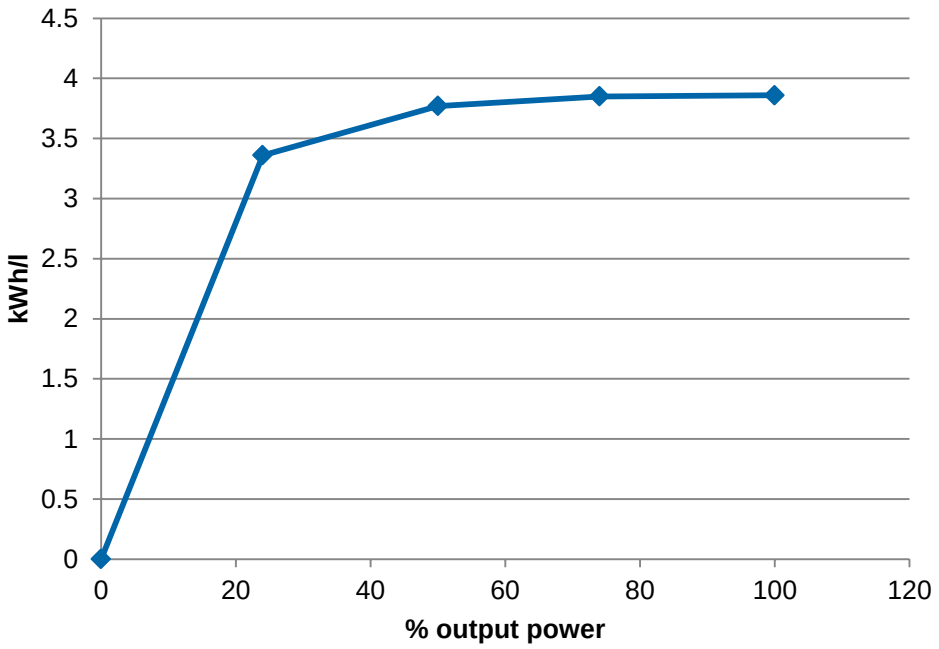
Backup Slides

Renewable Penetration

Penetration	Penetration Level		Operating characteristics and system requirements
	Inst.	Avg.	
low	0% to 50%	less than 20%	Control : conventional Diesel: run full time at recommended loading levels System: Renewable Generation is “negative load”
Medium	0% to 100+%	20% to 50%	Control: automation of set-point control Diesel: run below ideal operating range – reduced efficiency System: Add dump loads, RE curtailment, or energy storage
High	0% to 150+%	Greater than 50%	Control: Sophisticated control system Diesel: turned OFF for periods of time System: Add significant renewable generation, demand side control, curtailment, energy storage, power quality management (frequency & voltage)

Ranges defined by National Renewable Energy Laboratory (NREL)

Minimum load levels for Diesel



Fuel consumption of an 855kW diesel generation unit

High-Power Flywheels – Williams F1

- 2008 –KERS (Kinetic energy recovery system for F1) prompted Williams F1 to develop energy storage
- Hatch has partnered with Williams
- High duty cycle (>75%) without loss in performance
- Long life (20 yrs)
- Low standing loss (<1%)
- High round trip efficiency (>86%)
- Industrial Applications include smoothing energy from cranes, hoists, and shovels