Complex Micro Grid Use Cases

The Case Studies of Graciosa Island and Bonaire

PPA 28th Annual Conference
4th July 2019 | Rarotonga | Cook Islands

Thomas Hellmich & Wilhelm van Butselaar

- Introduction of Wärtsilä and our market
- Case studies
  - Graciosa, Azores
  - Bonaire, Netherlands Caribbean

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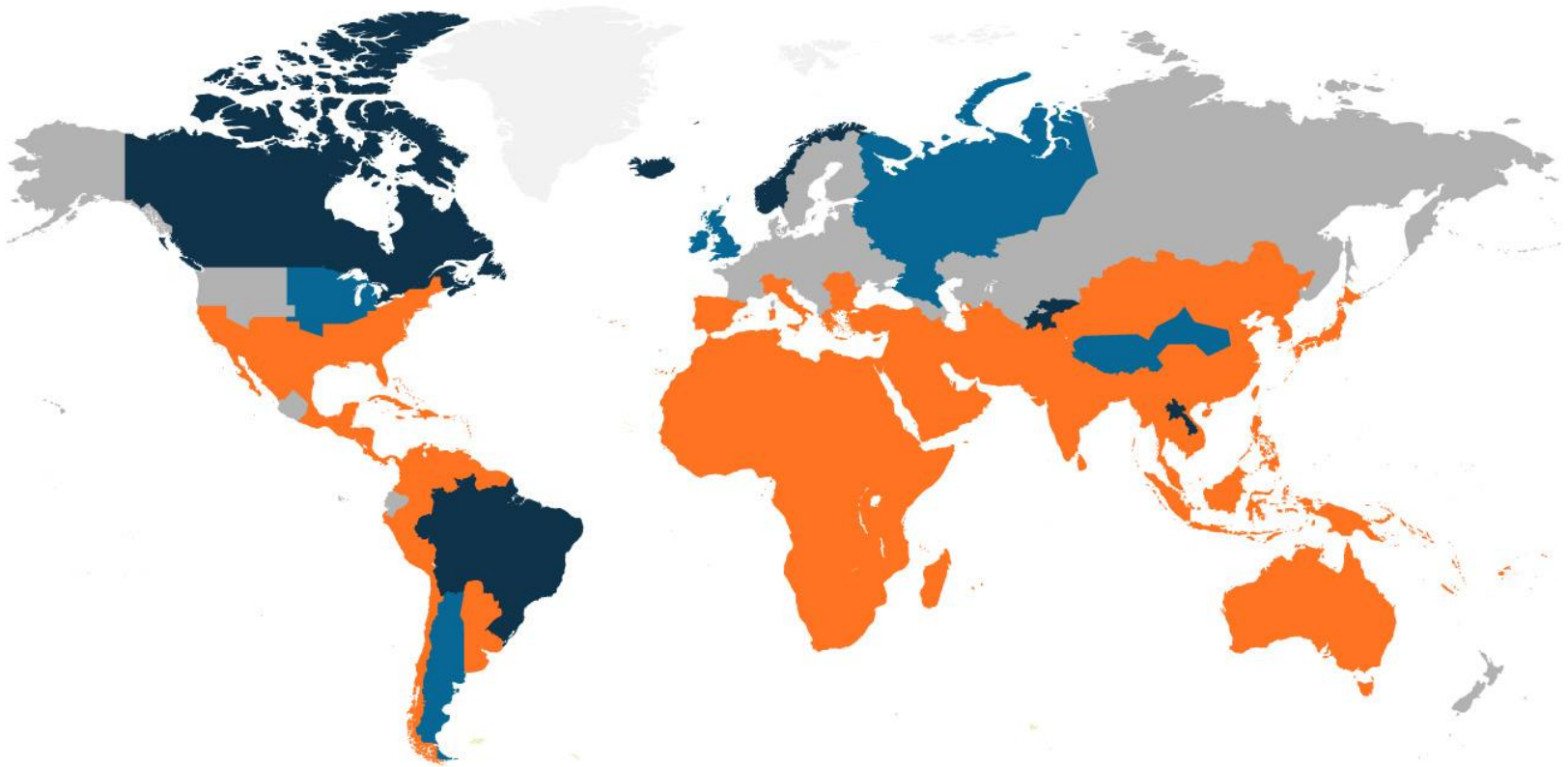
Main energy sources in a 100% renewable energy world

A high renewable world will require massive amounts of solar and flexibility

PV will become the main energy source in the Sun Belt with 22 TWp global capacity for the power sector



Source: Lappeenranta University of Technology

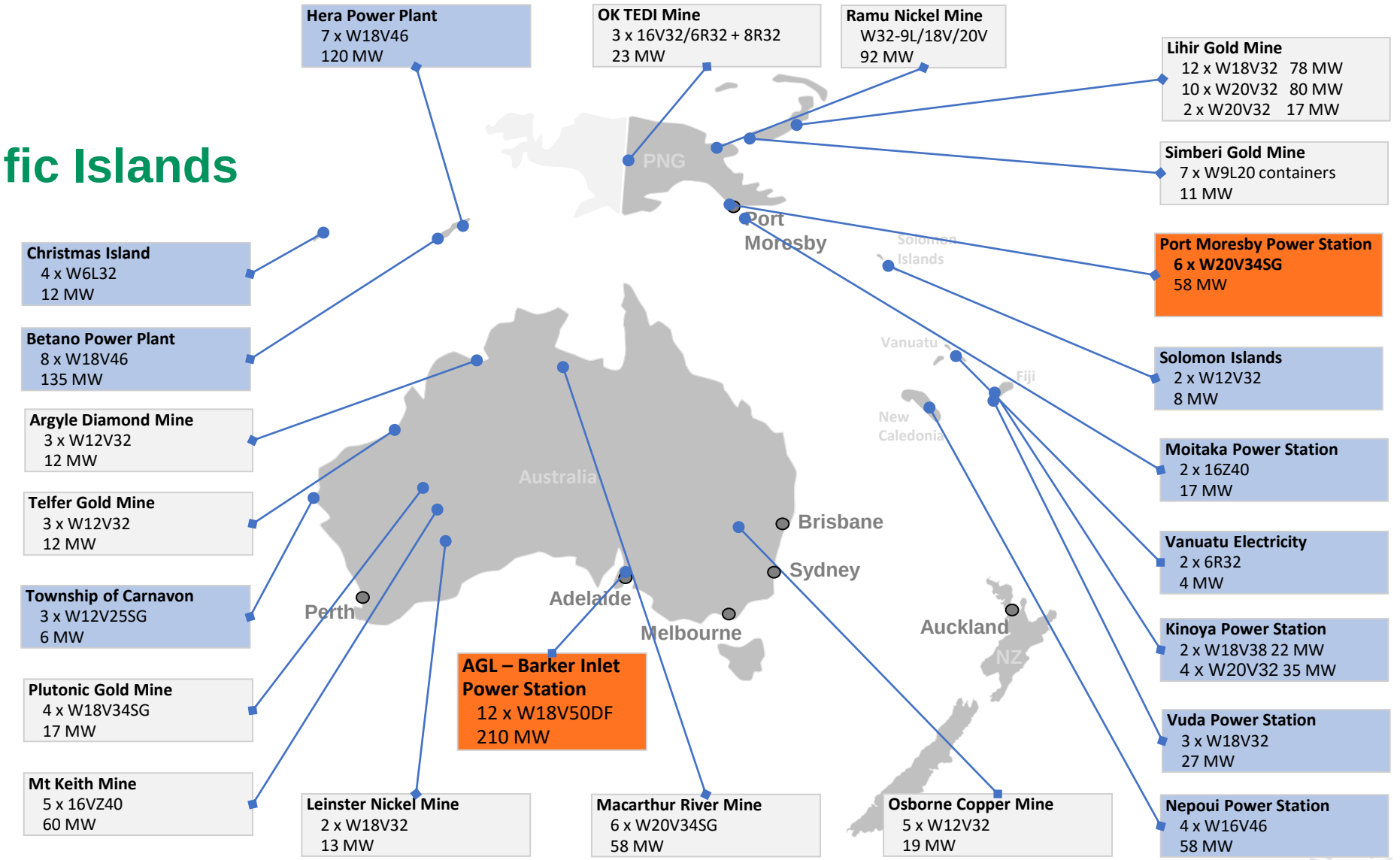
Could the Pacific Islands become the Saudi Arabia of Solar?

OUR BUSINESS AREAS

MARINE Business

ENERGY Business

Experience in
Australia & Pacific Islands



*in construction

Mining

Utilities

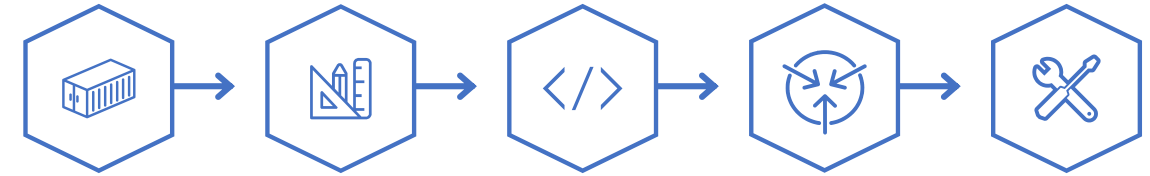
Barker Inlet Power Station, Australia

Customer	**AGL (Gentailer)**
Type	Wärtsilä 50DF multi-fuel power plant
Operating mode	Flexible
Gensets	12 x Wärtsilä 18V50DF
Total output	210 MW
Fuel	Natural gas & Diesel
Scope	Engineering, procurement & construction (EPC)
Delivery	2019

The largest engine-based power plant in Australia helping AGL to cope with the introduction of renewables and be ready five the 5 min settlement rules.

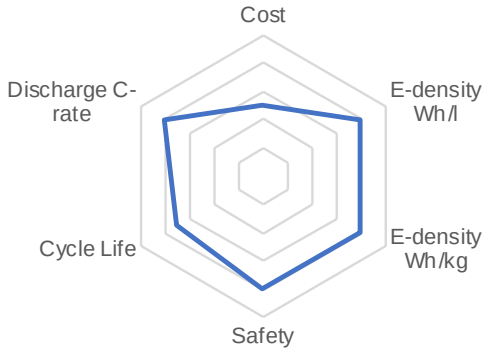
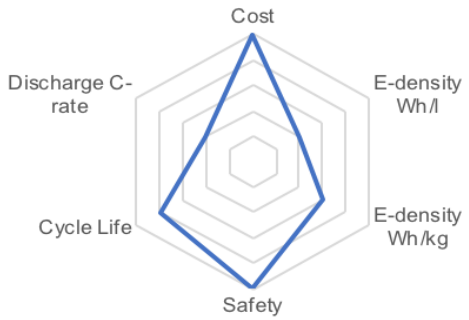
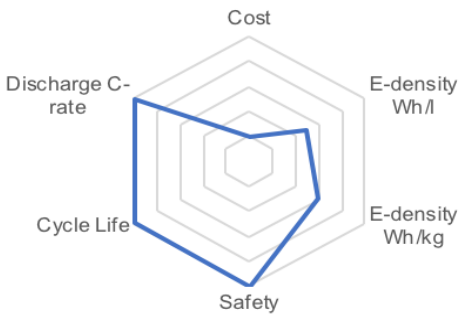
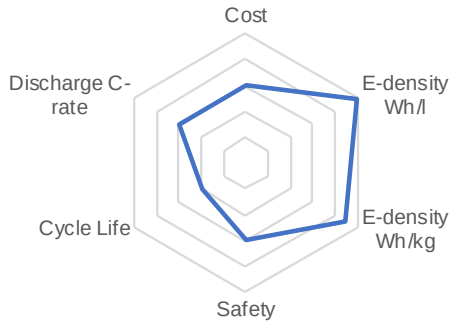
Industry Leader of Energy Storage and Hybrid Systems...

Energy storage technology, integration and software



- Founded in 1834
- Providing energy storage solutions since 2008
- Comprehensive capabilities including design, integration and energy optimization software
- Over 70 grid-scale systems in 9 countries integrated with solar, wind, fossil and hydro generation
- Delivered frequency regulation systems to four unique regulation markets across the world
- GEMS – proprietary software platform now in its sixth generation, used to integrate 16 different batteries to-date with a technology-neutral business model

Battery Selection
Best fit chemistry

NMC	LFP	LTO	NCA
Nickel Manganese Cobalt Oxide Oxide ($LiNiMnCoO_2$)	Iron Phosphate ($LiFePO_4$)	Titanate ($Li_4Ti_5O_{12}$)	Nickel Cobalt Aluminum Oxide ($LiNiCoAlO_2$)
SAMSUNG LG Chem	CATL BYD LISHEN	TOSHIBA Kokam	Panasonic
Market momentum with high energy density and all around good performance	Popular with Chinese OEMs for for safety but has much lower energy density	Superior performance, life cycle cycle and safety, but cost is too high	No Significant adoption in grid storage other than Tesla
			

Hybrid Deployments

alteo 6 MW ESS + 20 MW EPP

AEP AMERICAN ELECTRIC POWER 4 MW ESS + Hydro

CONTOURGLOBAL 6 MW ESS + EPP + Wind

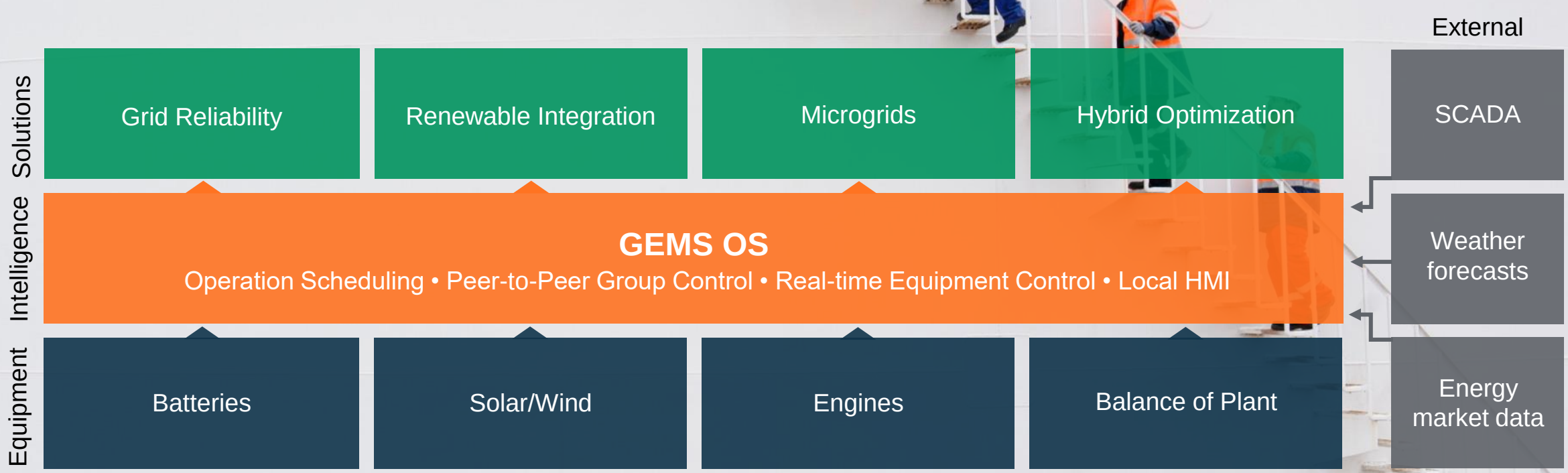
e·on Climate & Renewables 2 x 10 MW ESS + Wind

ARROYO ENERGY 14 MW ESS + 135 MW EPP

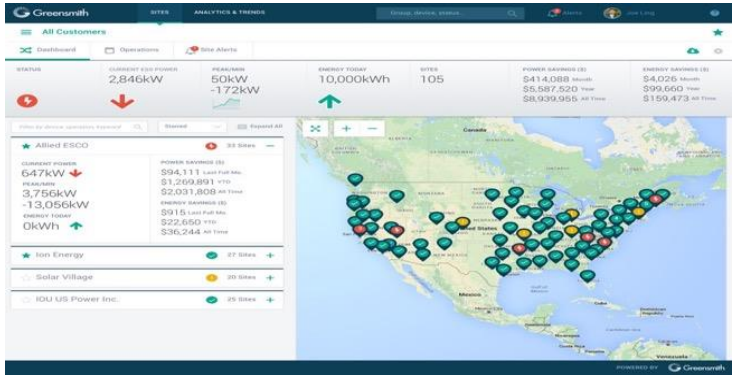
e·on Climate & Renewables 10 MW ESS + Solar

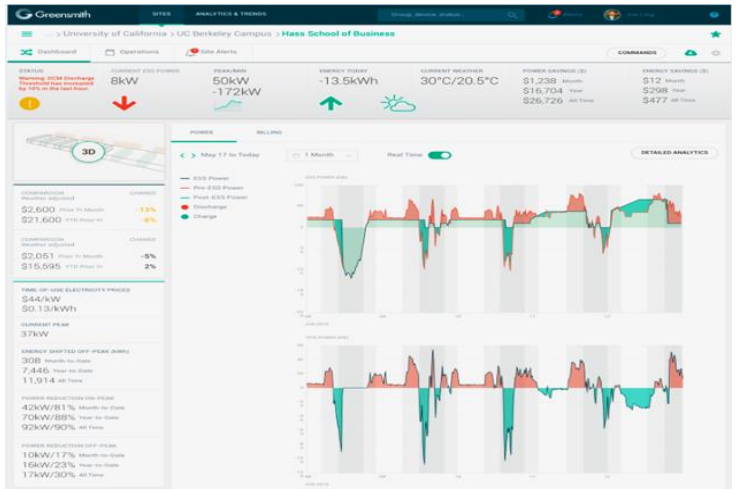
Photos: Greensmith

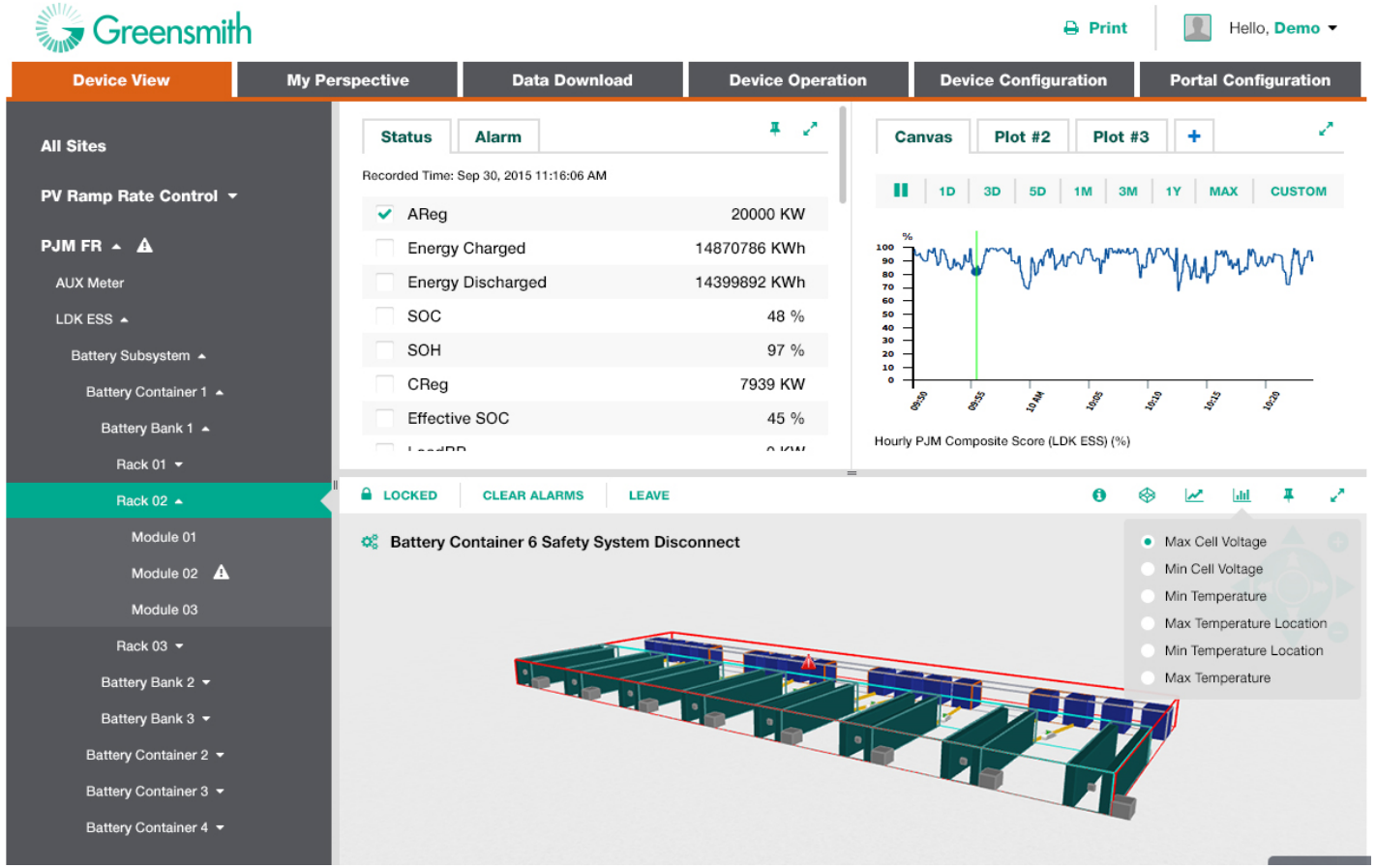
GEMS is built for Flexibility



Modern Software Tools and Architecture







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CASE STUDY - AZORES

RES 0%

How?

ENGINE
POWER PLANT
4.6 MW

TRANSITION

RENEWABLE ENERGY — 4.5 MW + 1 MW

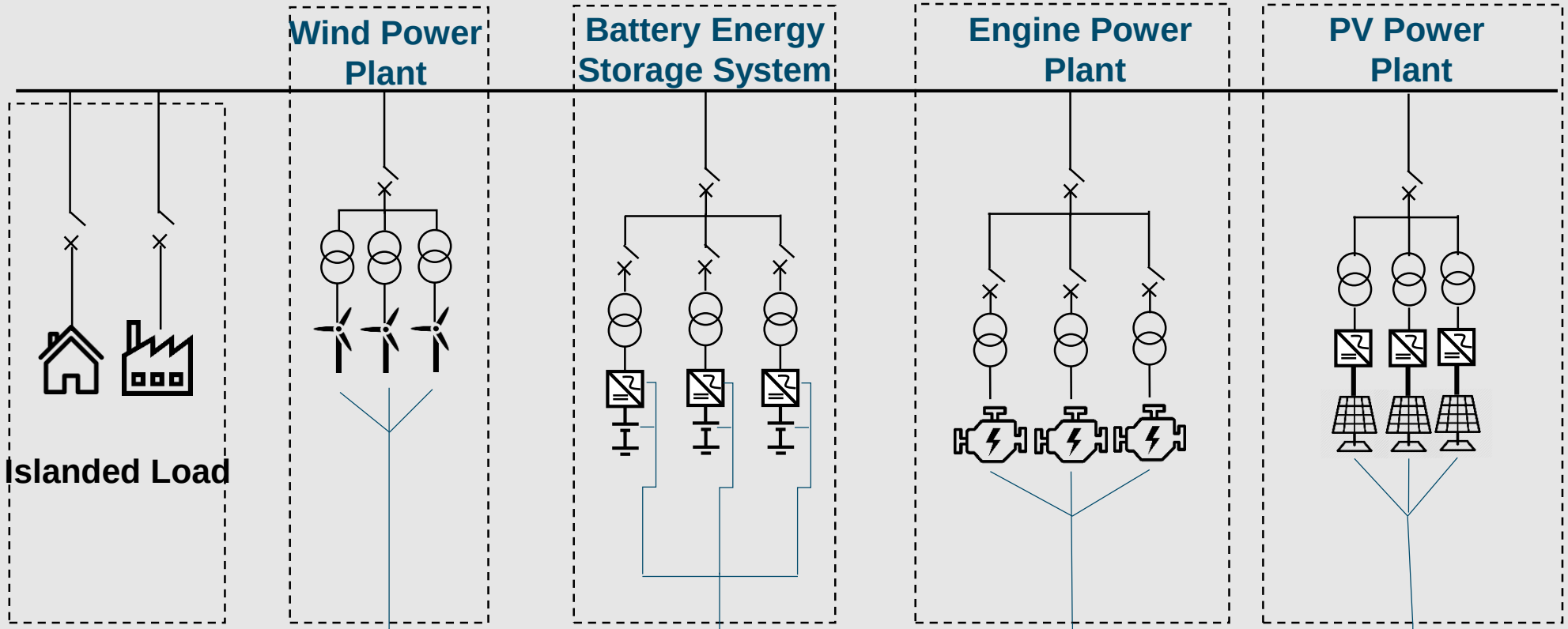
ENGINE POWER PLANT — 4.6 MW

ENERGY STORAGE — 6MW / 3.2 MWH

RES 65%

RES = Renewable Energy Sources

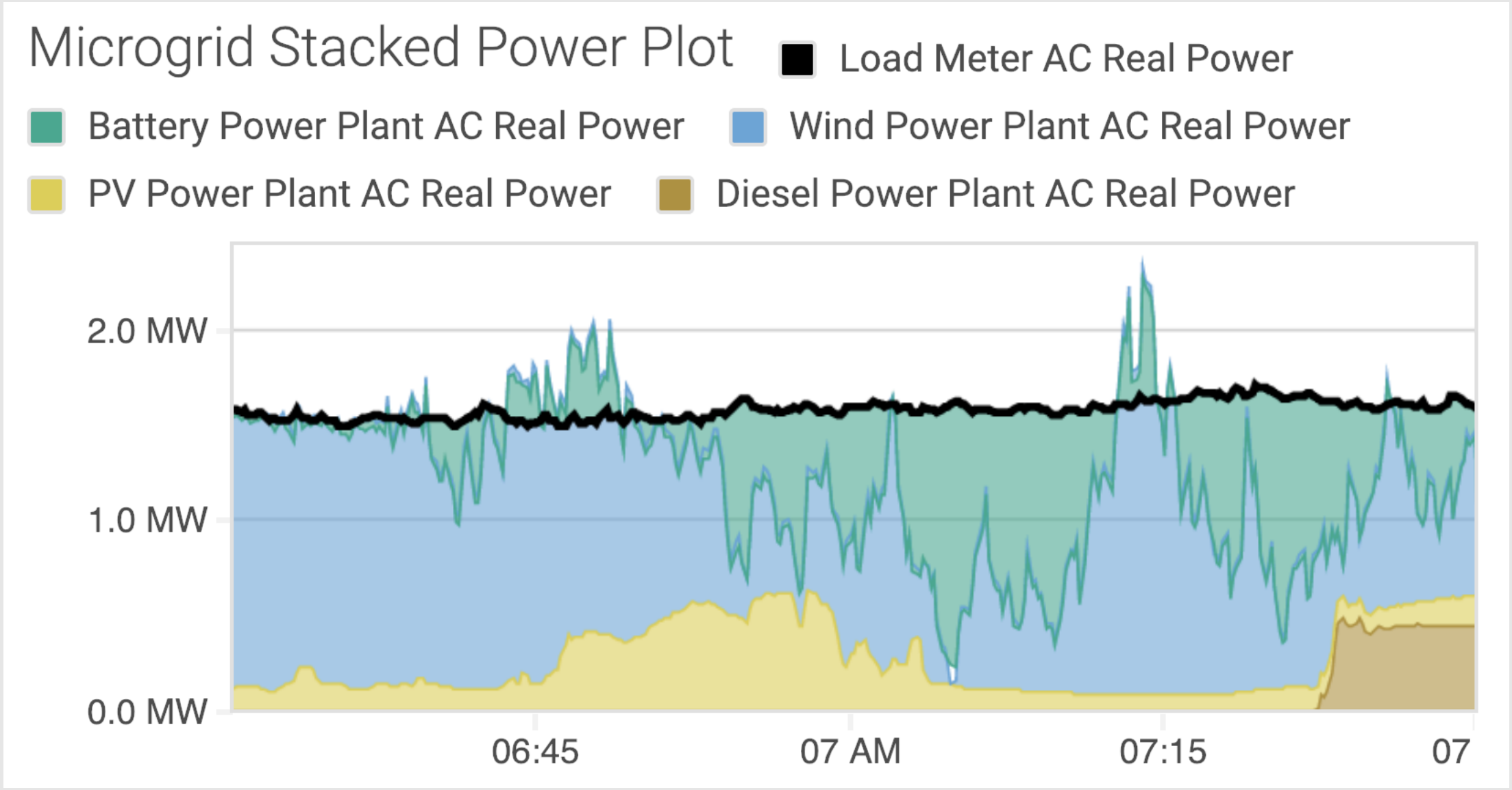
CASE STUDY - AZORES

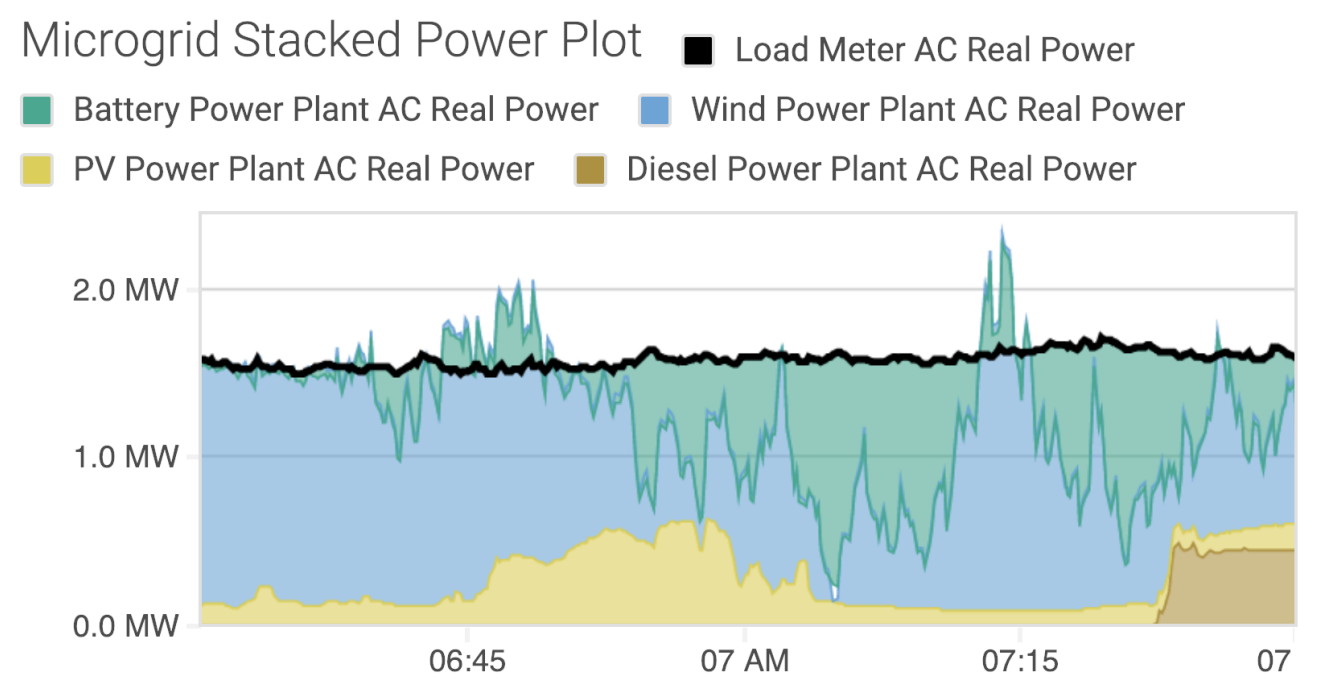


- Dispatch Optimization
- Load Forecast
- Renewable Forecast

- Weather Subscription
- Data Storage and Analytics
- Remote O&M

GEMS = Greensmith Energy Management System
PPC = Power Plant Controller


Microgrid Stacked Power Plot
Load Meter AC Real Power
Battery Power Plant AC Real Power
Wind Power Plant AC Real Power
PV Power Plant AC Real Power
Diesel Power Plant AC Real Power
2.0 MW
1.0 MW
0.0 MW
06:45
07 AM
07:15
07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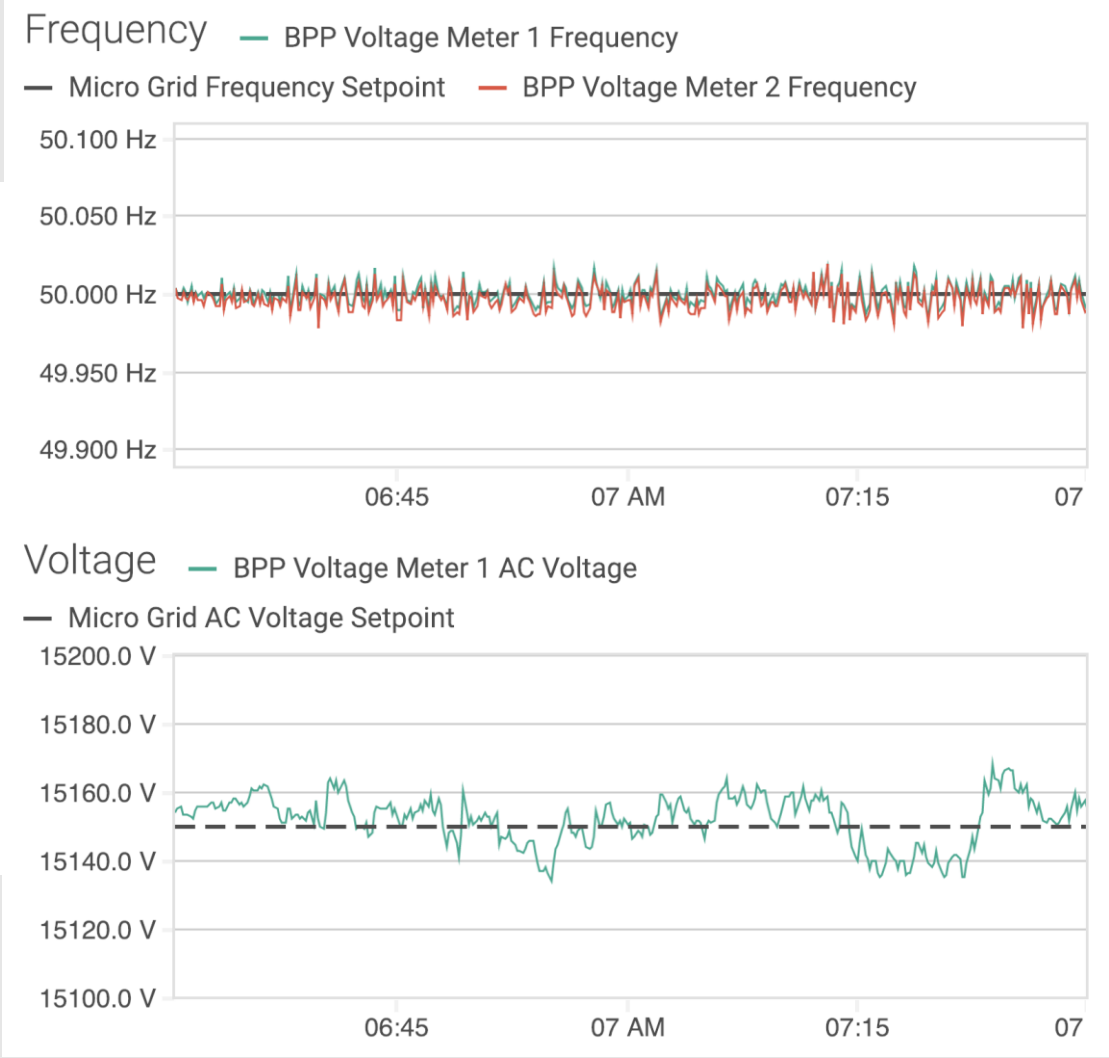
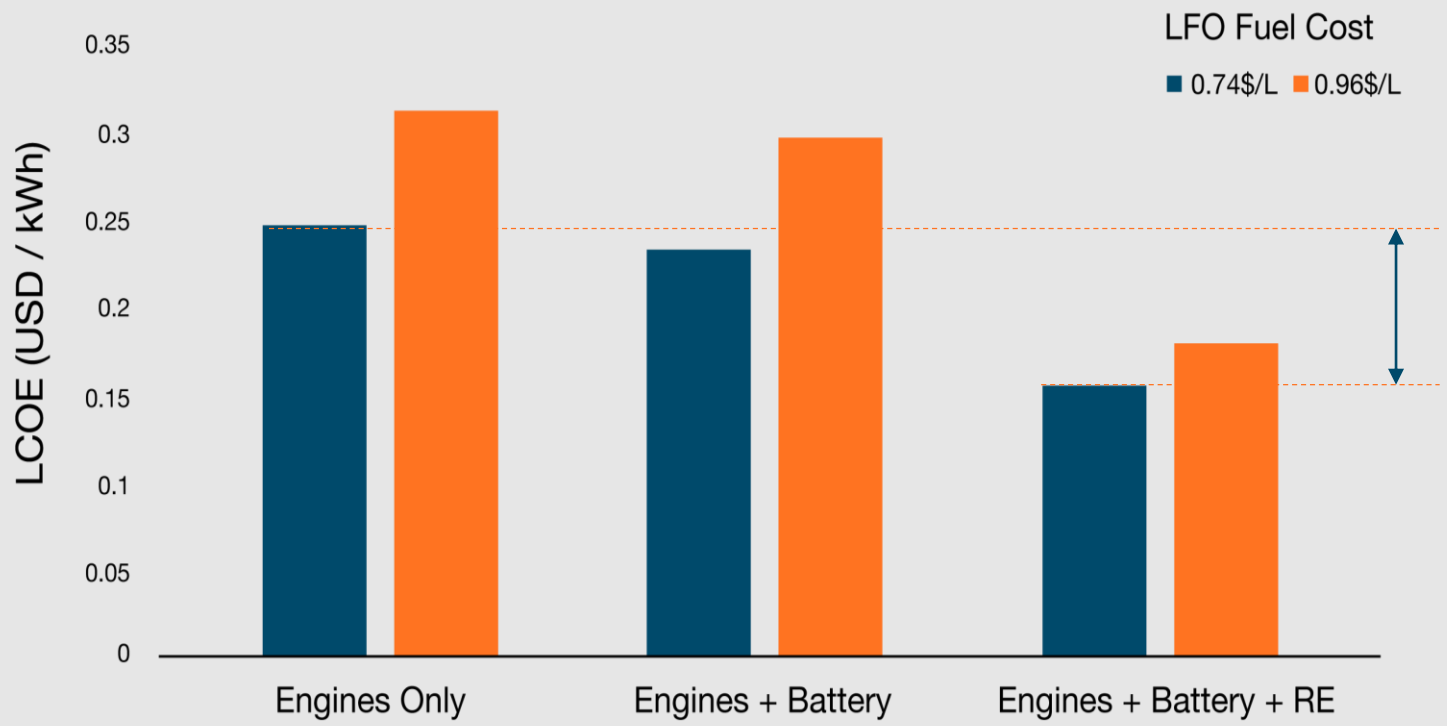

Frequency
BPP Voltage Meter 1 Frequency
Micro Grid Frequency Setpoint
BPP Voltage Meter 2 Frequency
50.100 Hz
50.050 Hz
50.000 Hz
49.950 Hz
49.900 Hz
06:45
07 AM
07:15
07
Voltage
BPP Voltage Meter 1 AC Voltage
Micro Grid AC Voltage Setpoint
15200.0 V
15180.0 V
15160.0 V
15140.0 V
15120.0 V
15100.0 V
06:45
07 AM
07:15
07

LCOE Savings



RES 0%

RES 65%
Renewables as baseload

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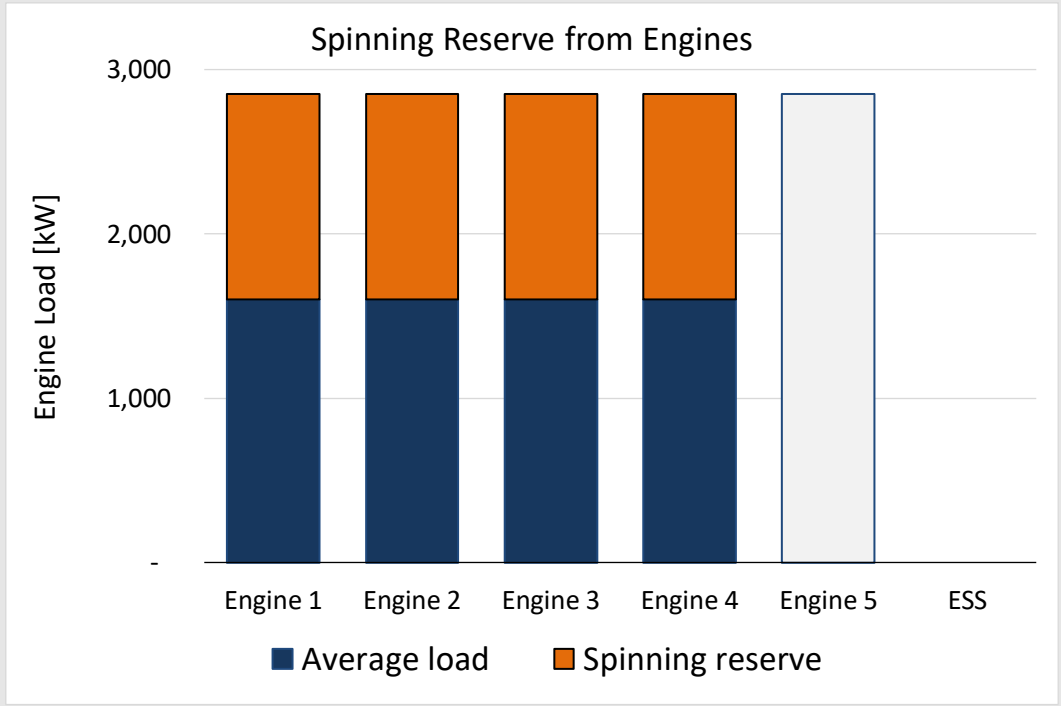
Bonaire Background

- Part of Netherlands Antilles in the Caribbean
- 50 miles from Curaçao, 60 miles from Venezuela Coast
- 18,000 inhabitants
- (5) heavy fuel oil engines; total of 14 MW
- (13) wind turbines; total of 11 MW
- Average renewable penetration pre-2019: 15-25%
- Challenge: wind curtailment and grid stability

Change in Operations

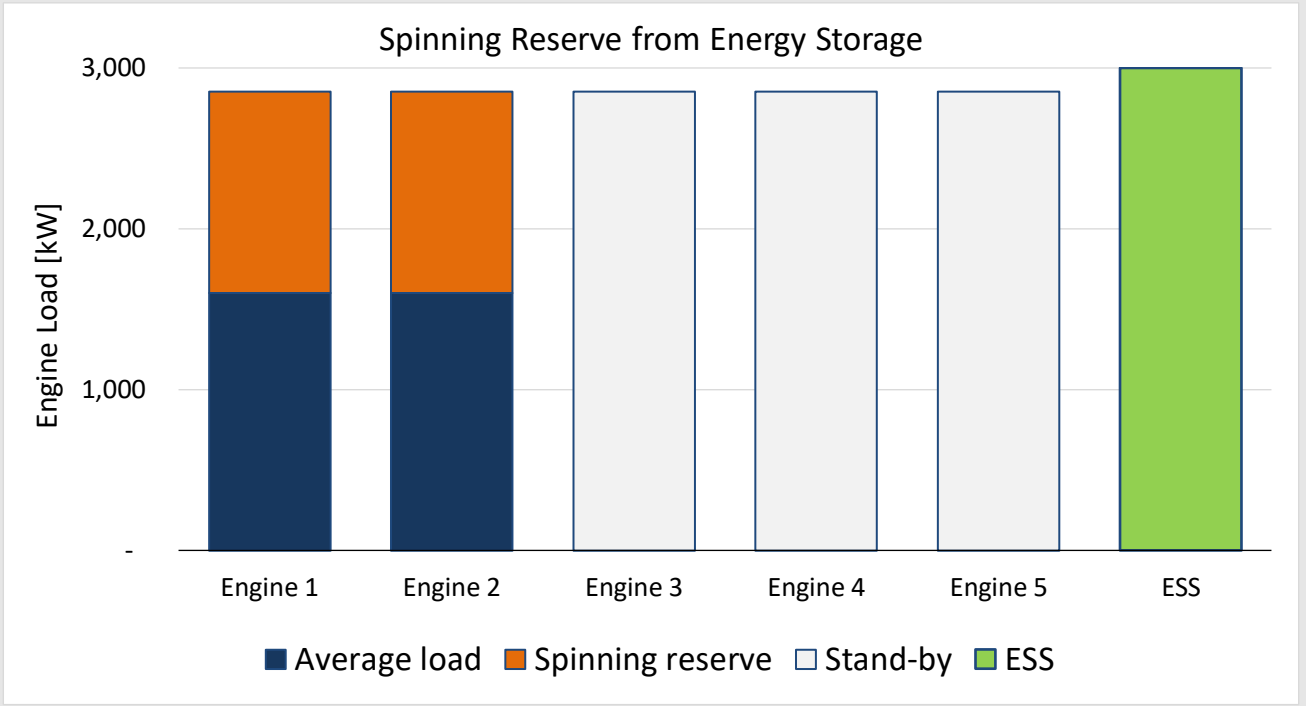
Example hour: 12 MW Load, 9 MW Wind, 4.5 MW Spinning Reserve Requirement

Before



- Engines power: 6.4 MW; reserves: 5 MW
- Wind power 5.6 MW Power
- Wind curtailment: 3.4 MW
- Engines operate at minimum load: 1.6 MW each

After



- Engines power: 3.2 MW; reserves: 2.5 MW
- Wind power: 8.8 MW
- Wind curtailment: 0.2 MW
- Energy storage reserves: 3 MW

THANK YOU FOR YOUR ATTENTION!

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