Integrating Renewables into the Grid

Applying MW Scale Energy Storage Solutions for Continuous Variability Management

John Wood

Why Is Storage Important?

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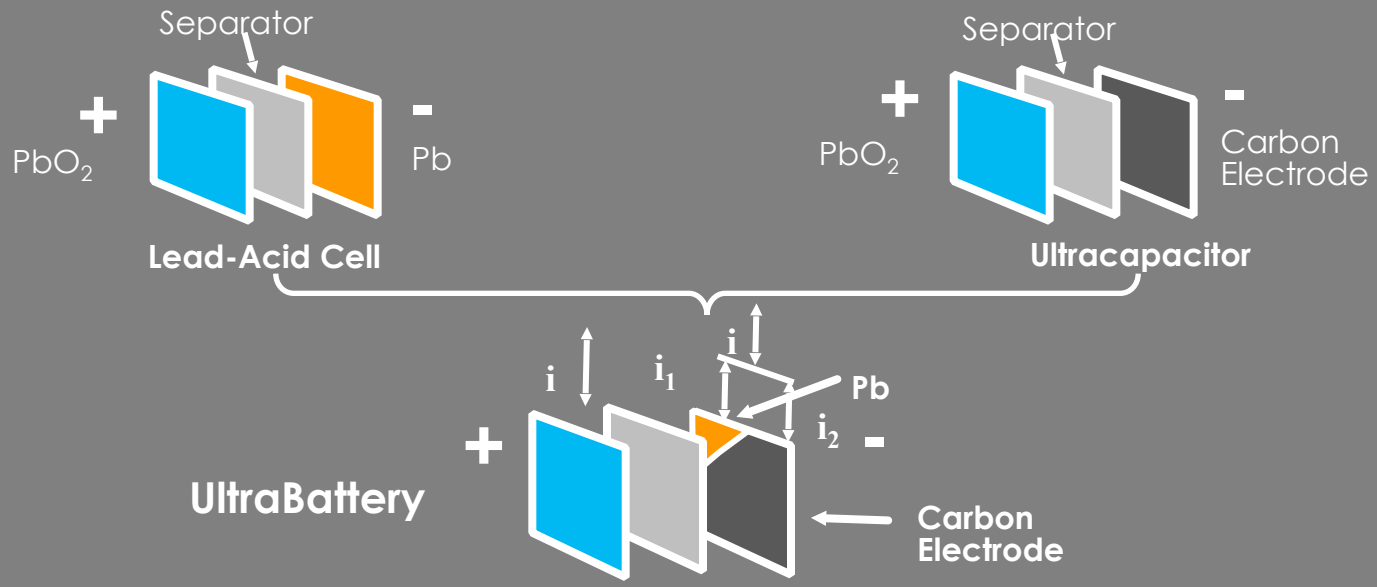
UltraBattery® Technology



UltraBattery®

The New Dimension in a Lead Acid World

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Starter Battery

Market Size:
$15B

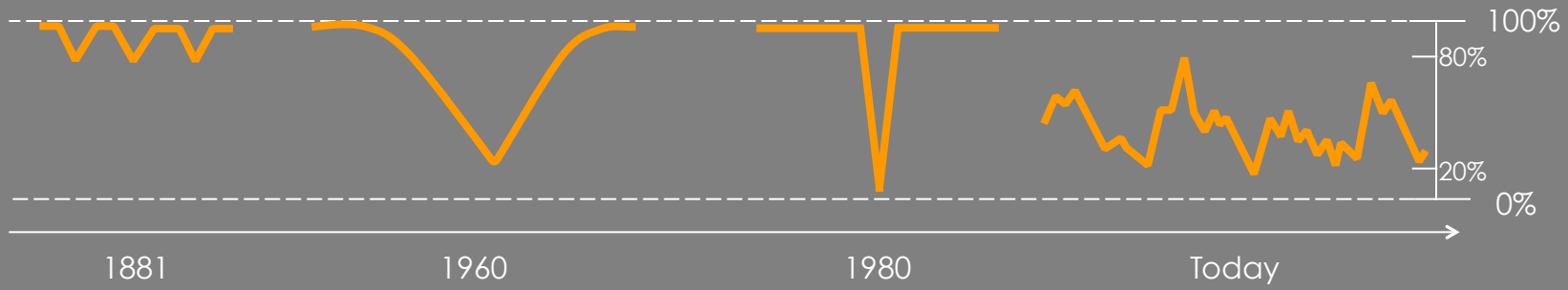
Motive Battery

Market Size:
$3.5B

Standby Battery

Market Size:
$6B

PSOC UltraBattery
New Lead-Acid Market



UltraBattery®

The New Dimension in a Lead Acid World

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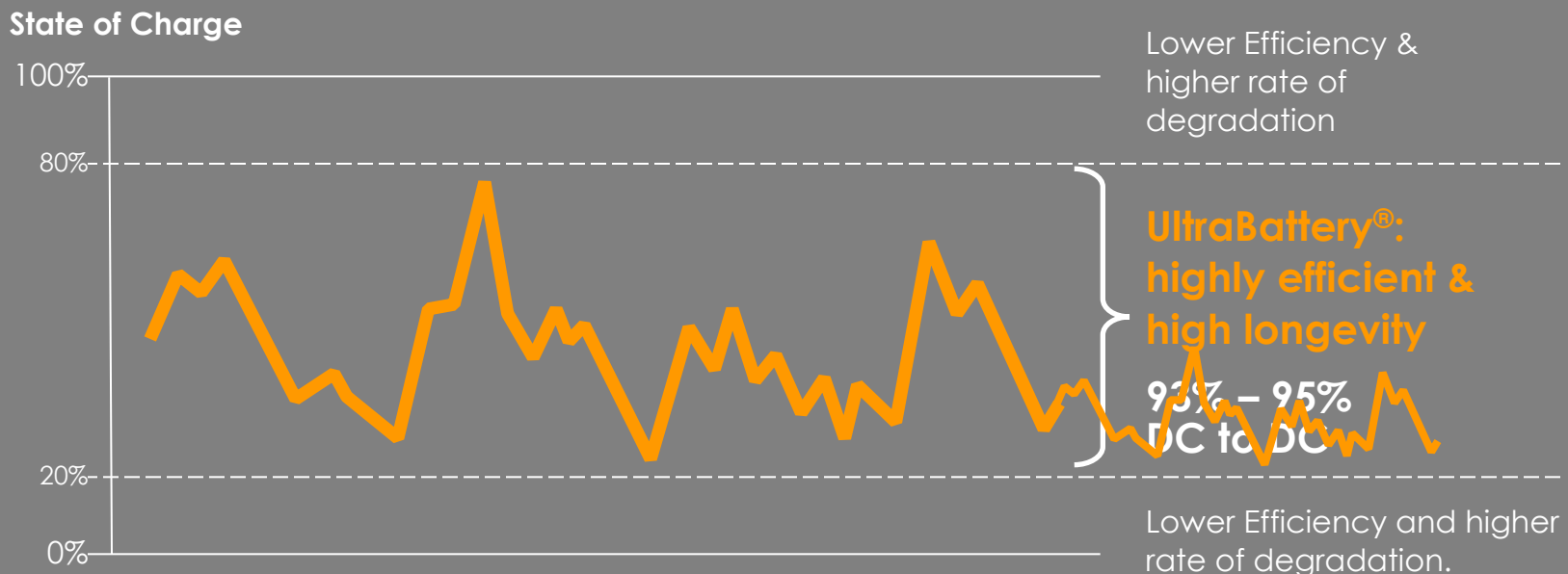
High Efficiency in Partial State of Charge Use



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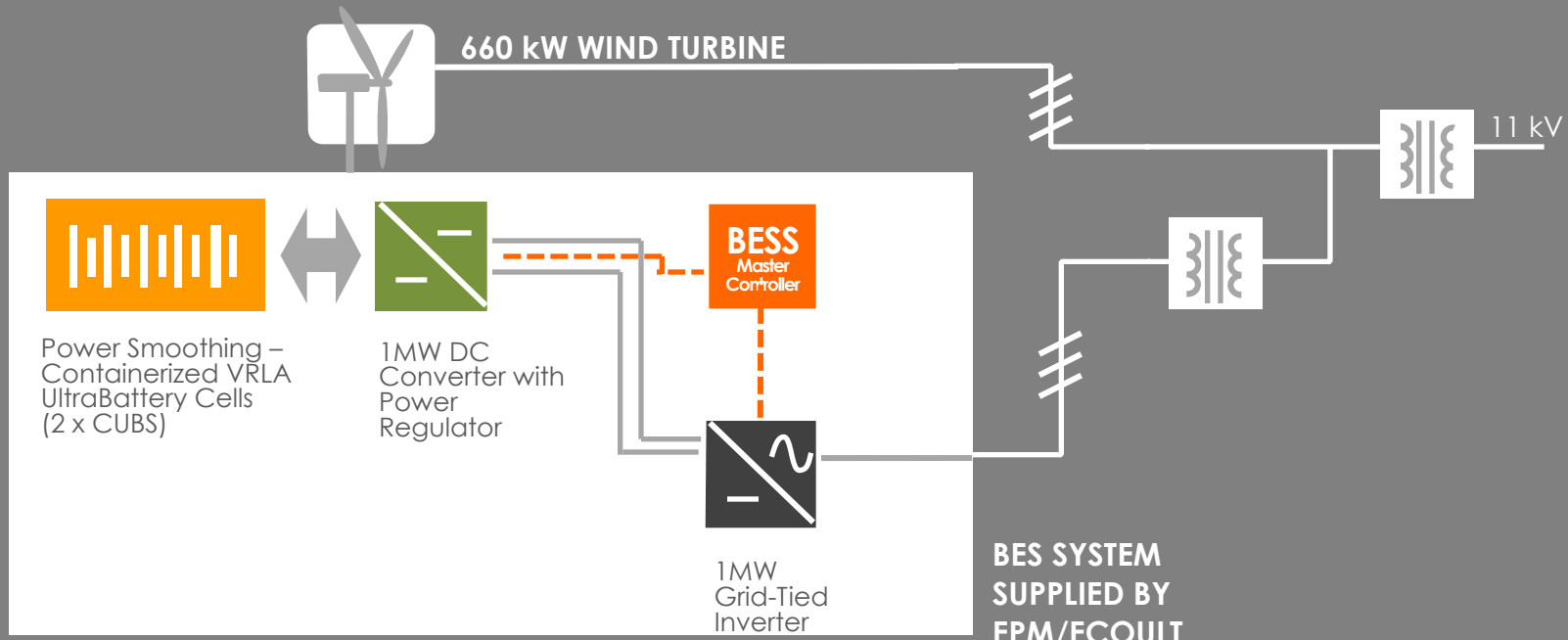
Direct Renewable Enhancement

Hampton Wind Farm

Wind Smoothing

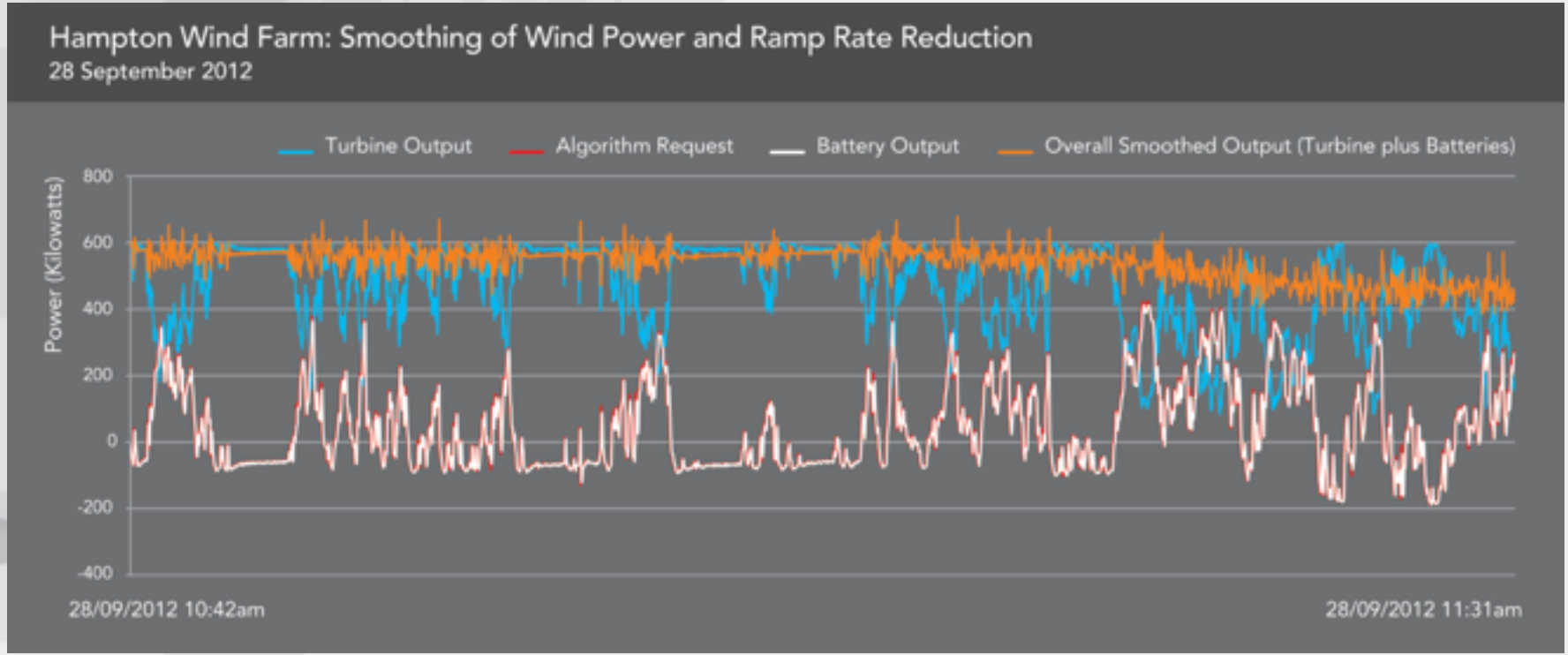
Electrical Single Line Diagram

Of Hampton Wind Farm Energy Storage System



Smoothing

Of Wind Output and Ramp Rate Reduction



PNM Prosperity Project

Solar Smoothing & Shifting/Firming

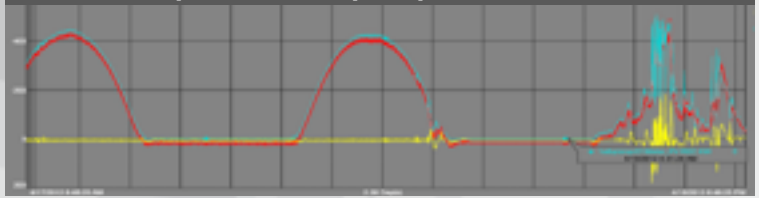
PV Smoothing

PV Output

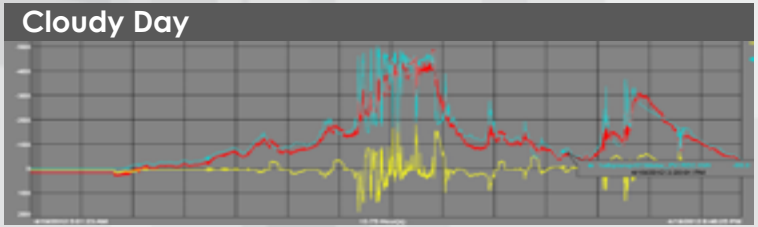
Battery Output

System Output

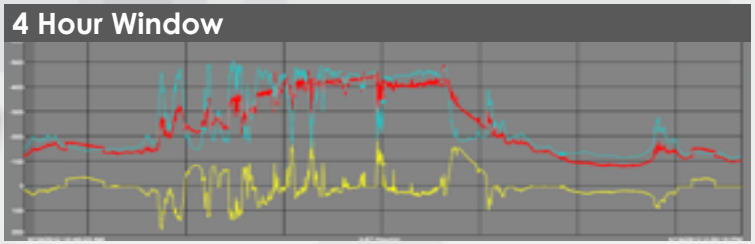
2 Clear Days & 1 Cloudy Day



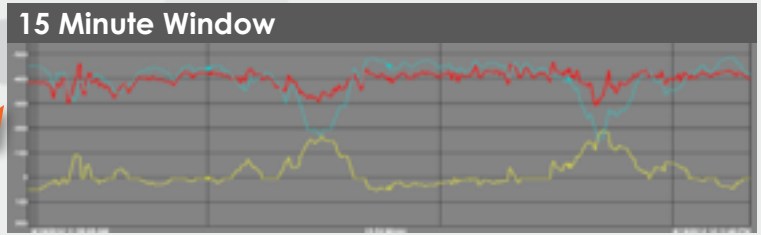
Cloudy Day



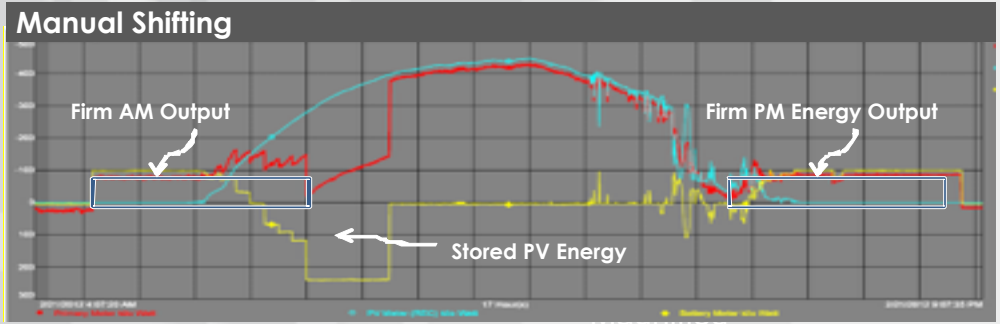
4 Hour Window

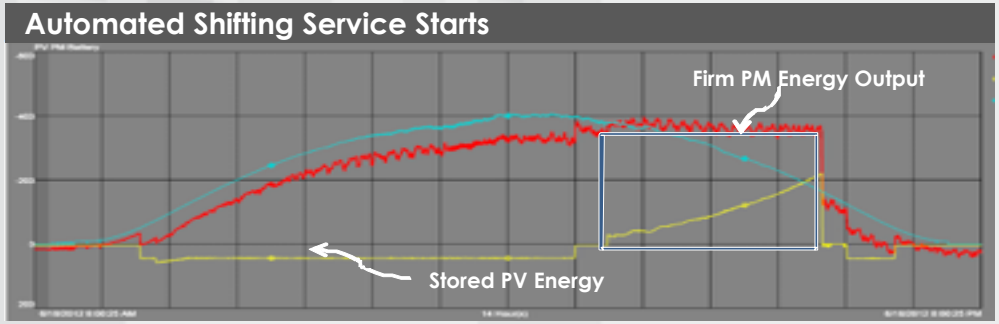


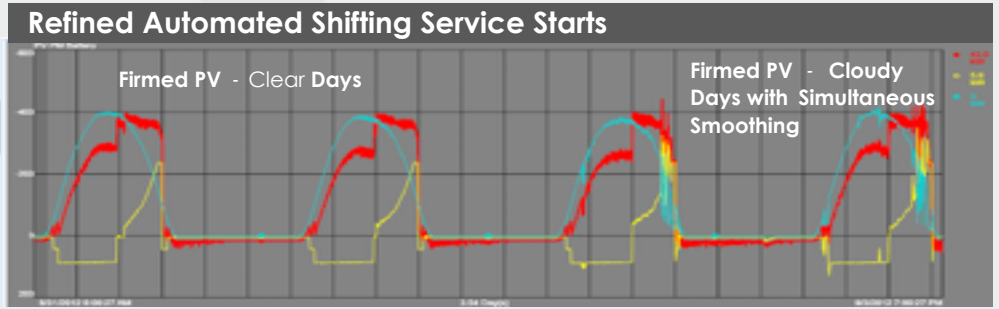
15 Minute Window



PV Firming







PV Output

Battery Output

System Output

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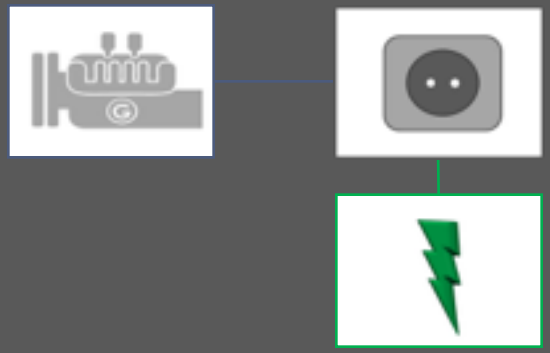
Enhancing Diesel/ Renewable Minigrids

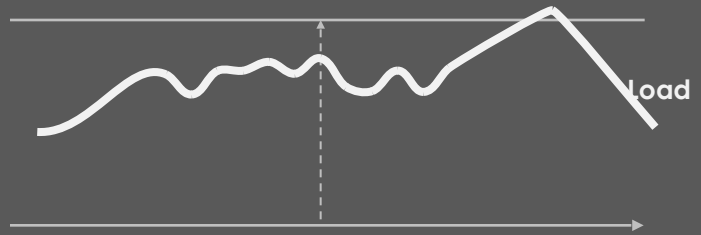
Microgrid Diesel Efficiency

Typical Diesel Generator Efficiency Curve

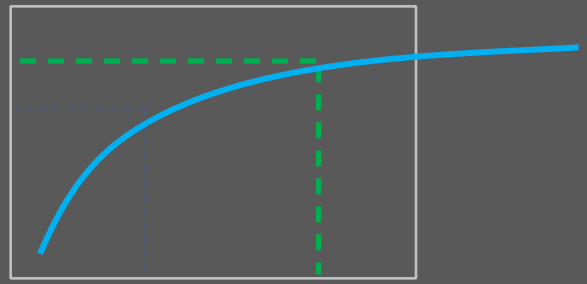
Source: XXX

Single Diesel





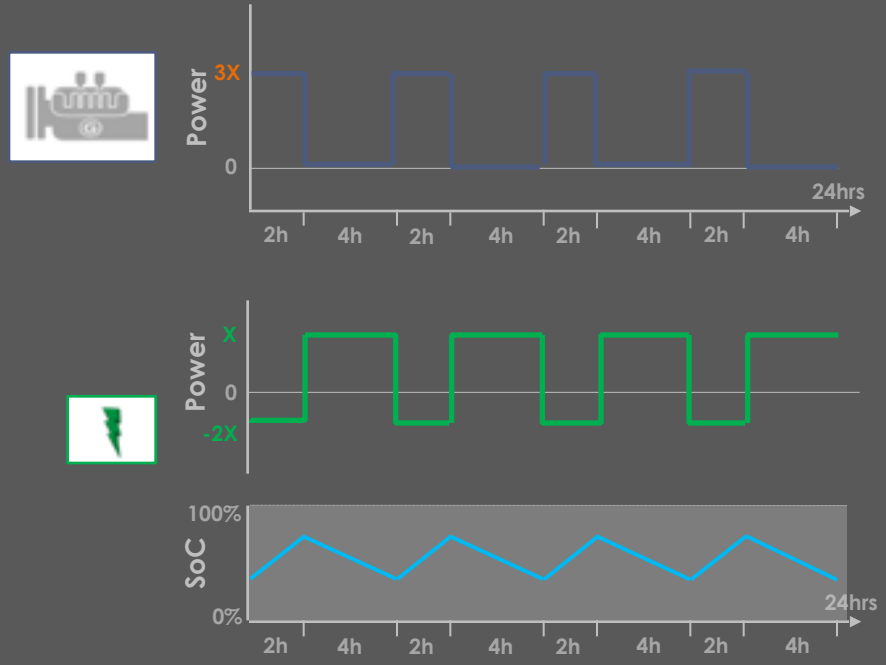
24 hours



Fuel Efficiency Curve

Single Diesel

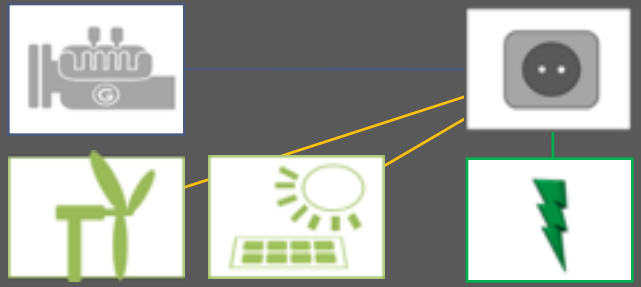
PSoC UltraBattery® Cycle

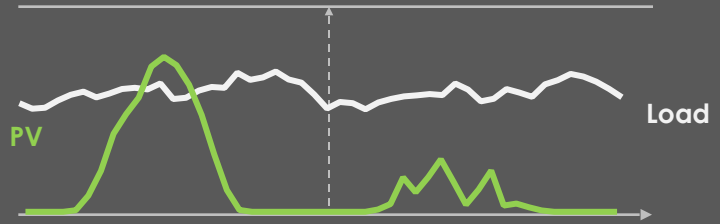


Single Diesel

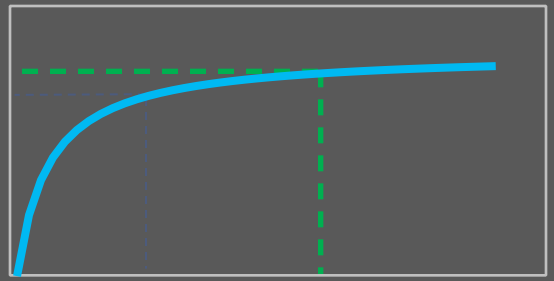
Diesel Efficiency – Using Diesel in the Efficient Band	PSoC Cycle
Diesel Consumption	- 10% to - 50%
LCOE	- 10% to – 30%
CO_2	- 10% to - 50%
Diesel Longevity	2.0X

Adding Renewables



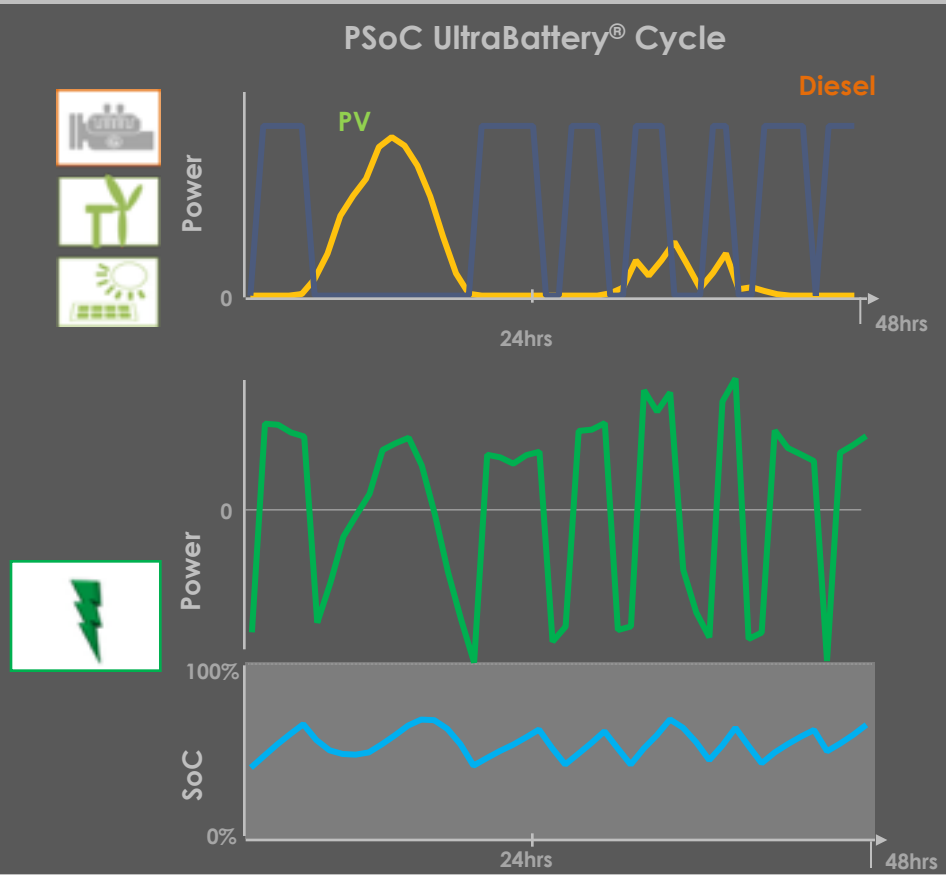


48 hours



Fuel Efficiency Curve

Adding Renewables



Adding Renewables

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PSoC UltraBattery® Cycle

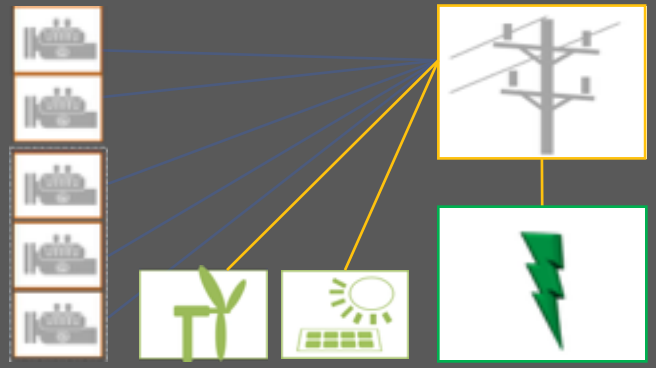
Match Renewable Power

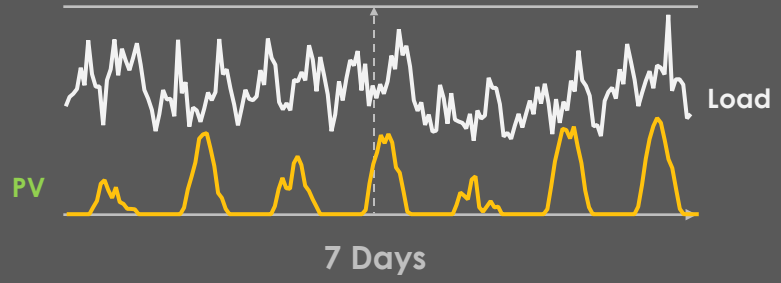
Manage Renewable Variability

	PSoC Cycle
Diesel Consumption	- 50%+
LCOE	- 30%
CO_2	- 50%+
Diesel Longevity	2.5X
Battery Replacement	2.5X

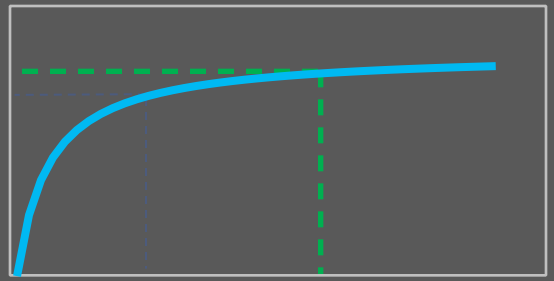
24hrs 48hrs

Multi Gas Diesel / Renewables





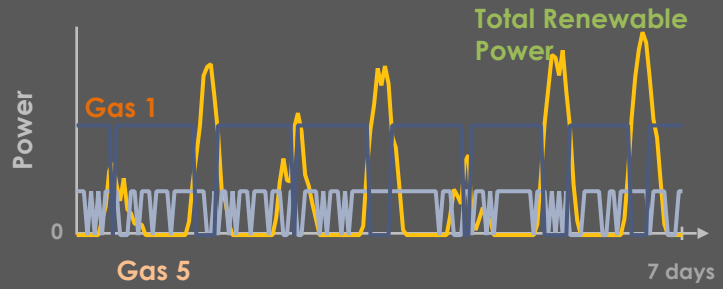
7 Days

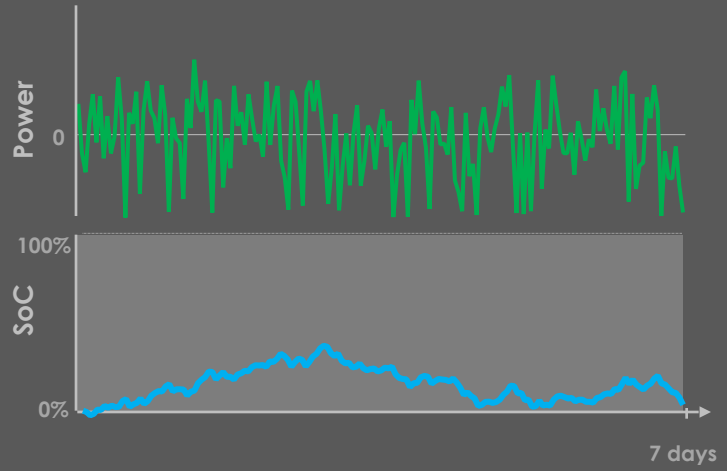


Fuel Efficiency Curve

Multi Gas Diesel / Renewables

PSoC UltraBattery® Cycle



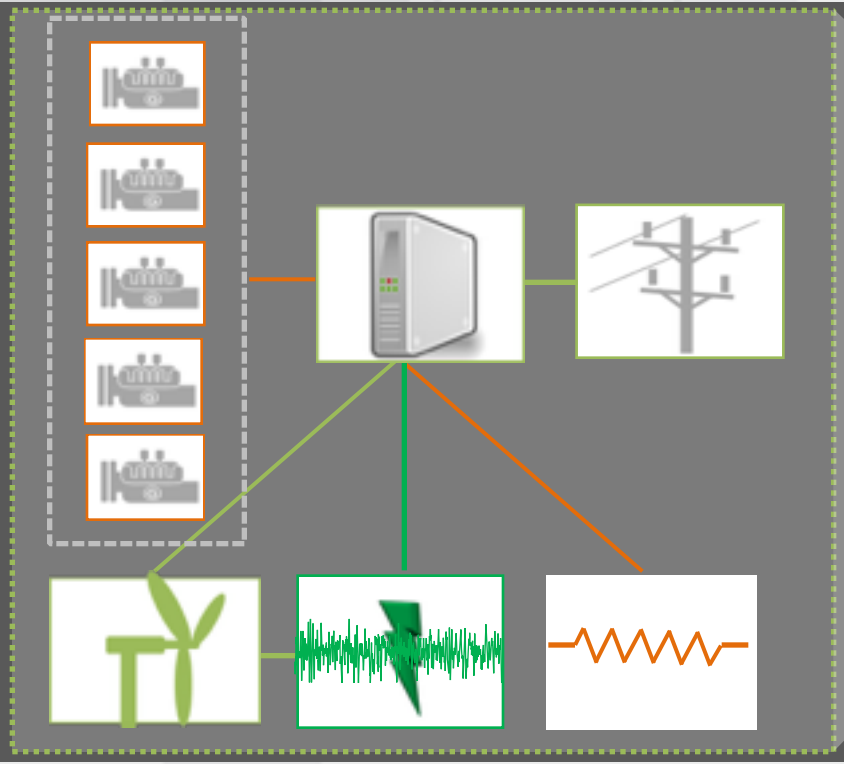


Multi Gas Diesel / Renewables

Diesel Efficiency – Using Diesel in the Efficient Band

	PSoC Cycle
Diesel Consumption	- 20%+
LCOE	- 5% to – 25%
CO_2	- 20%+

Mini Grid



Frequency Regulation

VAR Correction

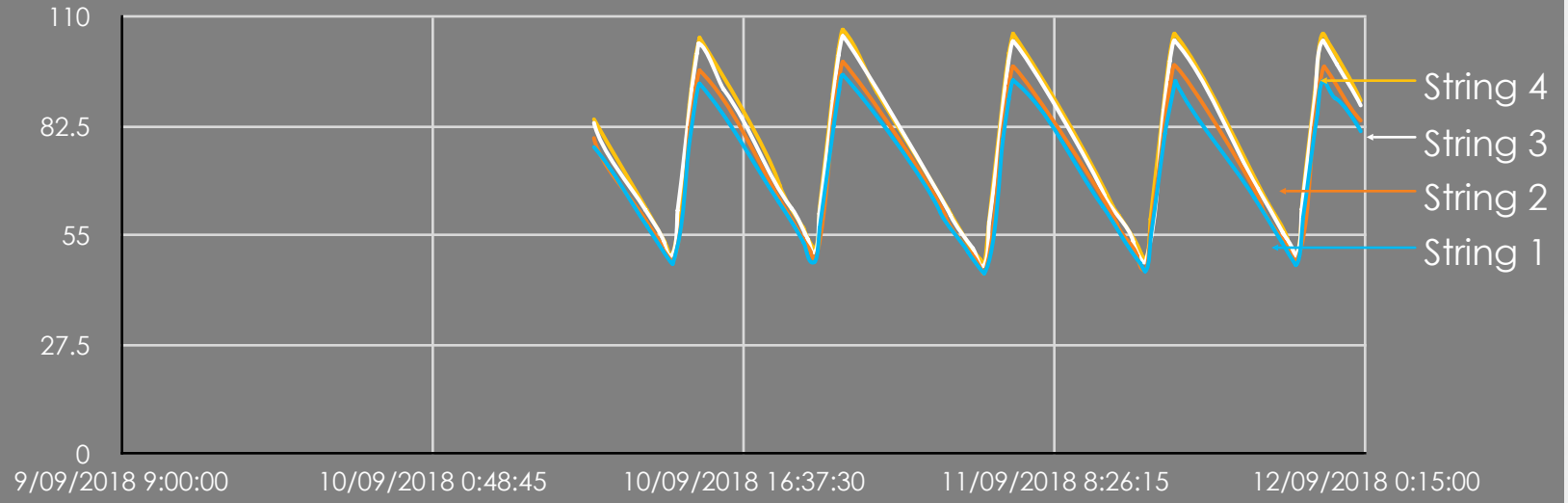
Spinning Reserve

Microgrid Diesel Efficiency

Microgrid Diesel Efficiency

3 Day Cycling

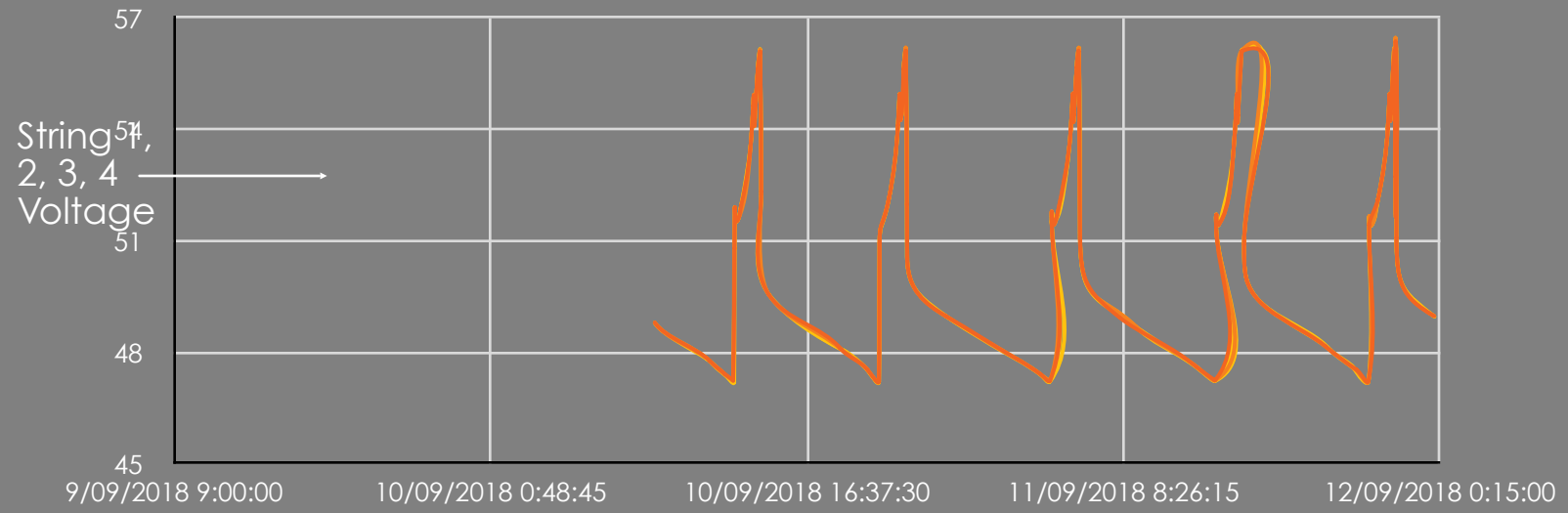
String State of Charge (SOC)



Microgrid Diesel Efficiency

3 Day Cycling

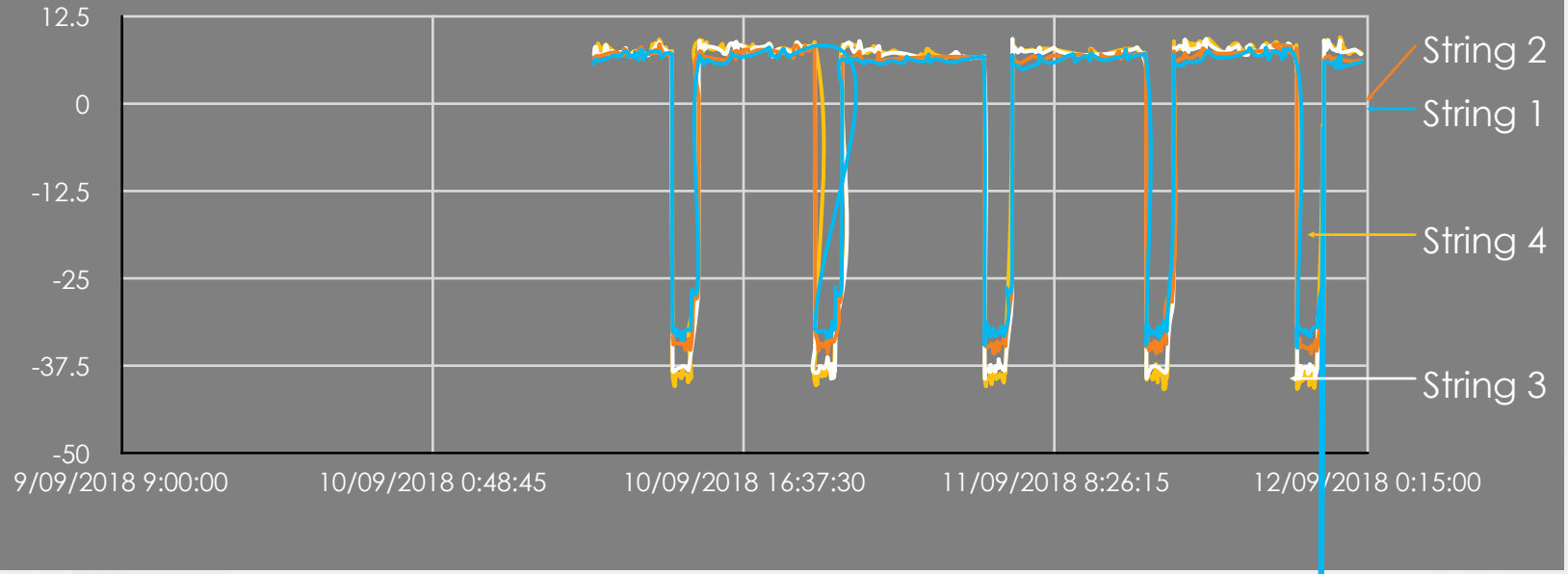
String Voltage



Telstra Microgrid Diesel Efficiency

3 Day Cycling

String Current

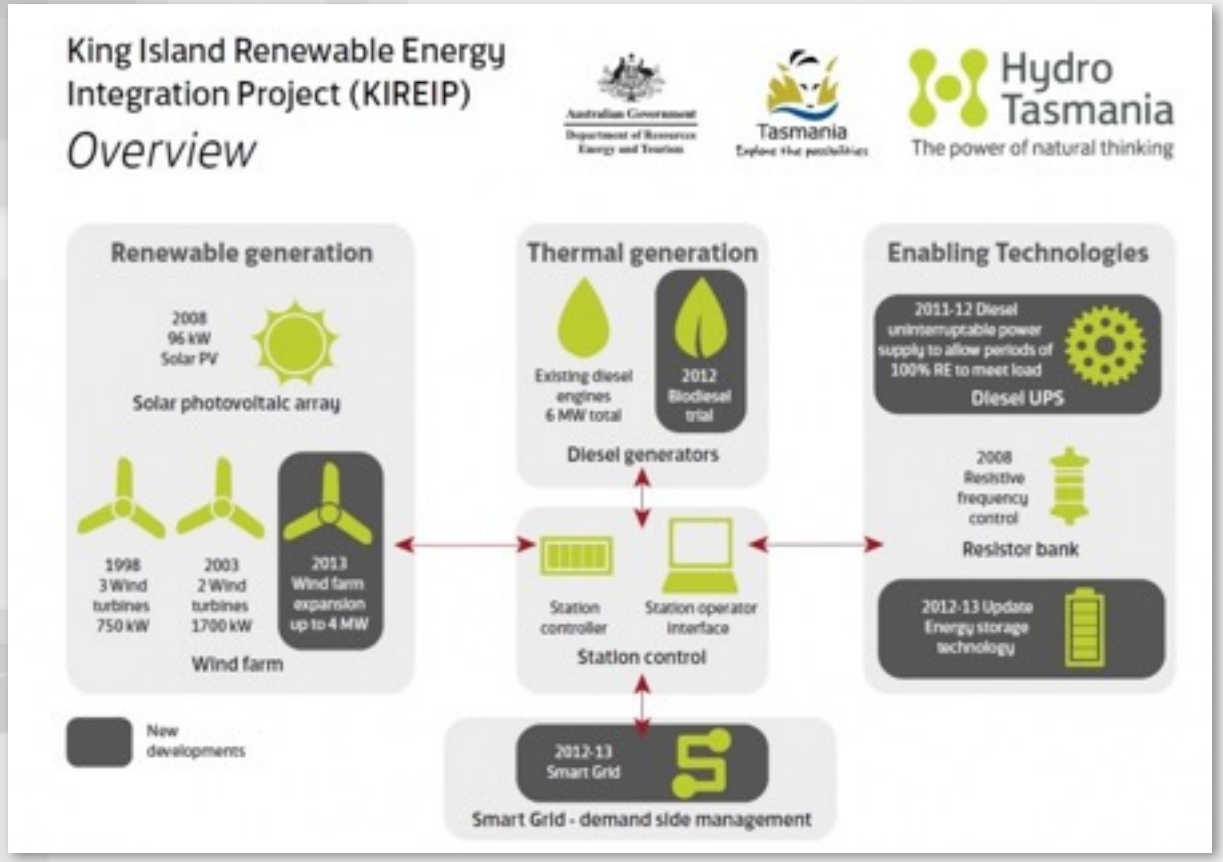


Current Projects

Hydro Tasmania – King Island Renewable Integration Project (KIREIP)

Renewables Integration and Diesel Reduction

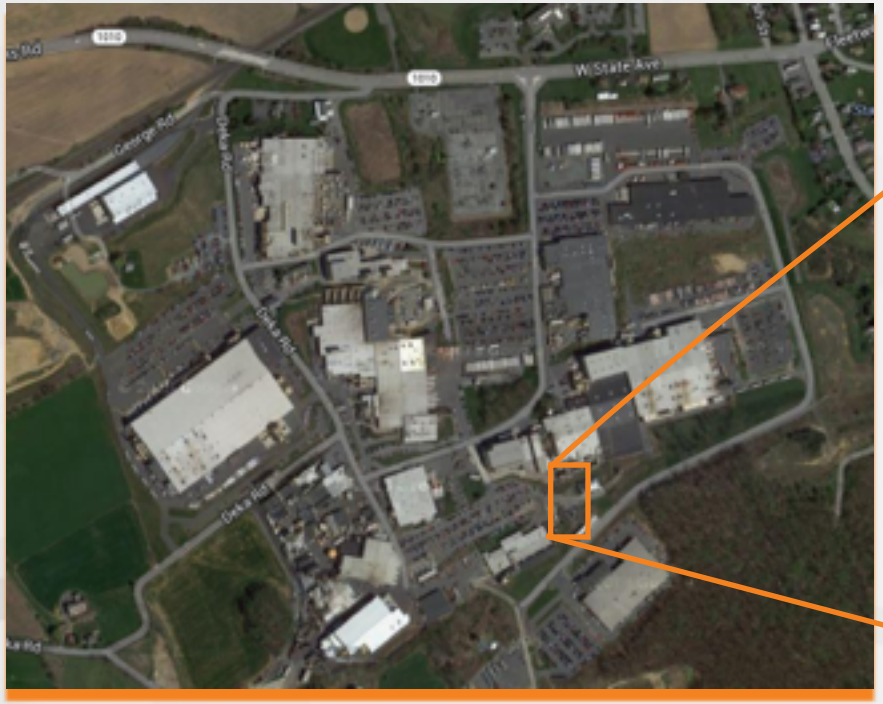
Hydro Tasmania - KIREIP Project



Addressing Variability on the Grid

PJM Frequency Regulation

Regulation Services



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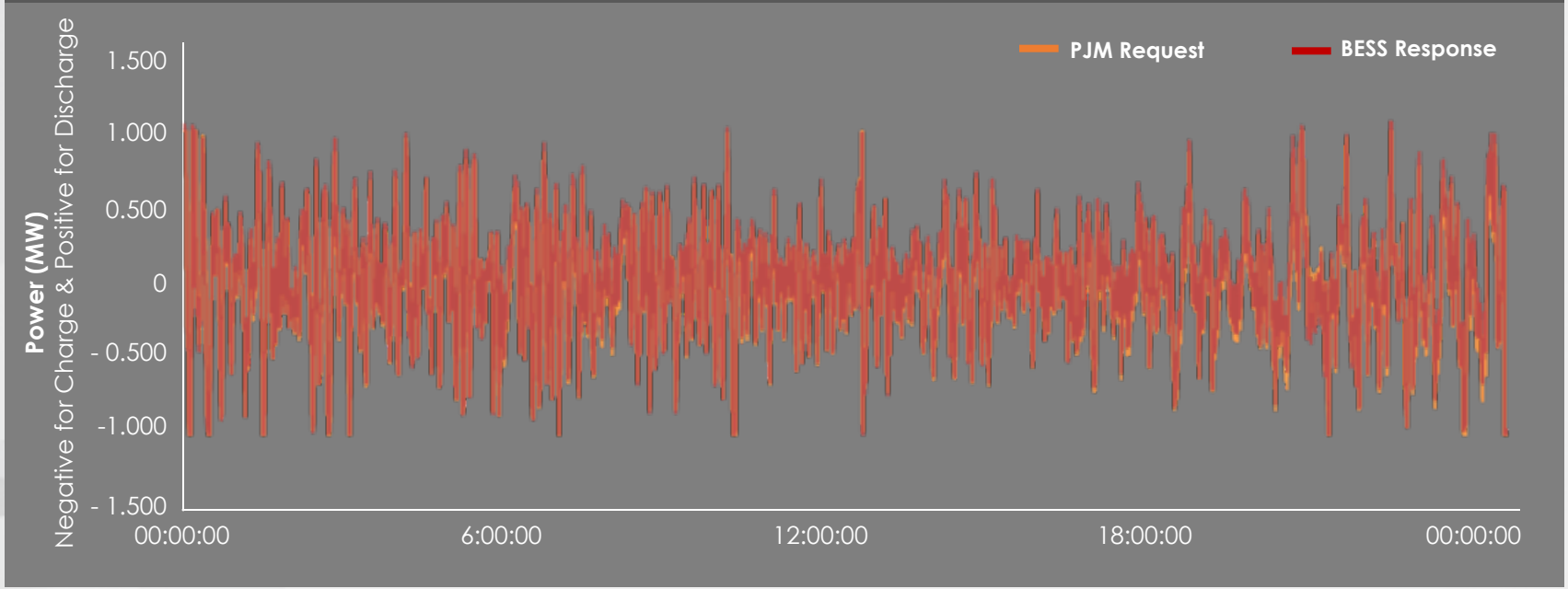
* The project is supported by funding from the U.S. Department of Energy under the Smart Grid Storage Demonstration Program.

Regulation Services on PJM

Dynamic PJM Regulation Services Signal, 22 May 2014



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Regulation Services on PJM

Traditional Regulation

Daily Mileage **141.7** MW

Mileage Ratio **1.0**

Dynamic Regulation

Daily Mileage **434.3** MW

Mileage Ratio **3.1**

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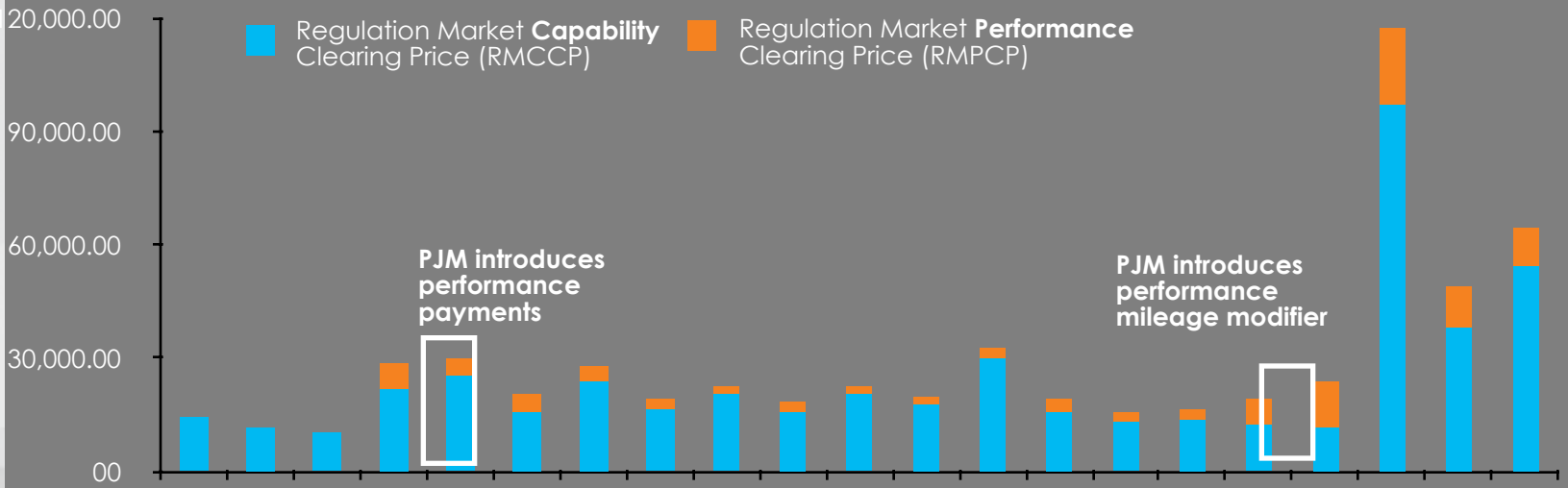
Regulation Services on PJM

Revenue of 1MW Regulation Plant Operated Continuously With 100% PJM Performance Score



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Combining Functions to Make Storage Economics Compelling

Dual Purpose

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Reserve Capacity

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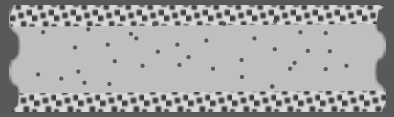
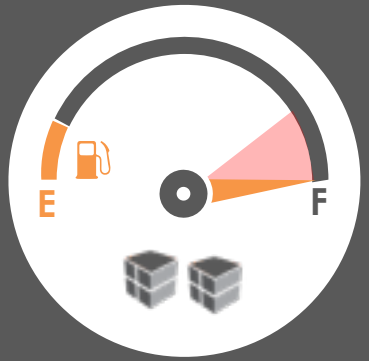
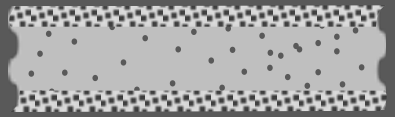
Conventional Battery
on Float

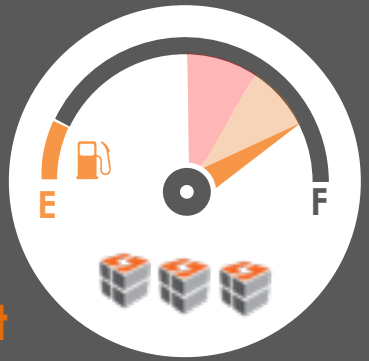




Reserve Event

Battery
in Partial State
of Charge





Reserve Event

PJM Frequency Regulation

Regulation Services

Storage Facility #1:

3MWFrequency Regulation

2x Power

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Multi-Purpose Storage System

Storage Facility #2:

100 kW Frequency Regulation

250kW UPS/Back-up

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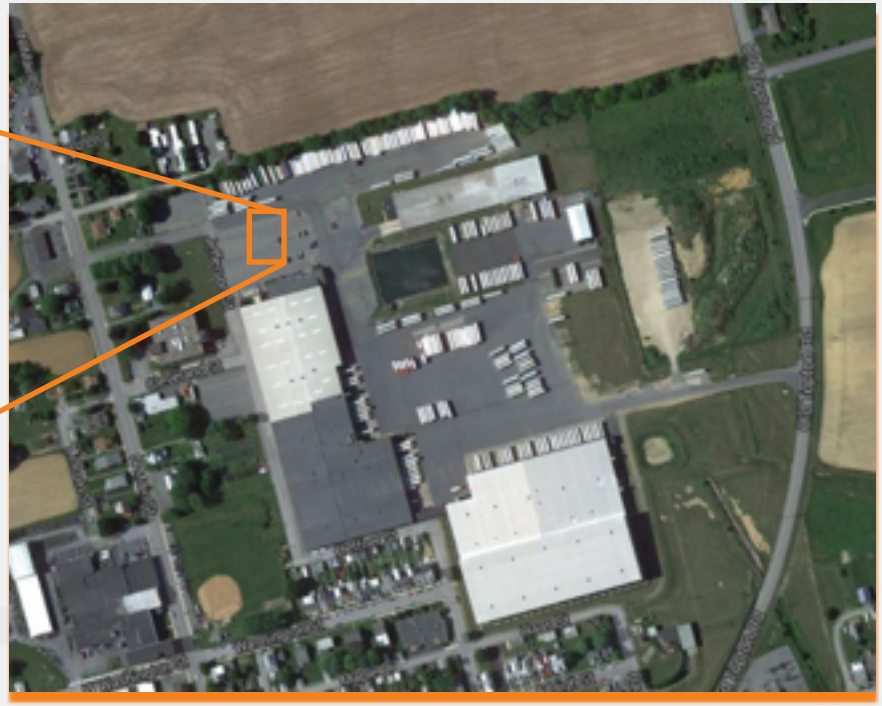
Multi-Purpose Storage System

Storage Facility #3:

200 kW Frequency Regulation

200 kWh Demand Management

200 kW UPS/Back-up



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Economics

Multi Purpose vs. Regulation Service

PURE REGULATION SERVICES	PJM RMCP **$38** MW/hr	IRR **15.0%**	Payback Initial Capital **5.0** years
MULTI PURPOSE	PJM RMCP **$38** MW/hr	IRR **45.0%**	Payback Initial Capital **3.0** years

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Marginal Differences to Support Multi Purpose

MULTI PURPOSE

1 Infrastructure and connection costs in place

2 Marginal cost to increase size of battery store + slightly larger footprint

3 IRR based on marginal cost of UltraBatteries and additional space required

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UltraBattery®
Partners

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UltraBattery Projects

Load Levelling*

Microgrid*

Load Levelling*

Peak Shifting*

Wind Smoothing

Solar Smooth. & Shift.

Diesel Hybrid Support

Reg. Services

kW

MW

*Courtesy of Furukawa Battery

Comprehensive Product Suite

Thank You

John Wood, CEO
www.ecoult.com
www.ultrabattery.com

Integrating Renewables into the Grid

Applying MW Scale Energy Storage Solutions for Continuous Variability Management

John Wood