PUBLIC

Grid Edge Solutions to accelerate renewable deployment in islands and remote locations

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POWERING GOOD FOR SUSTAINABLE ENERGY

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Opportunities in island utilities and remote locations

Drivers for Grid Edge Solutions

More affordable

- Imported fuel makes electricity two to five times more expensive than in the mainland
- Energy storage increases fuel efficiency

Stronger grid

- Energy storage stabilizes frequency and voltage, improves power quality
- Renewables are a local source decoupled from international fuel markets

Maximized renewables

- Quick development and installation
- Reduction of islands' contribution to climate change

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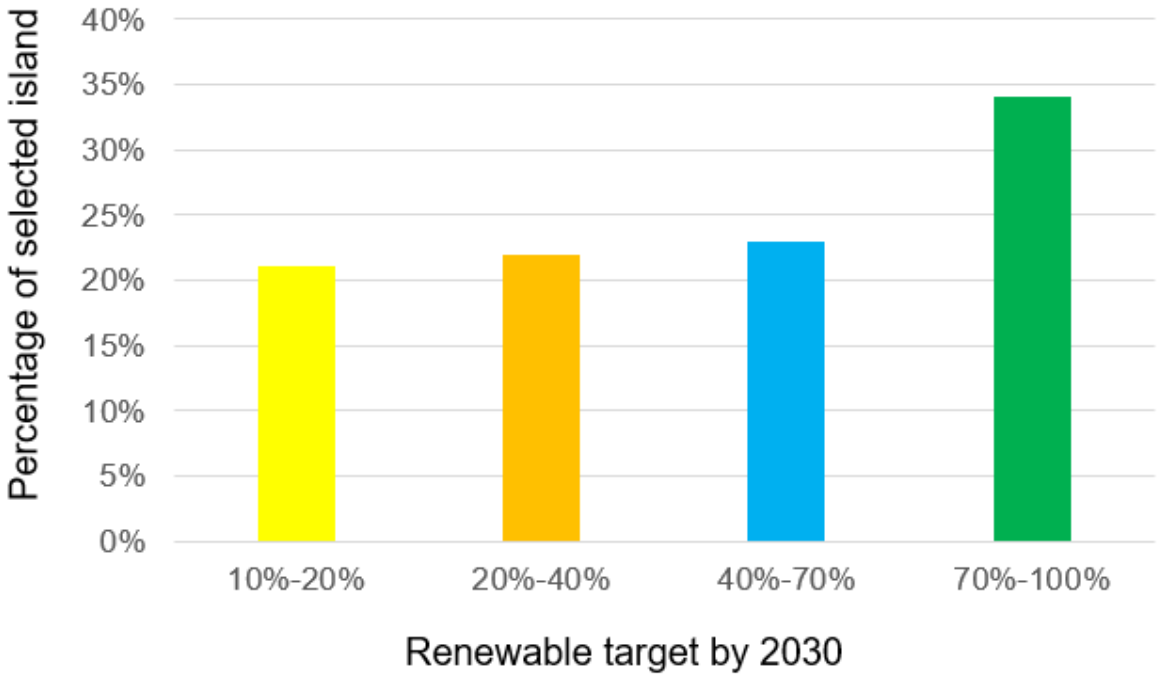
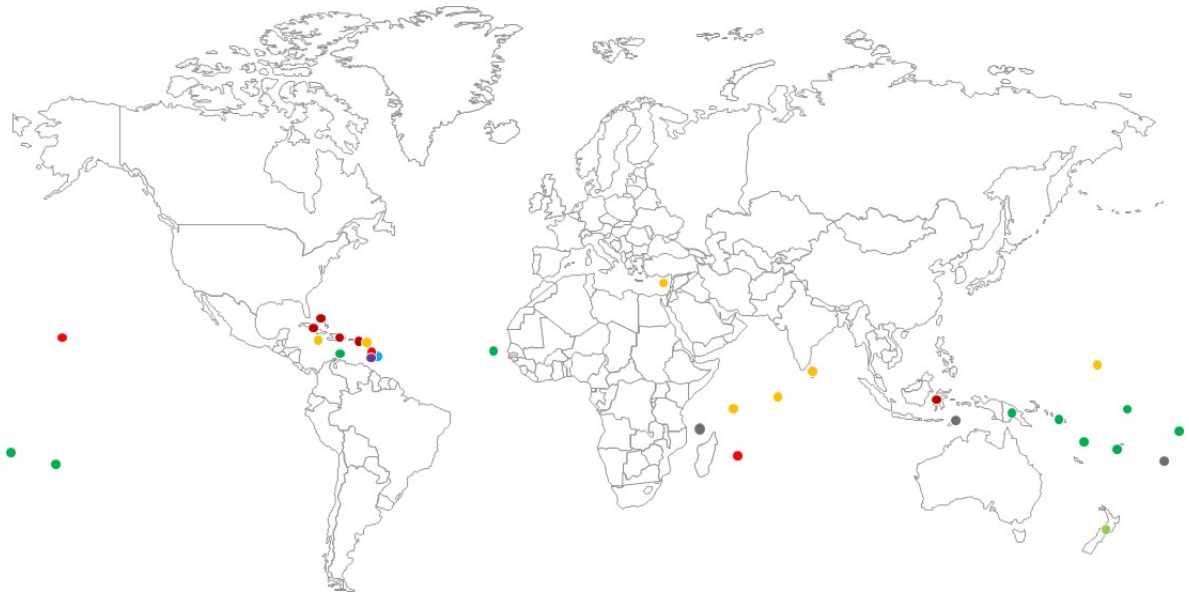
Island renewable goals

Islands with renewable goals



Map of selected islands with renewable goals



Product portfolio e-mesh™

Applications
SaaS Apps for improved performance

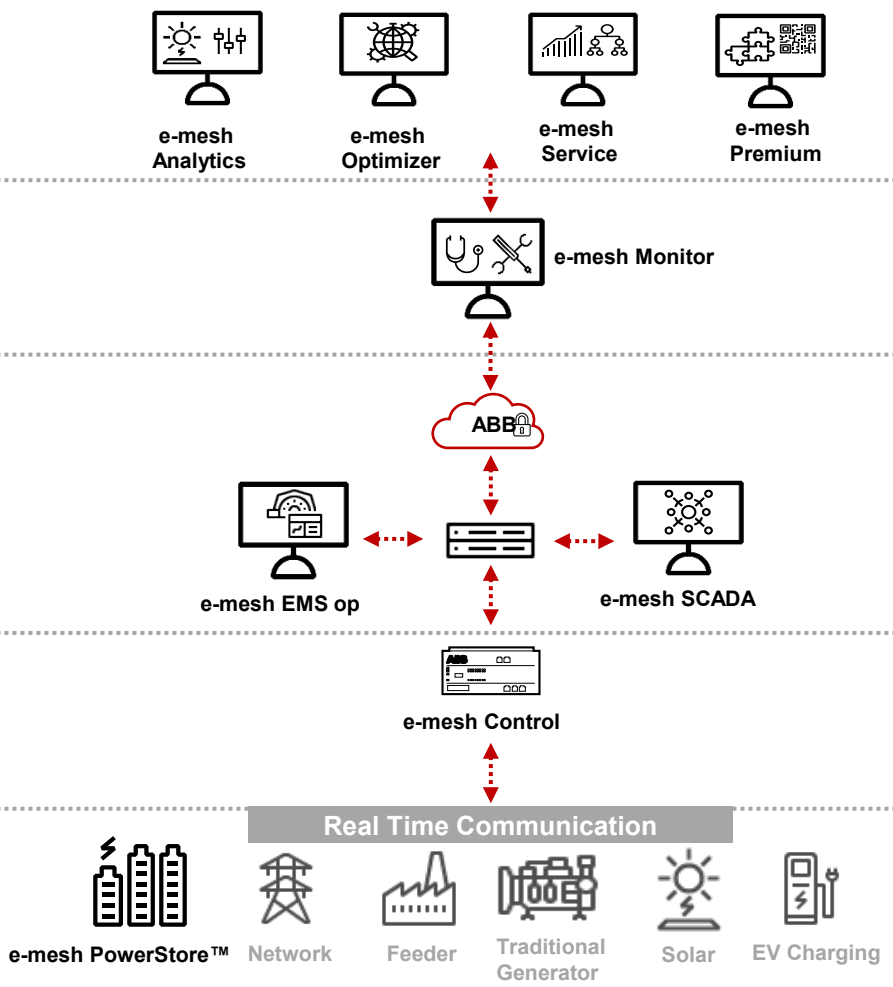
Monitor
Cloud enabled Remote monitoring and control

EMS
On premise energy management solution

SCADA
On premise plant automation solution

Control
Intelligent and efficient power management

PowerStore
Smart battery energy storage solution



On Cloud

- Energy Forecast, production and optimization planning
- Business KPI dashboards and reports
- Improved productivity and profitability

- Monitoring and control
- Bidirectional data flow
- Remote access

On premises

- Monitoring & Control
- Optimal energy production
- Operational & maintenance cost reduction

- Renewable power generation grid code compliance
- Network voltage control
- Feeder & Load demand management

- Smart battery energy storage solution
- Support for various applications including islanding, seamless transition, black start, spinning reserve etc.

Advantages of Battery Energy Storage Systems

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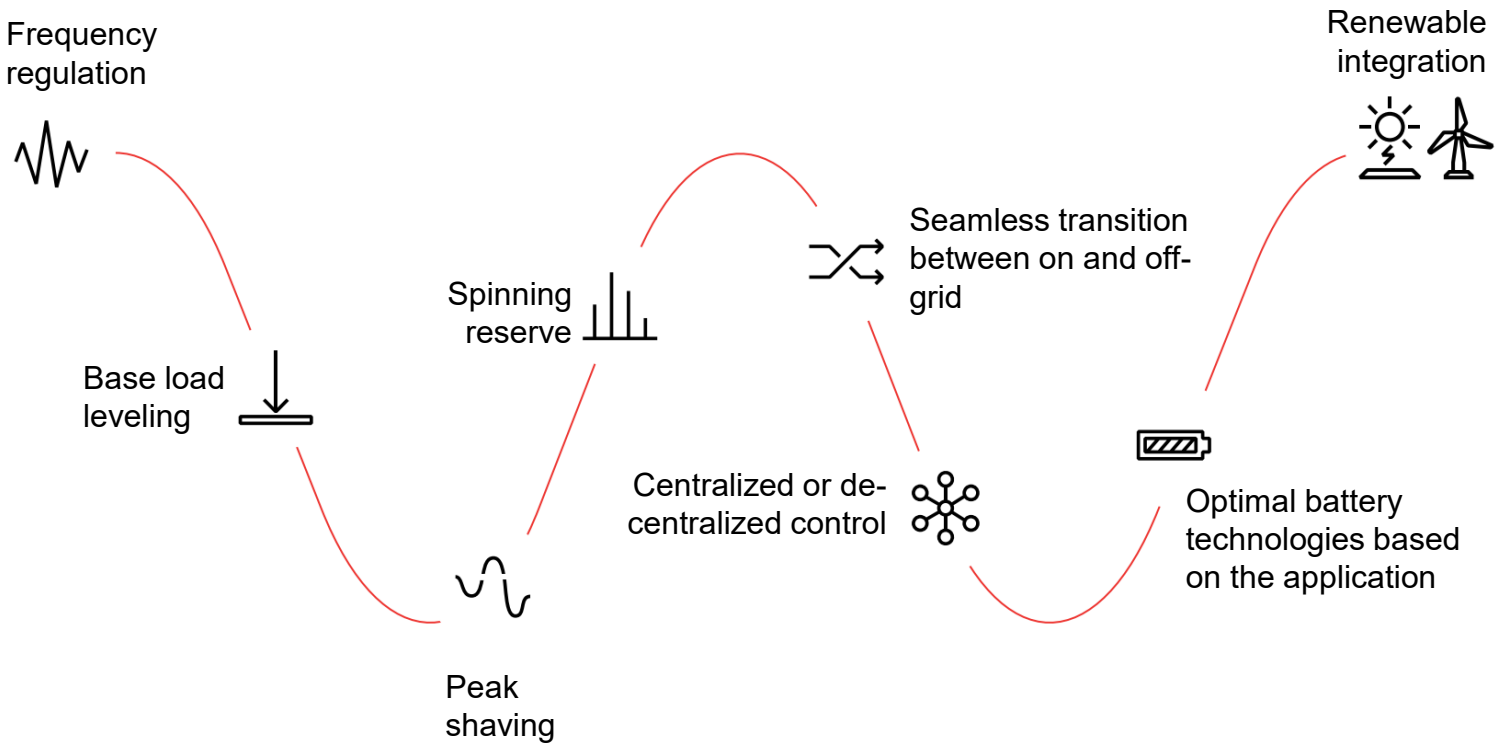
Highlights

- Designed for both grid-connected and off-grid applications
- Grid codes and standards compliant
- Intelligent and efficient power management system
- Pre-configured automation functionalities
- Productized design allows faster implementation
- Assures high level of cyber security
- Available in different sizes and configurations, based on two variants: Integrated and Modular



Energy Storage system - Enabling resilient and cost-effective access to power

e-mesh PowerStore Integrated & Modular

PowerStore Integrated: PS250 & PS500

The complete PCS and battery modules are integrated into a single outdoor enclosure.

Controller + Converter + AC & DC + Battery

PowerStore Modular: PS1000

The PCS and battery are housed in separate enclosures to achieve flexible power and energy ratings.

Controller + converter + AC & DC

Transformer

Battery

Island utilities: Grand Bahama, PowerStore/Diesel

About the Project

- **Project name:** GBPC Grid Stability
- **Location:** Freeport, Bahamas
- **Customer:** Grand Bahama Power Company (GBPC)
- **Completion date:** 2019

Solution

- PowerStore Battery (9.6 MW/7.3 MWh)
- e-mesh Control System
- Diesel (2 x 13.5 MW+ 1 x 18.5 MW + 6 x 8.7 MW)

Customer Benefits

- Improve power quality and provide load smoothing for the crane operation
- Help to manage the intermittencies of future solar PV
- Reduced dependency on fossil fuels and lower carbon footprint
- Stabilize the system by frequency and voltage support

Grand Bahama Power Company
An Emera Company

Grid Edge Solution improves power quality for the crane operation and supports future renewable developments.

Island utilities: Robben Island, PowerStore/Solar/Diesel

About the Project

- **Project name:** Robben Island
- **Location:** South Africa
- **Customer:** Department of Tourism, South Africa
- **Completion date:** 2017

Solution

- PowerStore Battery (500 kW/837 kWh)
- e-mesh Control System
- Solar PV (667 kW_p)
- Diesel (1 x 500 kW)

Customer Benefits

- Lower fuel costs and carbon emissions by 75 %
- Enabling the island to run on solar power for at least 9 months of the year
- Remote monitoring of the entire system from Cape Town
- Remote set-up eliminates the need to maintain a workforce on the island

tourism
Department:
Tourism
REPUBLIC OF SOUTH AFRICA

SOLA
FUTURE ENERGY

Web Story
Video

Grid Edge Solution enables Robben Island to run on solar power for at least 9 months in a year

Remote communities: Buckland, PowerStore/Wind/Diesel

About the Project

- **Project name:** Deering and Buckland Microgrid
- **Location:** Alaska, United States of America
- **Customer:** NANA Regional Corporation, Inc
- **Completion date**: 2018

Solution

- PowerStore Battery (400 kW/ 400 kWh)
- e-mesh Control System
- Solar PV (50 kW_p)
- Wind (2 X 100 kW)
- Diesel (2 X 475 kW, 1 X 175 kW)

Customer Benefits

- Stable, reliable and affordable power to the local community
- Maximum utilization of wind power
- Help communities achieve 100% renewable penetration
- Help customer to reach its goal - reduce reliance on imported diesel by up to 75 percent, by 2030

NANA

Press release

Grid Edge Solution provides stable, reliable and affordable power to the local community by maximizing renewables

Island utilities: Porto Santo, PowerStore/PV/Wind

About the Project

- **Project name:** Porto Santo
- **Location:** Porto Santo Island – Madeira, Portugal
- **Customer:** Empresa de Electricidade da Madeira (EEM)
- **Completion date**: 2019

Solution

- PowerStore Battery (4 MW/3 MWh)
- e-mesh Control System
- Solar PV (2.25 MW_p)
- Wind (1.5 MW)
- Diesel (4 x 4 MW)
- Network Manager ADMS

Customer Benefits

- Increase the contribution of renewables in the energy mix from 15 to 30 percent
- Stabilize the power system to address frequency and voltage fluctuations
- Reliable power supply, supported by renewable energy
- Meet the enhanced electricity demand during summers with a high inflow of tourists

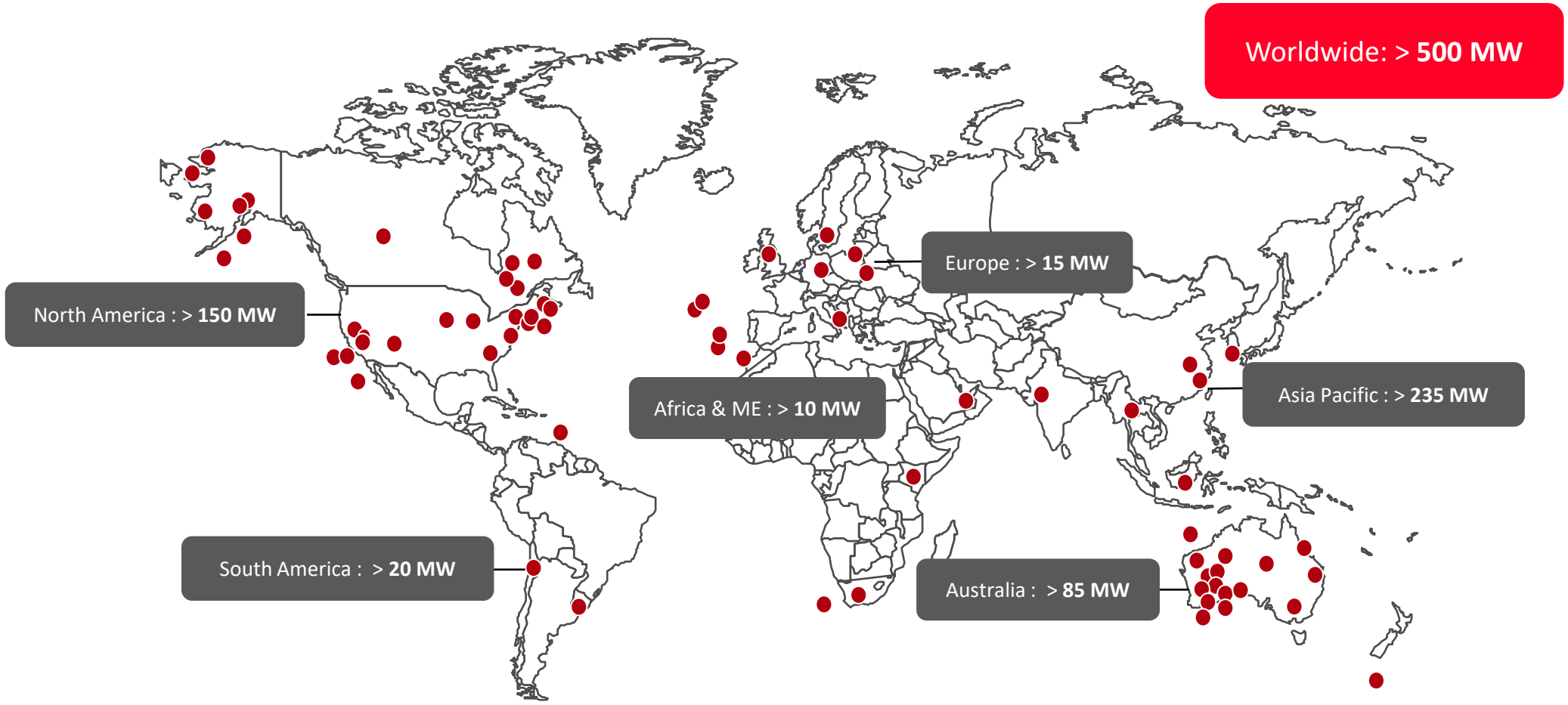
Electricidade da Madeira

Press release

Grid Edge Solution enables the island of Porto Santo to achieve clean-energy goals

Global installed base

Microgrids and BESS



Operational data, Business Case, Power System Studies

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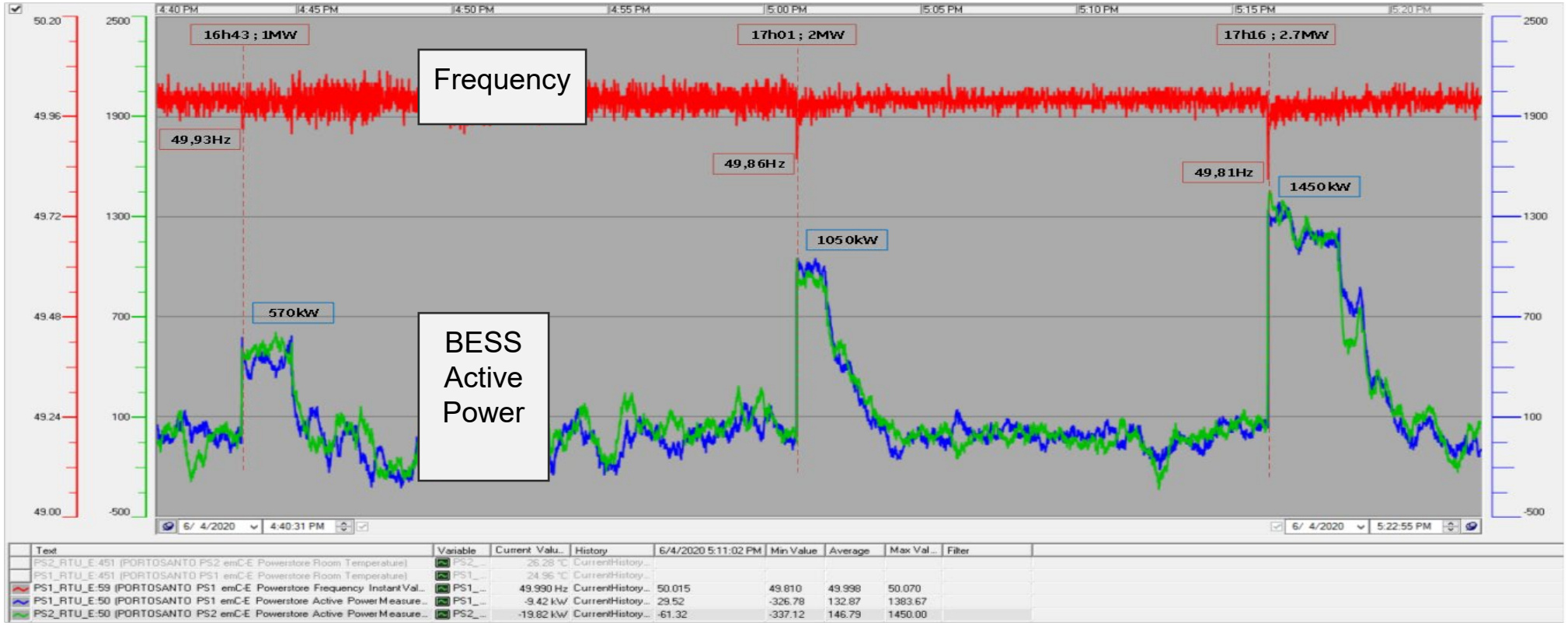
EEM Operational Measured Data for BESS Porto Santo Project

24 Hour Production Mix

BESS providing frequency support during high renewable contributions

EEM Operational Measured Data for BESS Porto Santo Project

Testing for Generator outage events



BESS response during DG trips, sustained the frequency within a safe margin and avoided load shedding.

Business case for Grid Edge Solutions

Scenarios

– Island load of 11.2 MW average with 15 MW peak
– 9 x 2 MW diesel generators, all manually operated
– The grid suffers from occasional voltage and frequency issues

Base Case

– Solar installed cost: USD 1.5 / $W_{p,}$
– Battery cost: USD 300/kWh
– Delivered diesel fuel cost: USD 0.75 / L
– 9% discount rate with 2% inflation rate over 20 year project life

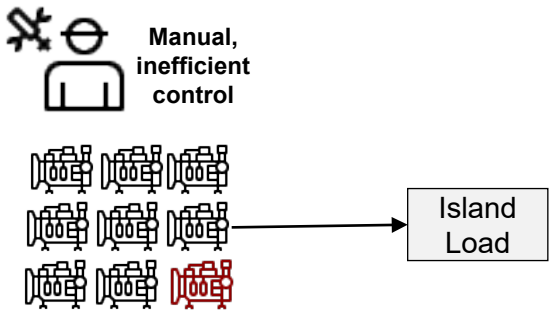
Assumptions

BC **Base case**: Diesel-only
RR **Renewable ready**: Battery Energy Storage System and Diesel
MR **Medium renewable**: Moderate solar PV with BESS and Diesel
HR **High renewable**: Lots of solar PV with BESS and Diesel

A techno-economic case study

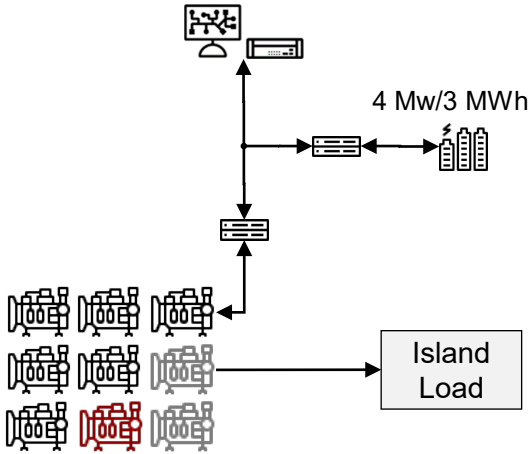
An integrated hybrid approach in islands

BC Base case: diesel only »



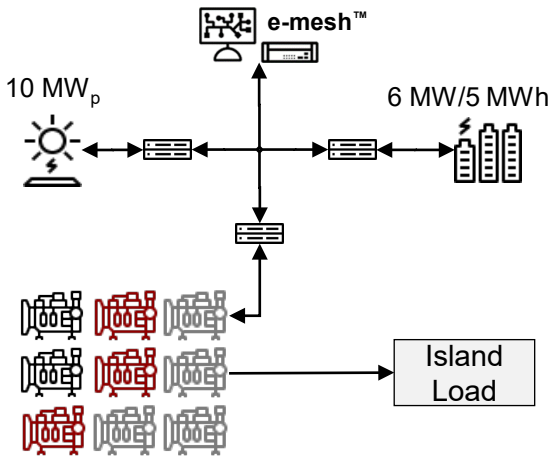
- Generators are manually switched
- One generator as reserve
- Unable to accept more renewables

RR Renewable ready »



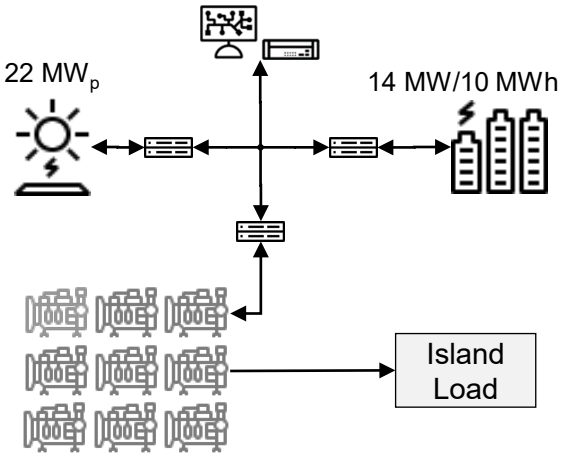
- BESS supplies reserve and short-term peak load
- BESS improves power quality and reliability
- Grid is ready for renewables

MR Medium renewable »



- Larger BESS provides more reserve
- BESS and PV maximize fuel savings and reduce generator hours

HR High renewable



- Increased renewable contributions
- During sunny daylight hours, all generators could be shut down

Smart controls enable an incremental pathway to affordable, strong, renewable electricity

Genset status: On On (for reserve) Off

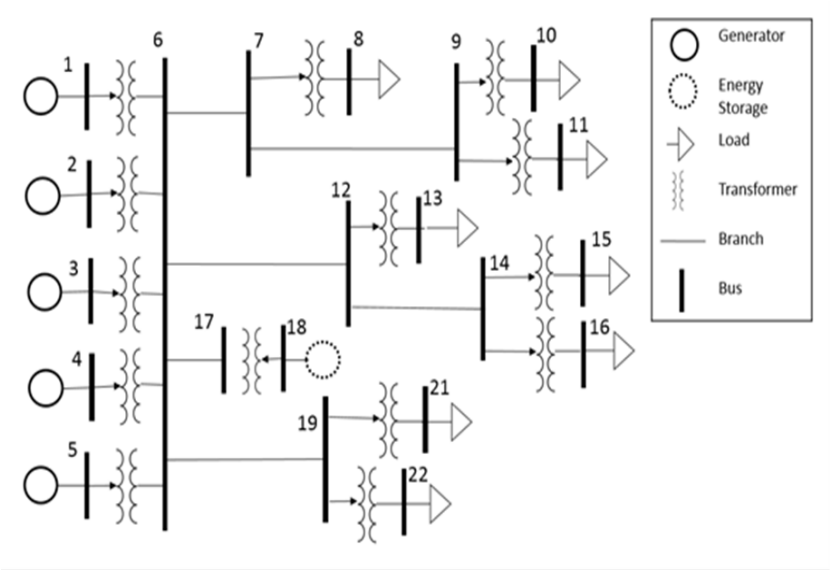
An integrated hybrid approach in islands

	Base case: diesel only	Renewable ready	Medium renewable	High renewable
LCOE[1] (USD/MWh)		 -2%	 -13%	 -18%
Power Quality	 Poor	 High	 High	 High
Renewable Contribution[2]			 20%	 35% Solar Diesel
Investment (MUSD)	0	3	20	43
IRR[3]	-	27%	24%	19%
Payback (years)	-	3.8	4.1	5.3

Incremental hybridization for lower costs, stronger grids, and increased renewable contribution

Dynamic analysis for Grid Edge Solutions

System Configuration



Island utility power system

Load ranges between 10 MW to 13 MW including a 3 MW crane.

Supplied by five diesel generators and planning for a 4MW wind farm

Existing under frequency load shedding protection system

Grid code requires ramp rate control for the proposed wind farm

Energy Storage applications

The energy storage is 3 MW/1.5 MWh with the objectives of

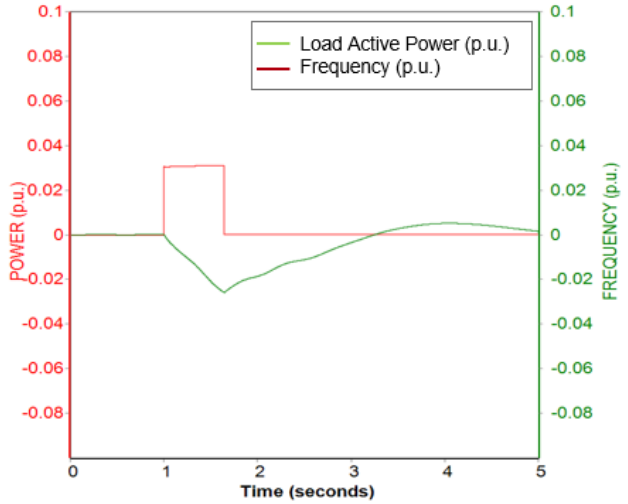
- Ensure stable operation without one of the diesel generators
- Support frequency and voltage during contingency events
- Improve power quality issues and ramp rate control

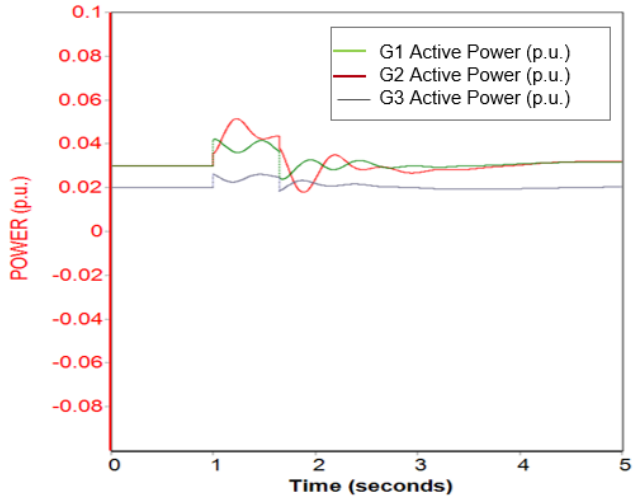
A power system Case Study: Energy storage response to load step changes, and generator trip events are simulated

Dynamic analysis during load step change events

Before BESS

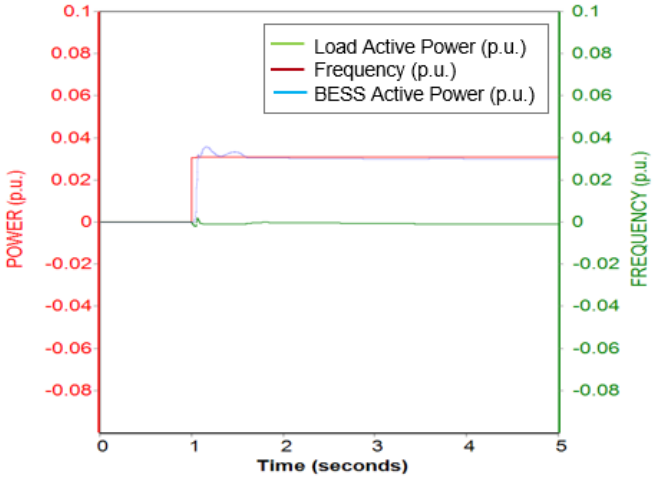
- 0.026 p.u. Max frequency deviation
- Load Shedding

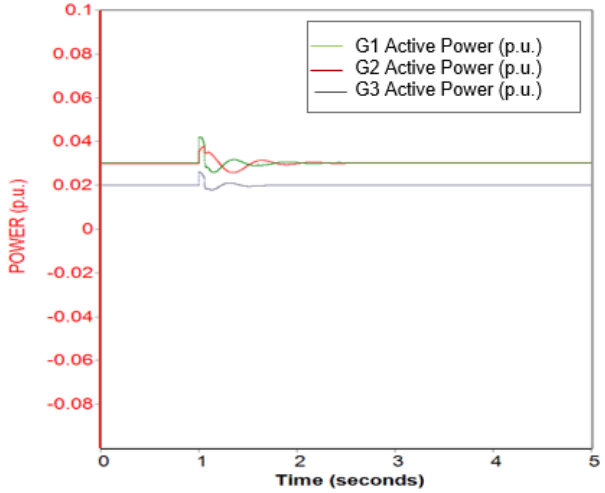




After BESS

- 0.002 p.u. Max frequency deviation (p.u.)
- No Load Shedding
- Energy Storage response time is 0.06 s





The BESS response time is calculated based on the time it takes BESS to reach 90% of the step change.

Dynamic analysis during generator trip events

BESS benefits in this generator trip events are:

- Reduce frequency excursion
- Avoid load shedding
- Provide Frequency ride through capabilities
- Supply voltage ride through capabilities
- Stabilize the grid during severe events

Generator Trip	Parameter	Before BESS	After BESS
Trip a 5MW generator	Frequency nadir (p.u.)	-0.039	-0.004
	Load shedding (MW)	3.5	0
Trip a 4MW generator	Frequency nadir (p.u.)	-0.034	-0.005
	Load shedding (MW)	2	0
Trip a 3 MW generator	Frequency nadir (p.u.)	-0.029	-0.003
	Load shedding (MW)	1.4	0

Frequency Nadir is the minimum frequency reached after contingency event.

Key Takeaways

BESS allows to:

- Maximize fuel savings through the highest possible renewable integration
- Provide high power quality by stabilizing the power systems against fluctuations in voltage and frequency
- Ensure a reliable, stable and sustainable energy future
- Minimize deployment time through fast and safe installation and commissioning on-site

Contact Information

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