Operational Strategies of Microgrids for Power Quality Enhancement

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Outline

1. Introduction
2. Use Cases of the Microgrid Controller
3. Core Functions of the Microgrid Controller
    1. Grid Stabilization
    2. Economic Load Dispatch and Control
4. Case Studies in Japan
    1. Isolated Island (Oki Island)
    2. Large-scale Renewable Energy Power Plant (Hokkaido)
5. Southeast Asia Expansion
6. Application for Rapid Growth of Data Centers
7. Takeaways

Introduction

Background

The penetration of renewable energy into the power grid

Challenges

Fluctuations in unstable frequency and voltage

Particularly, significant effect of fluctuations due to the small overall capacity of microgrids

Curtailment of renewable energy during excessive power generation

Traditional Approach

Thermal power for adjustment:
- Cannot be started immediately
- Adjustment range is insufficient with operating constraints

Pumped-power generation for storage:
- Takes a long time to implement (more than 10 years)

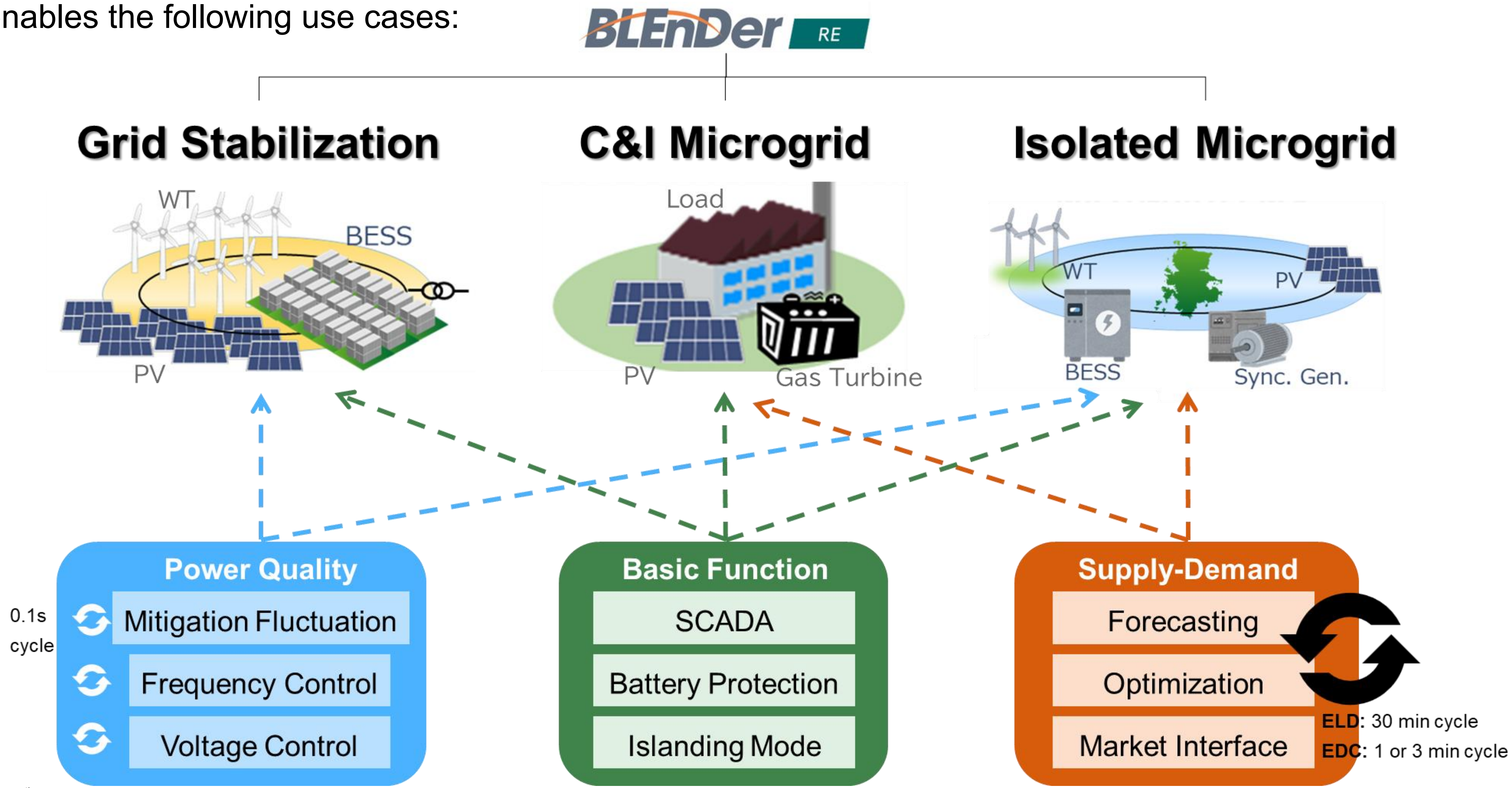
Solution

Microgrid Controller + BESS

Use Case of Microgrid Controller

MELCO created and continues to develop microgrid BLEnDerRE as a microgrid controller.

This enables the following use cases:



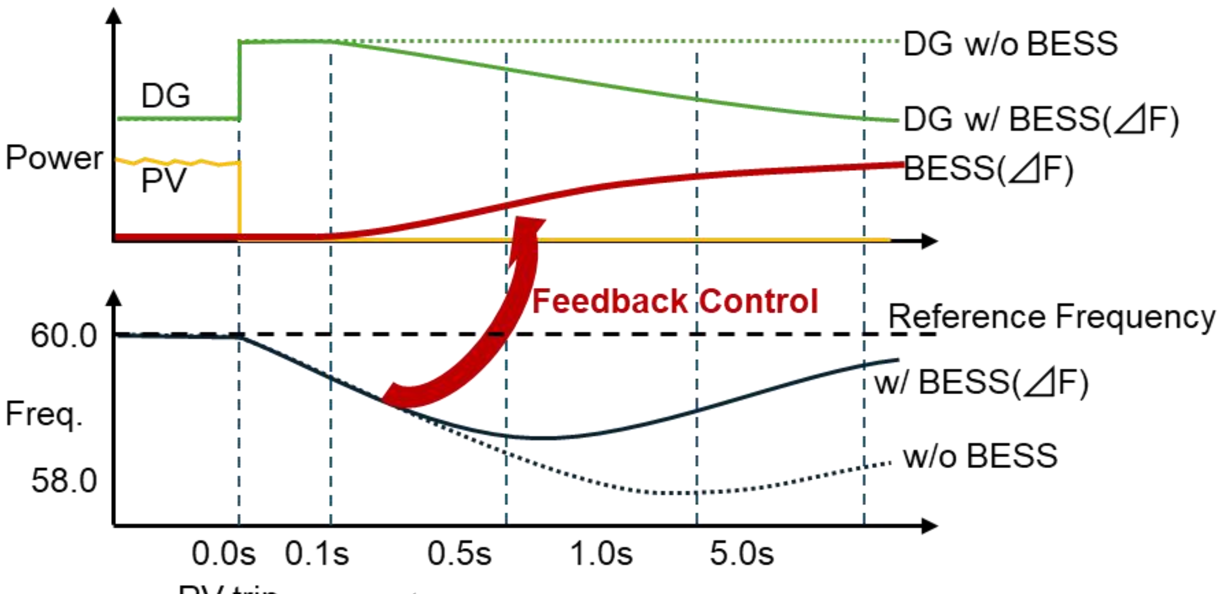
Core Functions of Microgrid Controller

Grid Stabilization

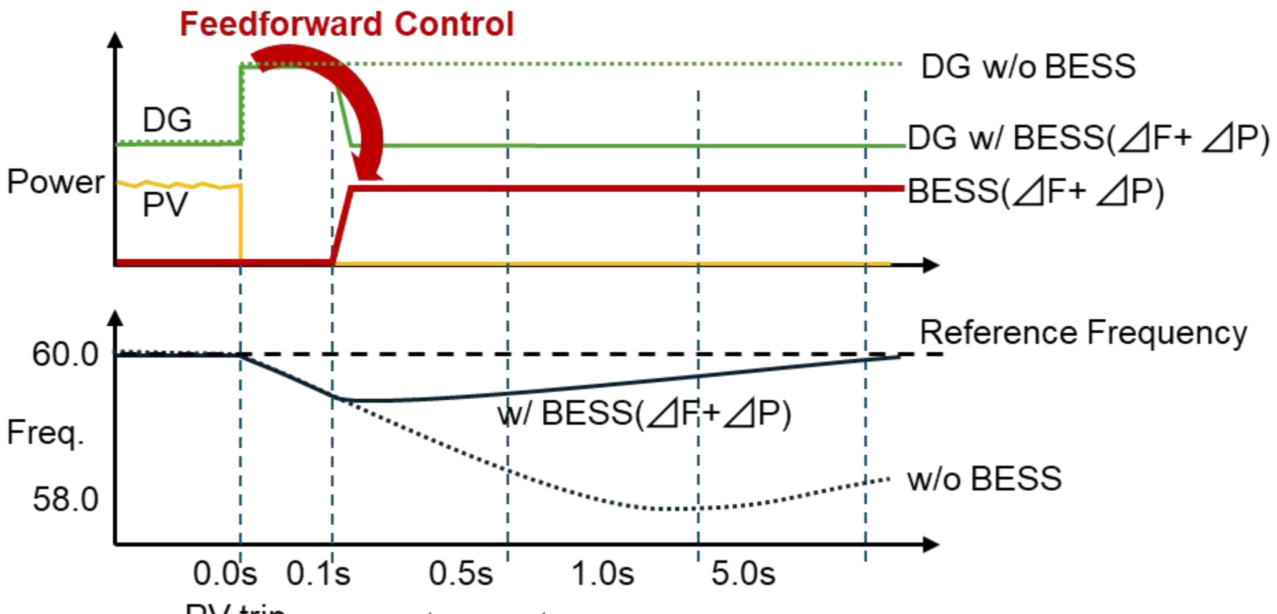
There are two control methods for grid frequency stabilization, ⊿F and ⊿P.

⊿F	✓ Detects frequency fluctuations and applies feedback control according to the rate of change. ✓ Operates about 0.5 seconds after the event occurs.
⊿P	✓ Detects the mismatch between mechanical input and electrical output of synchronous generators directory at high speed and applies feedforward control. ✓ Operates about 0.1 seconds after the event occurs.

⊿F+⊿P results in less frequency fluctuation and allows to return to the reference frequency more quickly.



⊿F control

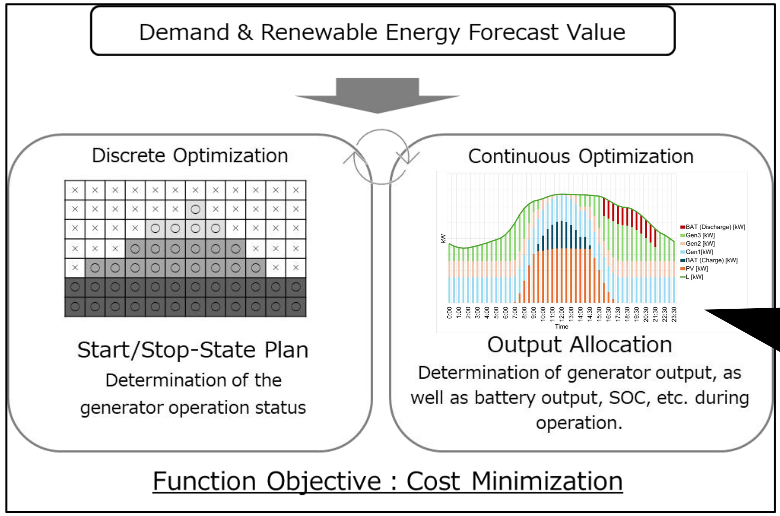


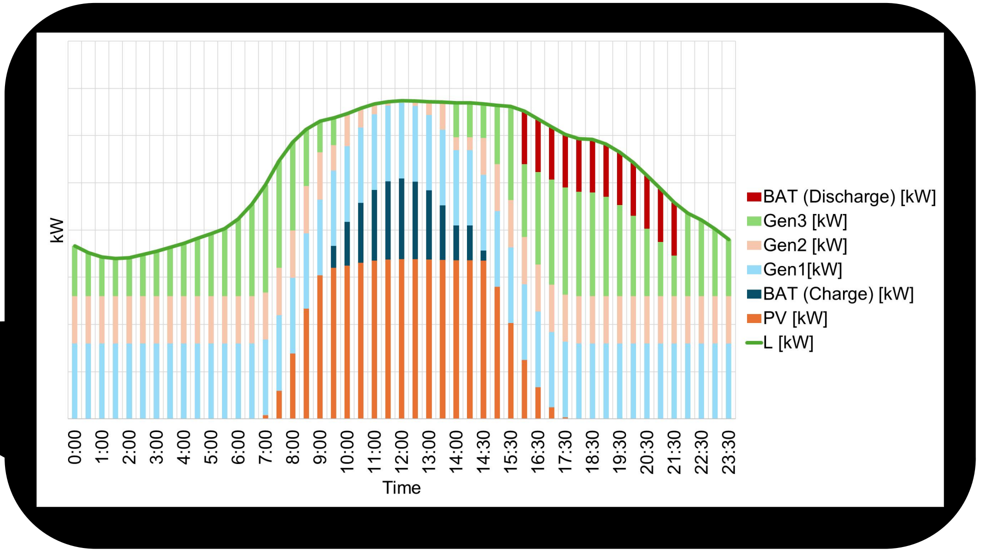
⊿F+⊿P control

Core Functions of Microgrid Controller

Economic Load Dispatch and Control

	ELD (Economic Load Dispatch)	EDC (Economic Load dispatching Control)
Objective	Minimize power generation costs	
Function	Two types of optimization calculations: ✓ Unit Commitment: discrete value optimization for determining generator and battery operating states ✓ Load Dispatch: continuous value optimization for determining generator setpoint, battery setpoint, and optimal battery operation throughout the day.	Based on the results of ELD, this function conducts optimal supply and demand control in response to the forecast error.
Operation Period	Every 30 minutes for up to 48 hours.	Every 1 or 3 minutes for up to 2 hours.





4-1 Case Studies in Japan

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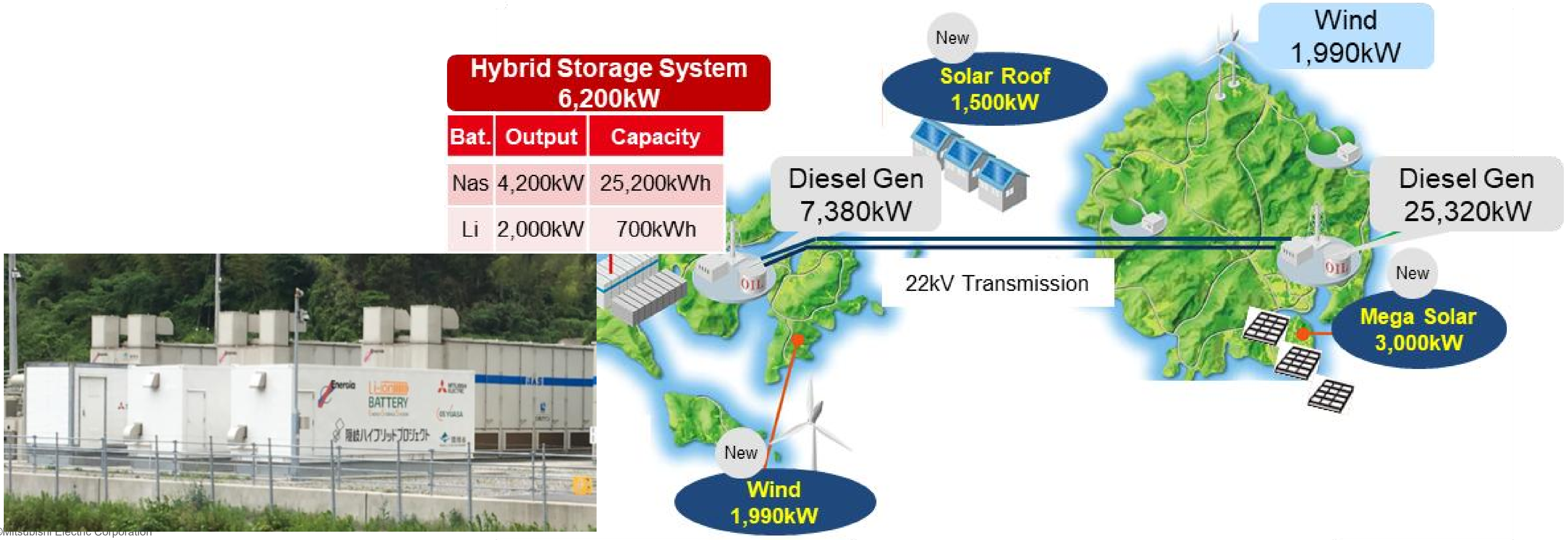
Changes for the Better

Use Case	Isolated Island (Optimization & Stabilization)
Location	Oki Island (Shimane Prefecture)
System Objective	Stabilize long-term and short-term fluctuations of load and renewables
Capacity	✓ PV: 4.5 MW ✓ WT: 4 MW ✓ LiB (High-output LiB to prevent short-term fluctuation): 2 MW / 0.7MWh ✓ NaS (Large capacity NaS to prevent long-term fluctuations) : 4.2 MW / 25.2MWh

Hybrid Storage System 6,200kW

Bat.	Output	Capacity
Nas	4,200kW	25,200kWh
Li	2,000kW	700kWh



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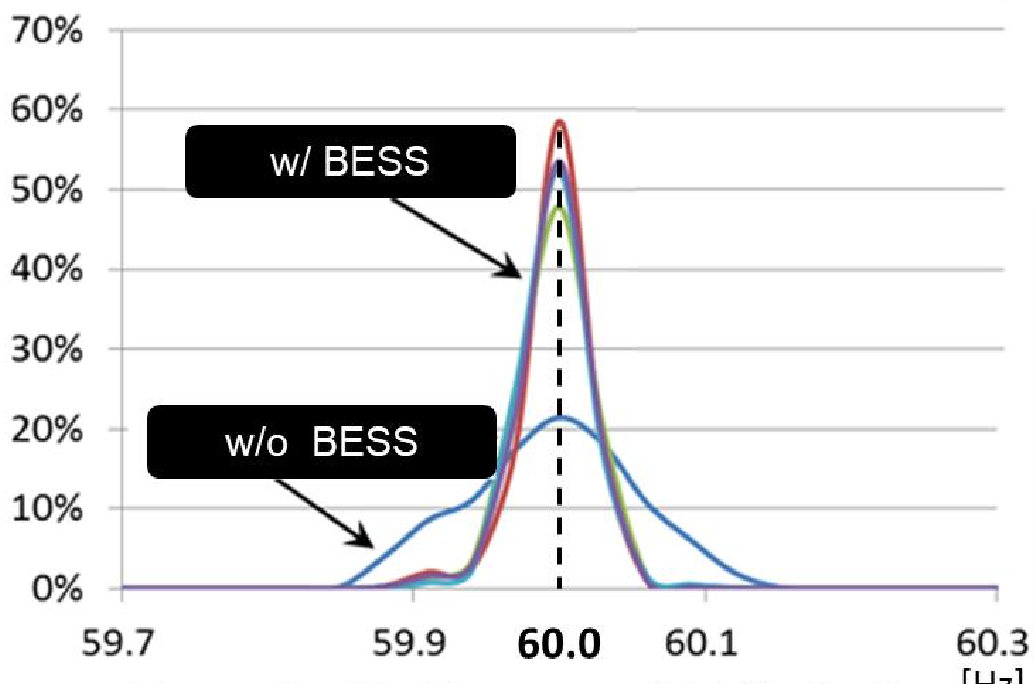
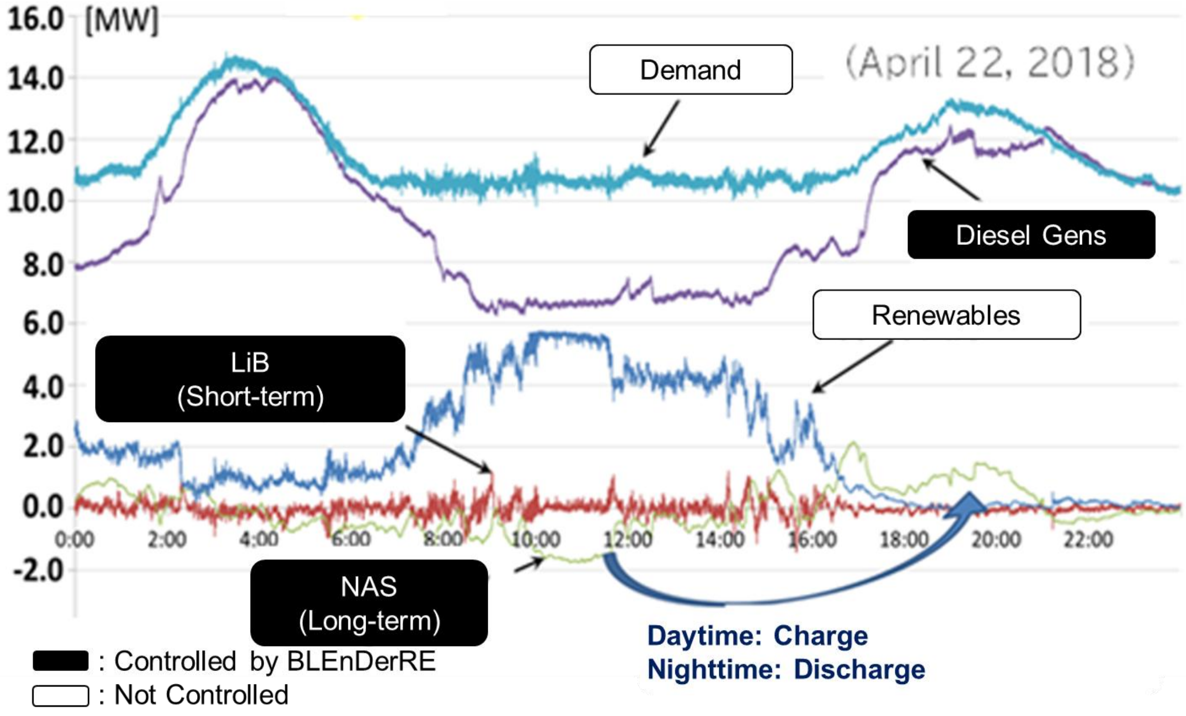


Power Quality (Frequency Distribution)



Case Studies in Japan

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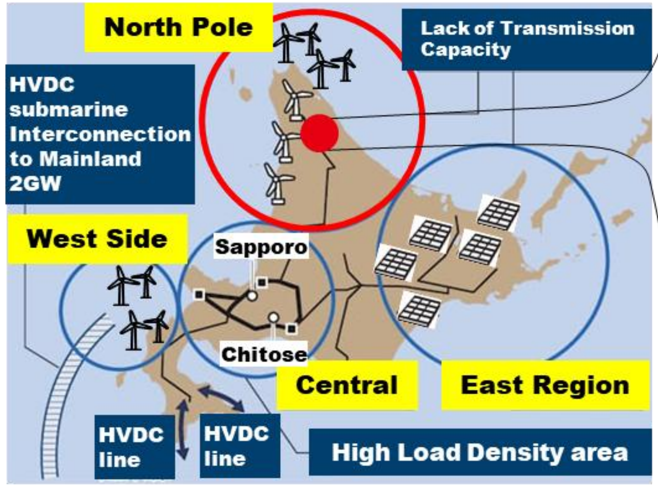
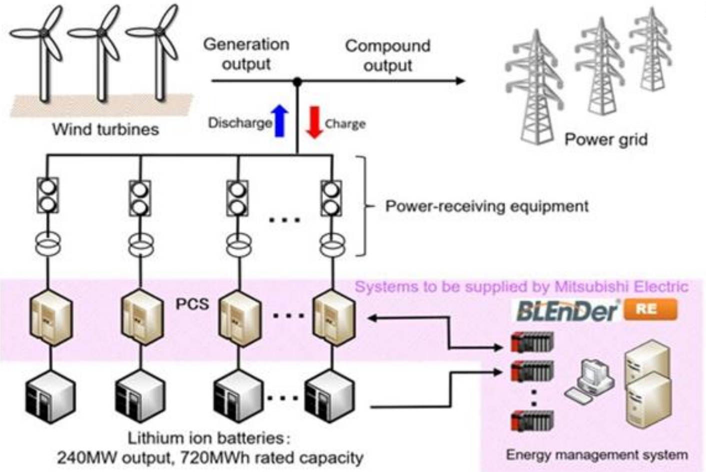
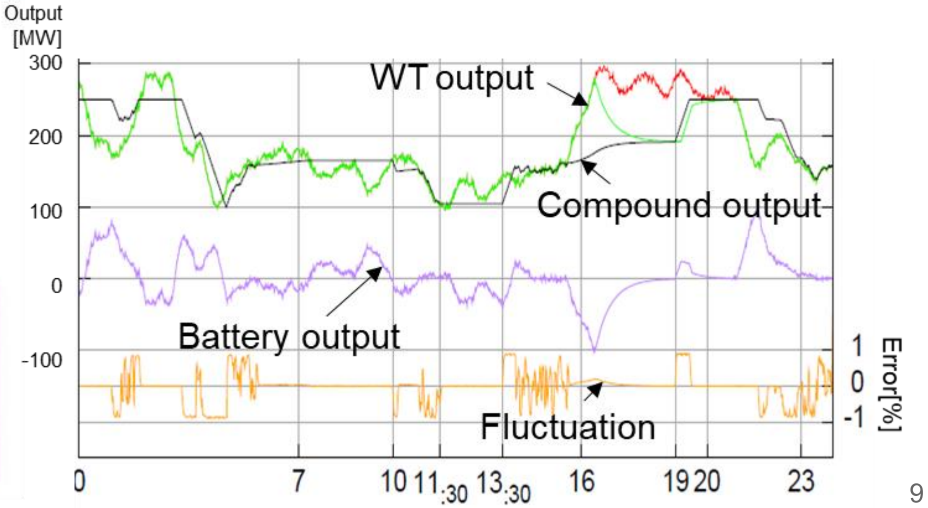
Changes for the Better

Use Case	Large-scale Renewable Energy Power Plant
Location	Wakkanai (Hokkaido)
System Objective	✓ Mitigate renewable energy output fluctuations ✓ Meet grid connection requirements (power output fluctuations under 1% / min)
Capacity	✓ Wind Farm: more than 600 MW ✓ LiB: 240 MW / 720 MWh







5 Southeast Asia Expansion

We met NTU representatives at Microgrid Symposium 2022, which led to a collaborative demonstration!

We implemented the technology we had in about six months to the REIDS[*1] Future Grid Platform.

*1 Renewable Energy Integration Demonstrator – Singapore

- ✓ Led by ERI@N[*2], Nanyang Technological University
  *2 Energy Research Institute @ NTU
- ✓ Semakau Landfill, 8 km offshore from Singapore's main island
- ✓ The largest microgrid testbed in Southeast Asia
- ✓ Improves the utilization of existing renewable energy
- ✓ Takes measures against short-term fluctuations in renewable energy

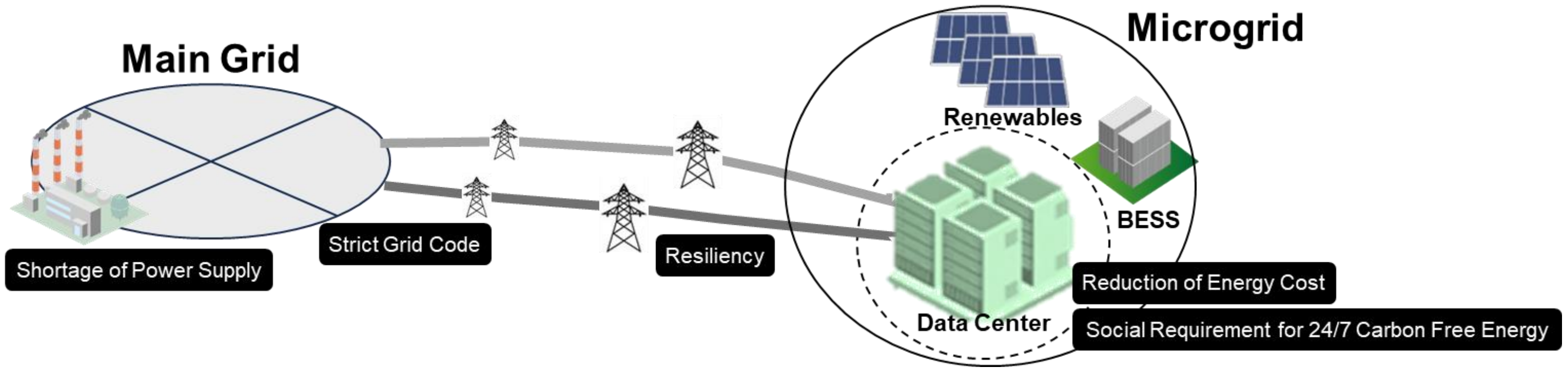
Overseas Projects List

Location	Year	Use Case
Uliastai, Mongolia	2023	Co-location with PV on remote island
Semakau Landfill, Singapore	2025*	
Ebeye Island, Marshall Islands	2026*	

*Planned

Application for Rapid Growth of Data Centers

Data centers require a large power supply and have certain power grid connection constraints. Due to this, location constraints pose a major challenge for rapid expansion. Additional challenges include improving energy efficiency and integrating renewables in power generation expansion.



Location Constraints

- ✓ Shortage of Power Supply (GW scale)
- ✓ Strict grid Code (Power Flow / Voltage Limitation)
- ✓ Unique Load Profile (Rapidly Change)
- ✓ Resiliency in case of Power System's Blackout

Energy Saving and Renewable Integration

- ✓ Reduction of Energy Cost
- ✓ Social Requirement for 24/7 Carbon Free Energy

Solution: **Grid Stabilization** + **Optimal Supply- Demand Dispatch** = **Microgrid**

7 Takeaways

Our technology…

Supports the high quality of power in Japan and is being expanded overseas

- ✓ Provides long-term optimization and short-term stabilization as a core function, to solve problems brought about by the penetration of renewables.
- ✓ Automates the entire process of forecasting, supply and demand planning, and real-time control.
- ✓ Has the capability to flexibly adapt to use cases that emerge as global trends change, such as the growth of data centers.

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Changes for the Better