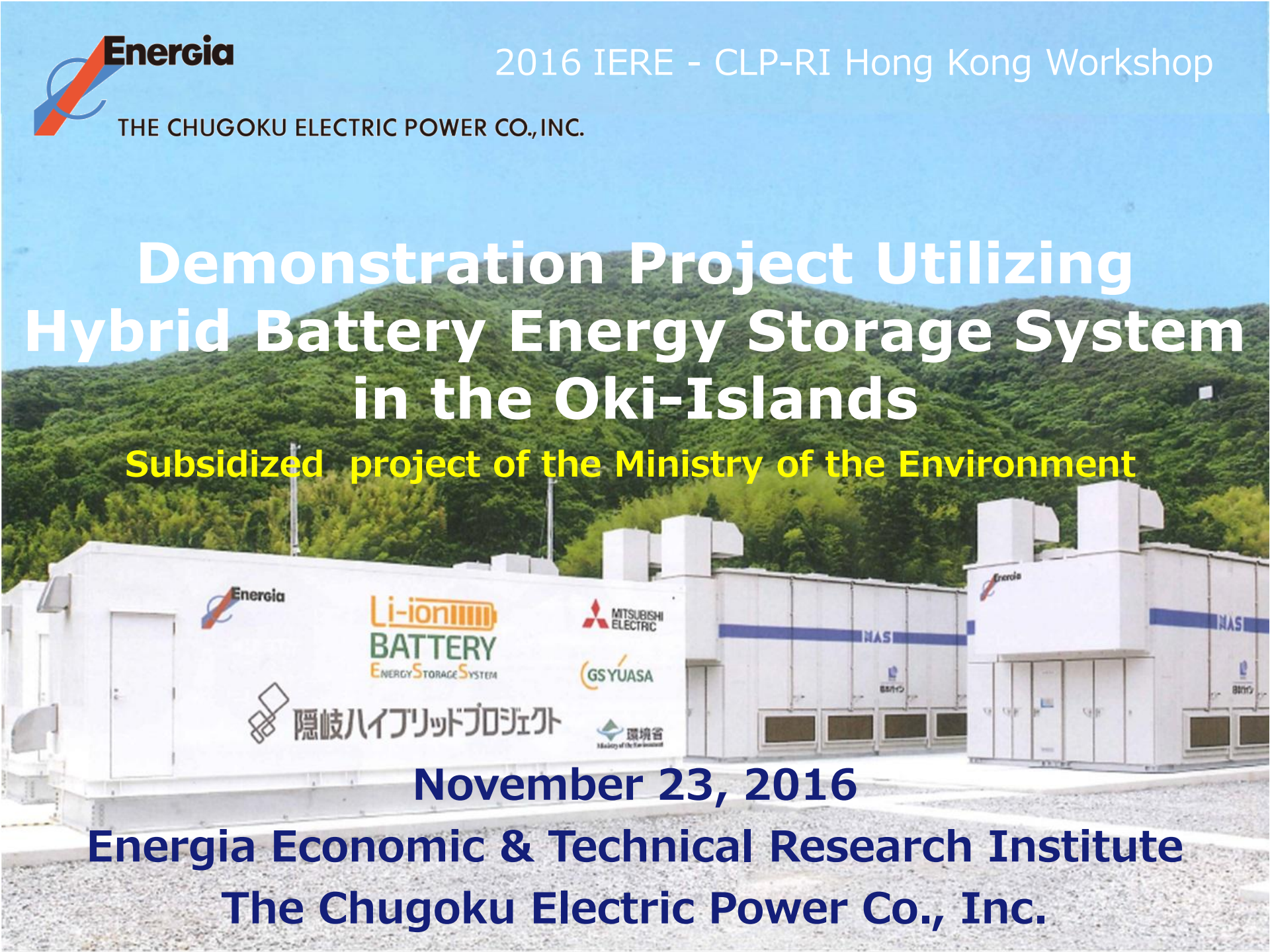
Energia

THE CHUGOKU ELECTRIC POWER CO., INC.

2016 IERE - CLP-RI Hong Kong Workshop

Demonstration Project Utilizing Hybrid Battery Energy Storage System in the Oki-Islands

Subsidized project of the Ministry of the Environment



November 23, 2016

Energia Economic & Technical Research Institute

The Chugoku Electric Power Co., Inc.

1. Overview of Demonstration Project utilizing Hybrid BESS in the Oki-Islands

Remote Islands introducing Energy Storage System (ESS) with penetration of Renewable Energy in Japan

- **In most cases, single or small capacity of ESSs have been introduced.**
- **Demonstration project in the Oki-Islands is the first technical challenge utilizing Hybrid BESS with coordination control in Japan.**

Legend

FW : Fly Wheel
LiC : Li-ion Capacitor
LiB : Li-ion Battery
NaS : Sodium-sulfur Battery
Lead :Lead-acid Battery

Oki-Islands
LiB 2MW, NaS 25.2MWh

Tsushima
LiB 3.5MW

Ikinoshima
LiB 4MW

Izu-Oshima
LiC 0.5MW, Lead 8MWh

Takeshima
LiB 0.02MW

Kuroshima
LiB 0.05MW, Lead 0.25MWh

Tanegashima
LiB 3MW

4 islands(**Nakanoshima et al.**)
Lead 0.02MW each

Amami-Oshima
LiB 2MW

Yonaguni
LiC 0.15MW

Tarama
LiC 0.25MW

Kitadaito
LiC 0.1MW

Miyako
NaS 4MW

Hateruma
FW 0.19MW, Lead 1.5MWh

(Source :Press release, Media, etc.)

Challenges for high penetration of Renewable Energy Sources(RES) in the Oki-Islands

Short term fluctuation

Output fluctuation of RES due to such as transit of cloud

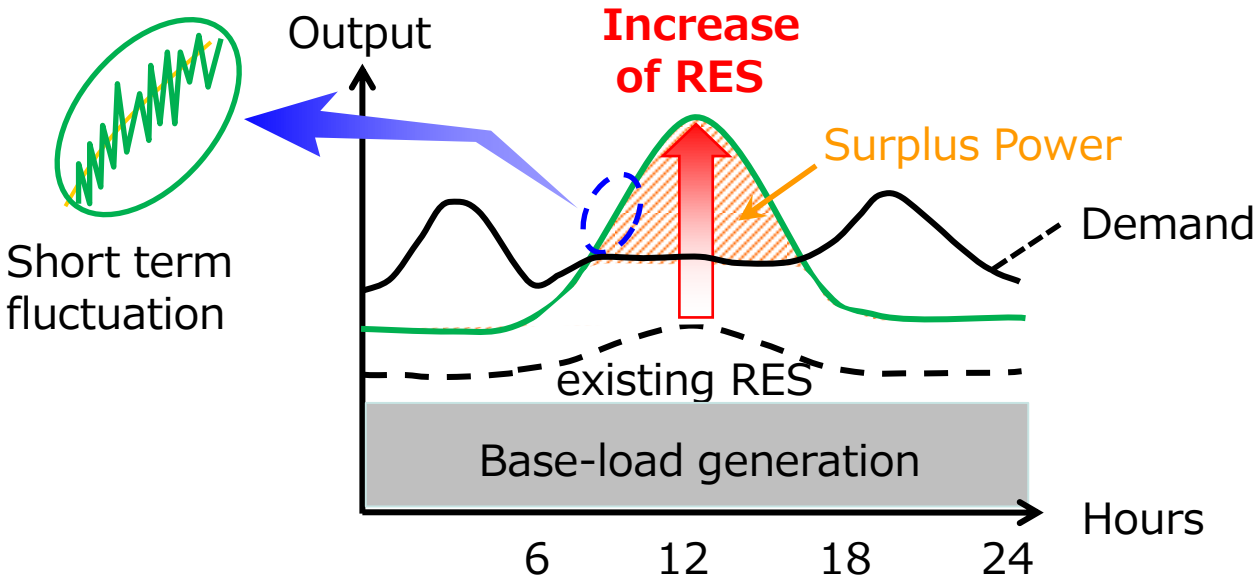
Long term fluctuation

Output fluctuation of RES due to such as change in position of the sun

without measures

Lack of frequency regulation capacity

Production of Surplus power

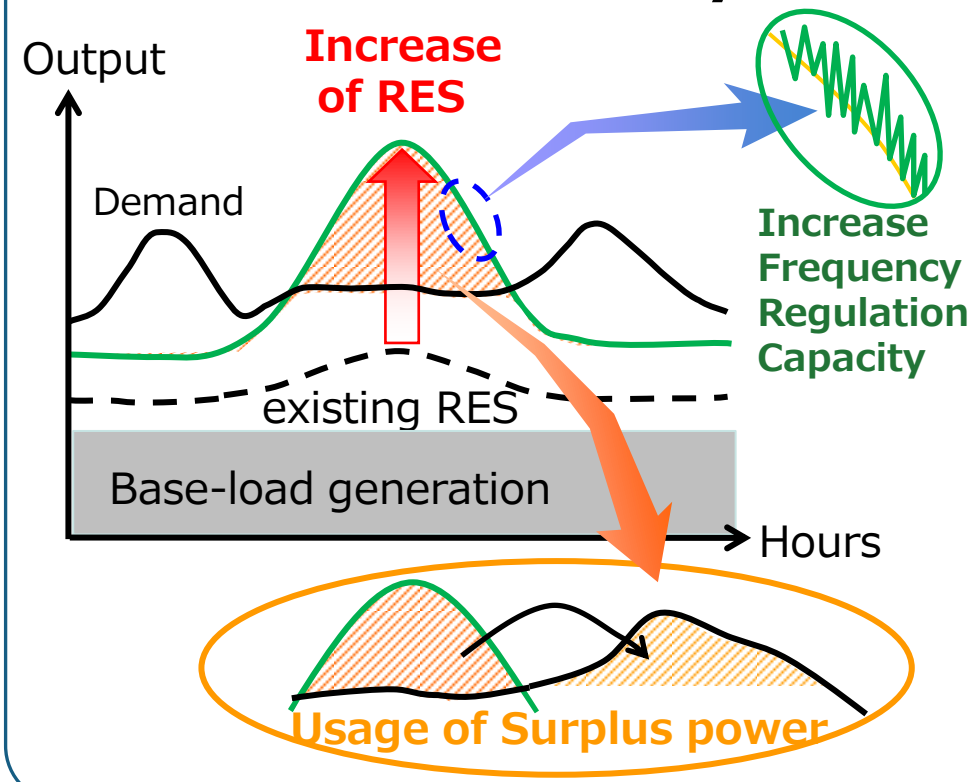


Concept of Hybrid BESS

Measures for Short term fluctuation | **Challenges** | **Measures for Long term fluctuation**

Simultaneous solution

Hybrid BESS



Measures for Short term fluctuation
↓
Li-ion battery
Small capacity, high-power

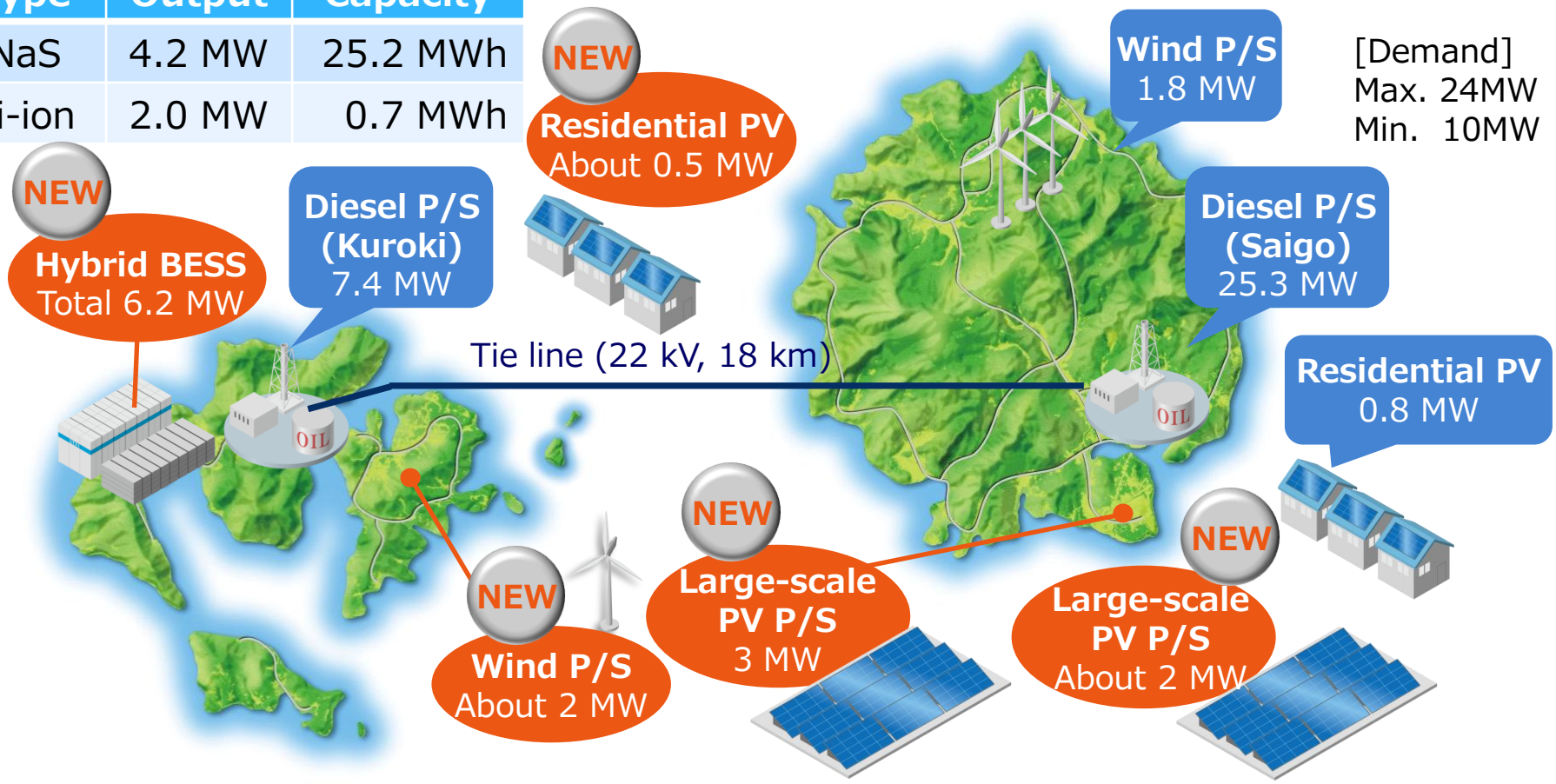
Coordination Control

Measures for Long term fluctuation
↓
NaS battery
Large capacity

Outline of the Demonstration Project

- **Period : From Sep. 2015 to Mar. 2019 (3.5 years)**
- **Coordination control between existing Diesel generators and the Hybrid BESS, efficient charge-discharge management and control methods of BESS have been demonstrating in the project.**

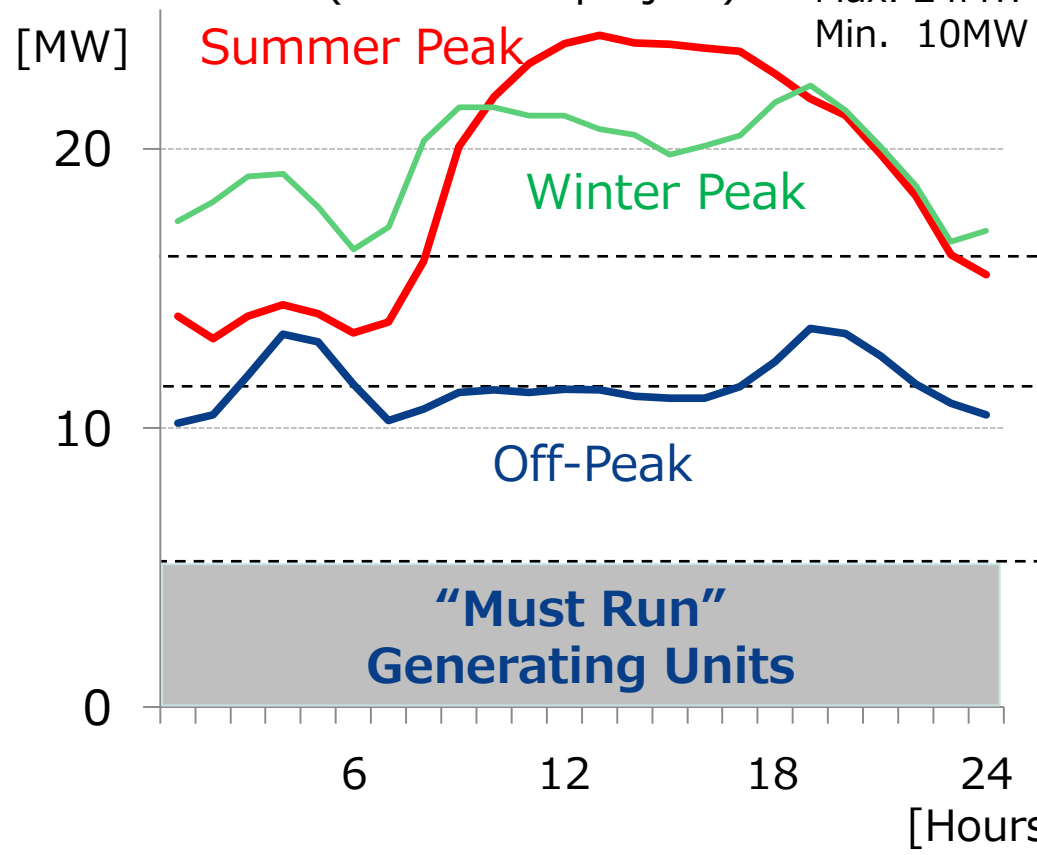
Type	Output	Capacity
NaS	4.2 MW	25.2 MWh
Li-ion	2.0 MW	0.7 MWh



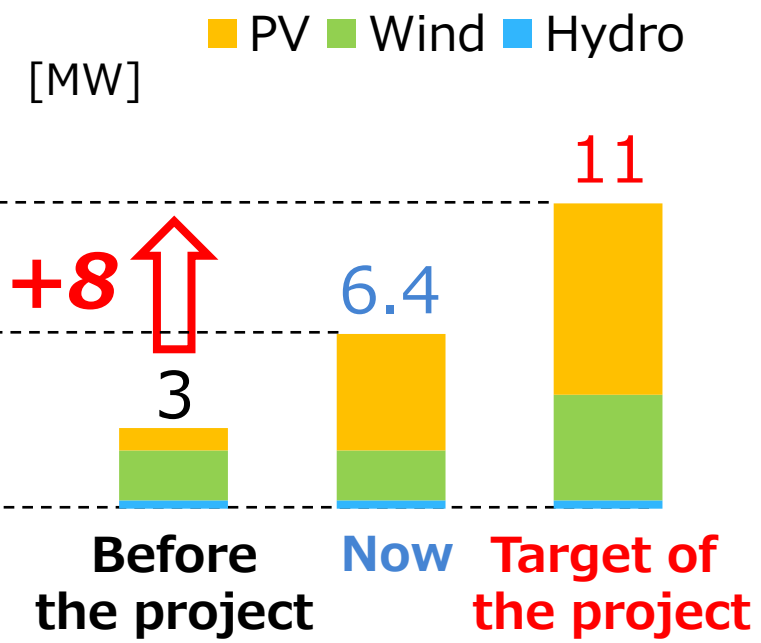
RES introduction plan

- **Aiming to introduce about 11 MW of RES in total, by newly introducing 8 MW in addition to existing 3 MW of RES, which exceeds the minimum demand (about 10 MW).**

Daily Demand Curve



RES introduction plan



Benefits of Hybrid BESS

■ **Compared with single BESS (NaS only), benefits are as follows.**

Operational Range of NaS Expansion

Combining with Li-ion, the frequency of "SOC Reset" of NaS can be increased.
Besides, NaS is not required to absorb short term fluctuation.

↓

By reducing margin, operational range of NaS can be expanded.

Heating-Loss of NaS Reduction

NaS needs heating in operation.

↓

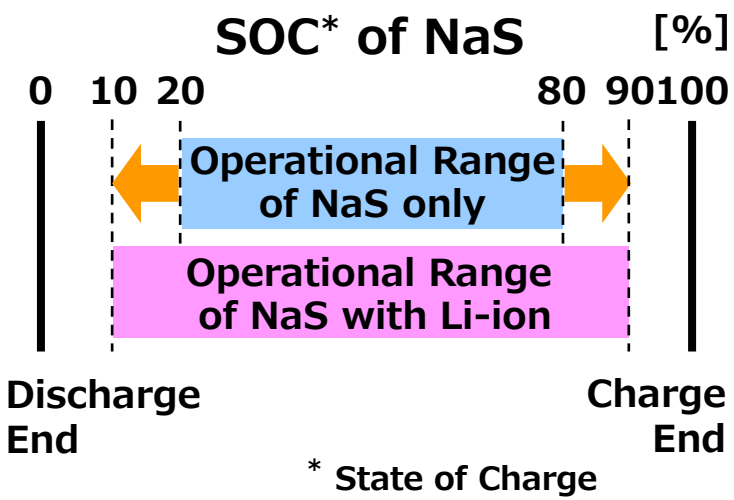
By reducing capacity of NaS, auxiliary power consumption can be decreased by about 30%.

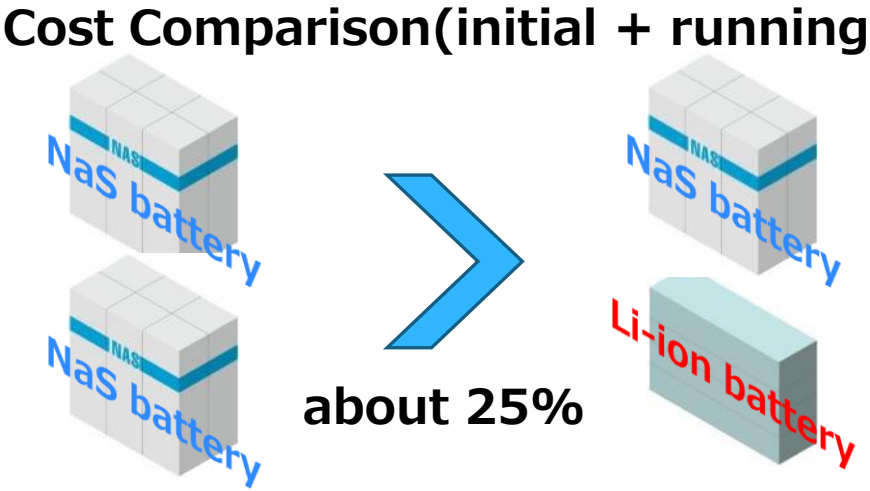
Introduction Cost Reduction

Cost per kW of Li-ion and cost per kWh of NaS are economical.

↓

By reducing capacity of NaS, introduction cost can be decreased by about 25%.

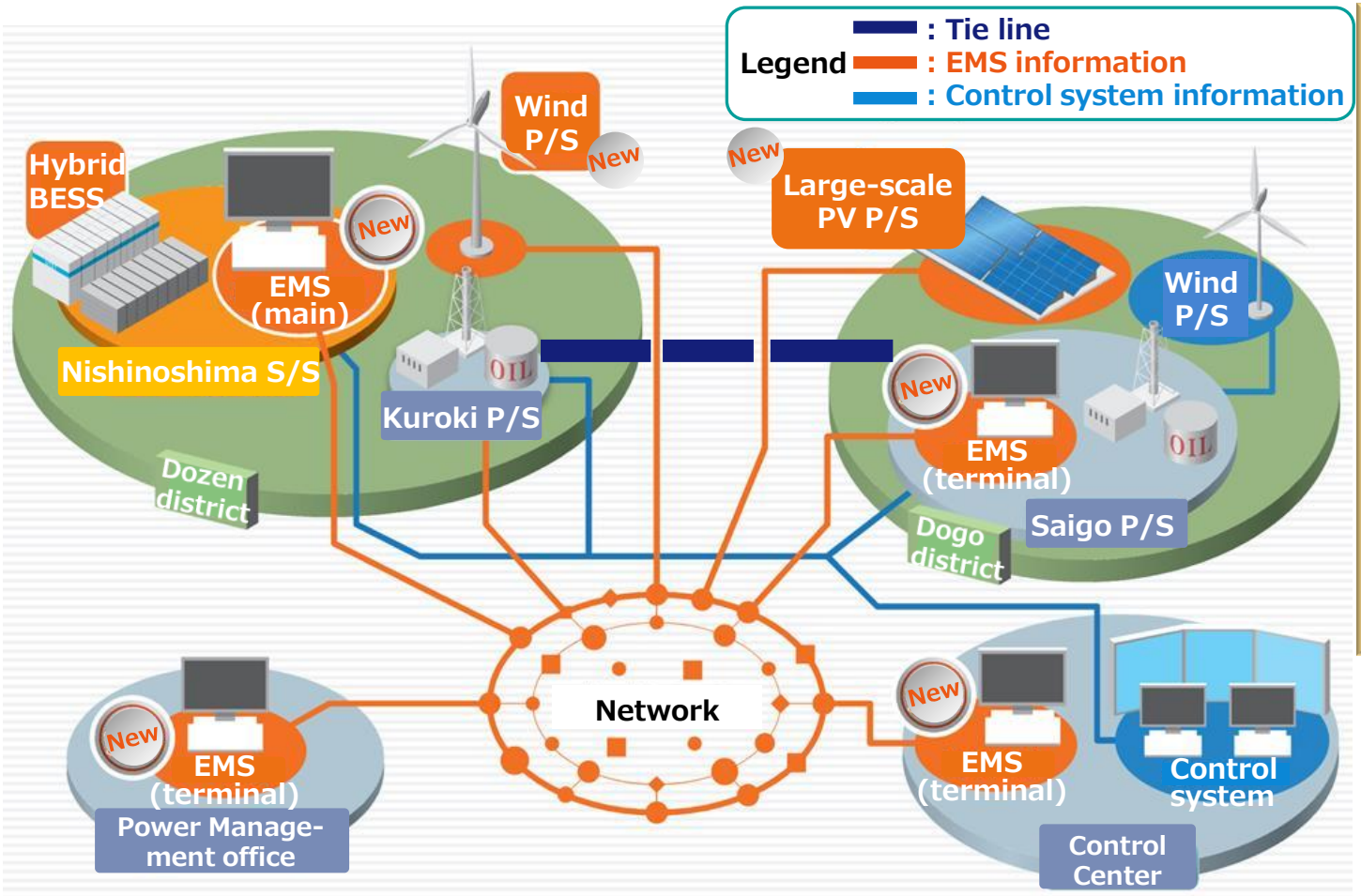




2. Control Method and Operational Performance of Hybrid BESS

Energy Management System (EMS)

- **To realize coordination control, we have constructed an EMS, linking the hybrid BESS, power stations and control center via communication network.**

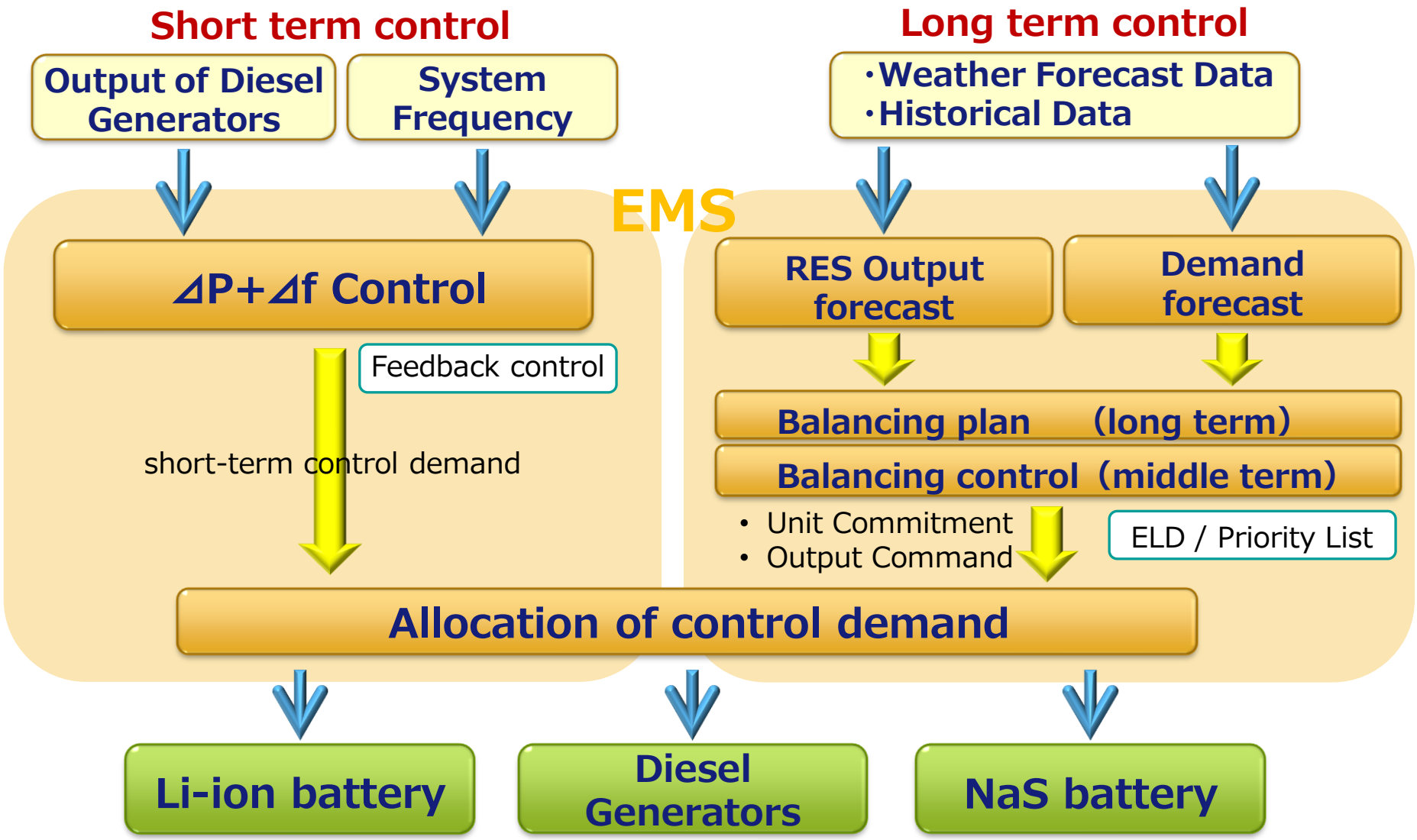


Main function

- Forecast of RES output and demand
- Charge/discharge control
- Diesel power generation control

Overview of control method

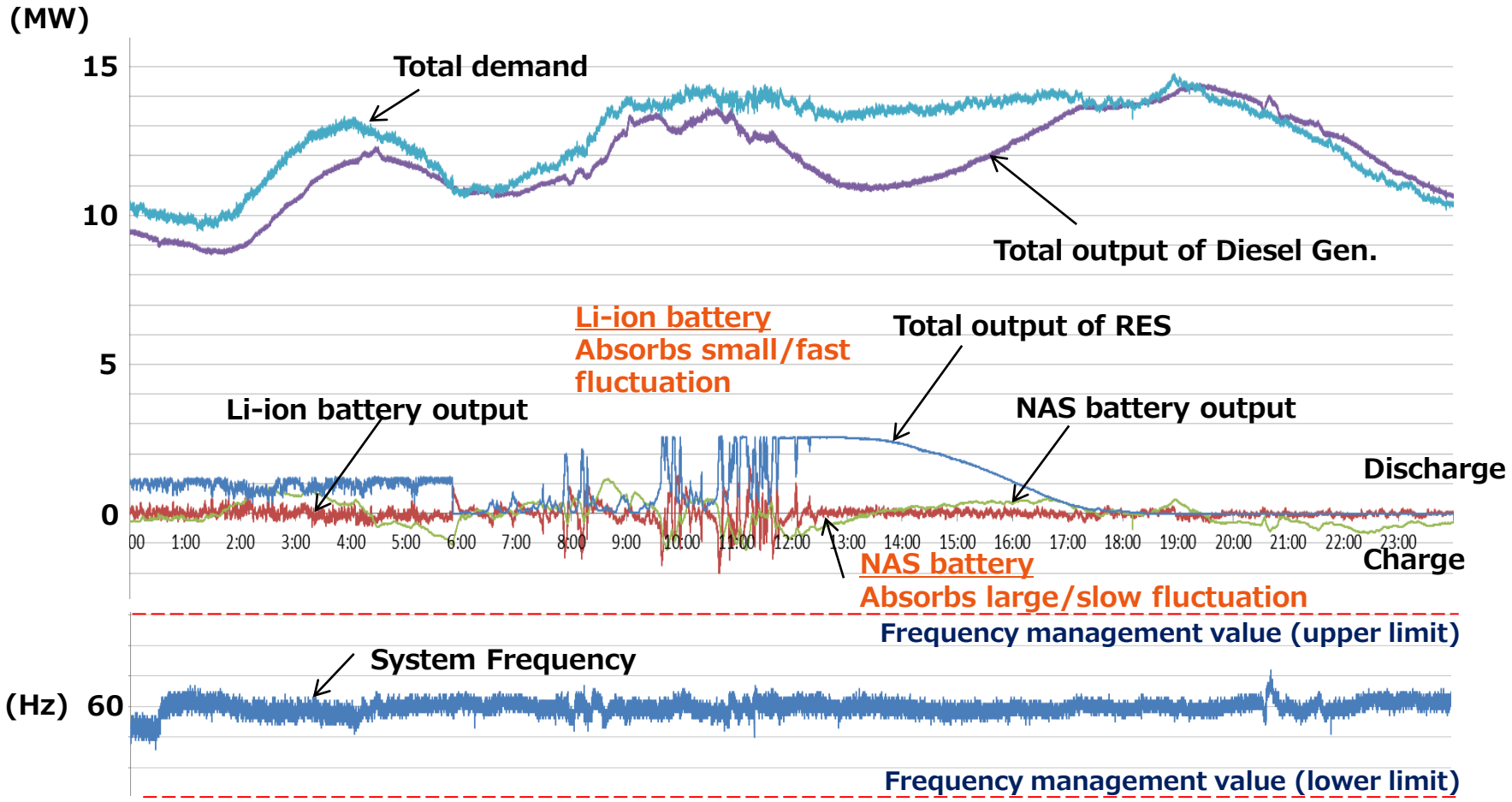
- **By means of unmanned automatic operation, coordinated control between BESS and diesel generators is executed.**



Operational performance of hybrid BESS

- **Up to the present time, the total capacity of RES integrated in the grid has reached 6.4MW, about 60 % of this project's target, and coordinated control performance has been generally satisfactory.**

Example of operational performance (Aug. 31, 2016)



3. Study utilizing Simulation

Optimal combination of BESS output

- **Before the Demonstration Project, the amount of acceptable RES and the required power output and capacity of BESS have been determined by simulation.**
- **Alternative No. 2 in following table was selected.**

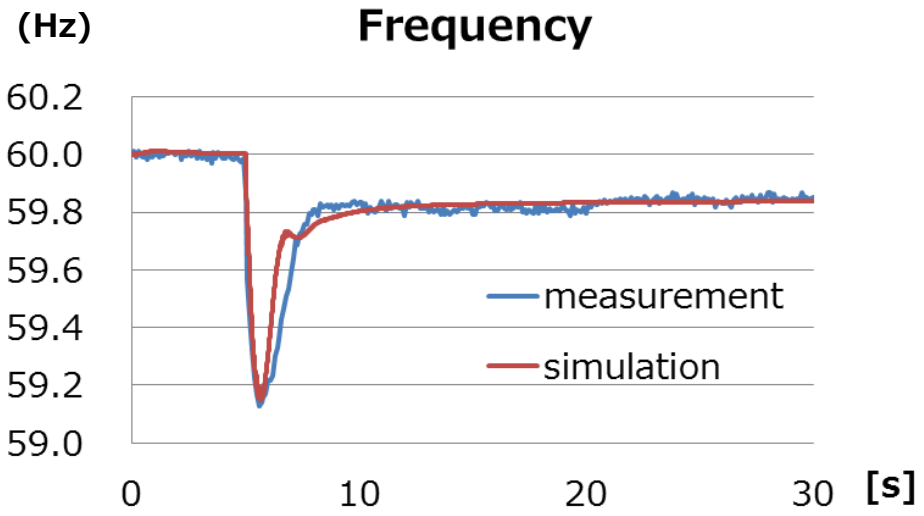
Alternatives	Output [MW]		Simulation result			Cost
	Li-ion Battery	NaS Battery	Capacity of tie-line	Charging/Discharging fluctuation	Frequency deviation	
No. 1	1.5	4.8	○	○ Within SOC range of each Batteries	○	△
No. 2	2.0	4.2	○	○ Within SOC range of each Batteries	○	○
No. 3	2.5	3.6	○	× Exceeds SOC range of NaS Battery	×	—

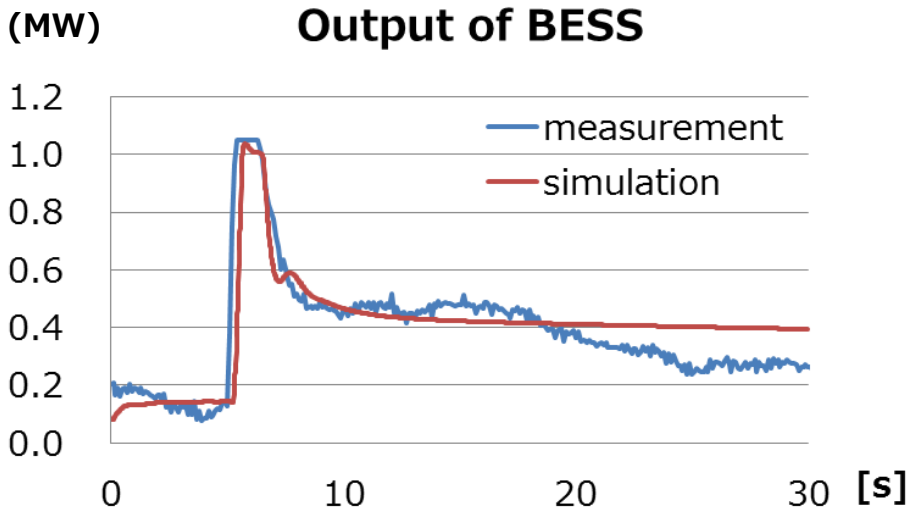
Simulation result for Short term Fluctuation (1/2)

- For dynamic simulation, an accurate model of diesel generators including governors is needed. Before the Demonstration Project, we made a model based on diesel generator dump tests with the help of CRIEPI.
- During the project, we have been trying to improve an accuracy of the model including BESS based on tests or disturbances.

- A Simulation result (after tuning) is shown below.

[Tool] CRIEPI's power system dynamics analysis program
[Condition] A diesel generator dump test

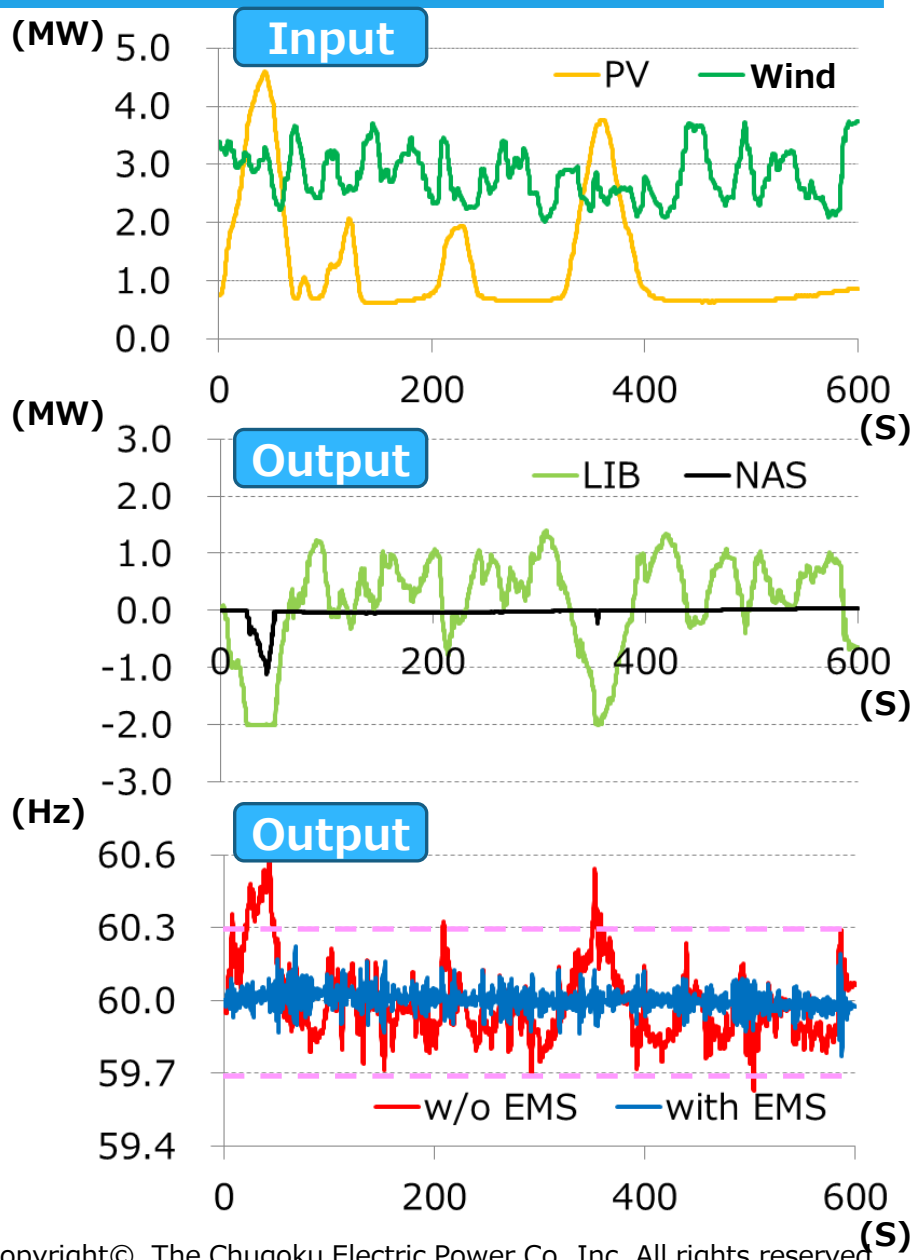




Simulation result for Short term Fluctuation (2/2)

- We are trying to revaluate the optimal BESS output using data obtained in the Demonstration Project.
- A Simulation result using the tuned model (in the previous sheet) is shown as example.

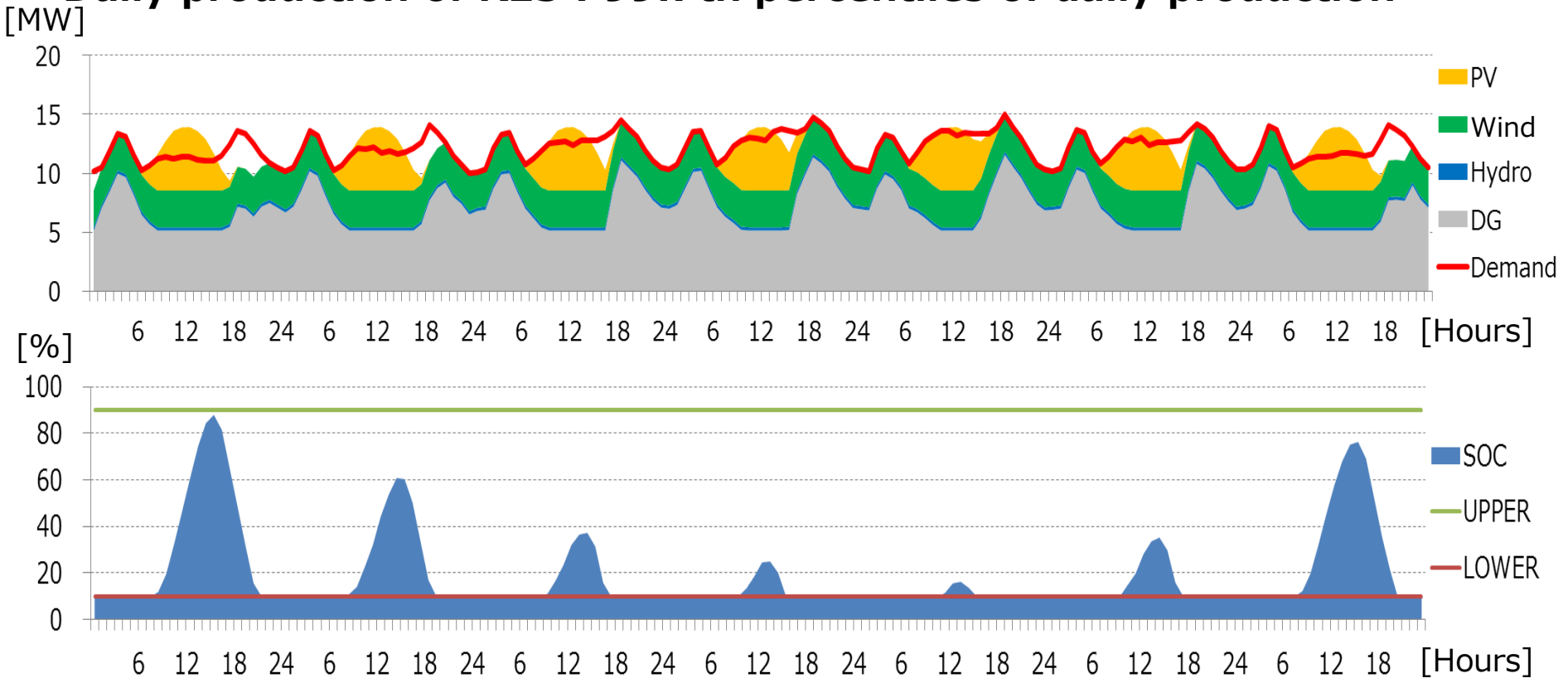
[Condition]
Total Capacity of RES : 11MW
Output of RES : Extrapolated from time-series data including 99.7th percentiles of fluctuation width



Simulation result for Long term Fluctuation

- **A Simulation result of Supply-demand control during a week is shown below as example.**

[Condition]
Light Demand Period, NaS : 4.2MW(25.2MWh)
Total Capacity of RES : 11MW
Daily production of RES : 99.7th percentiles of daily production



4. Conclusion

Expected effects and future prospects by the Demonstration Project

①Improvement of the power supply stability

- Introduction of RES and BESS improves the stability of power supply in an isolated power system

②Reduction of environmental impact

- By reducing fossil fuel consumption, CO2 emission can be reduced by about 10 thousand tons-CO2 per year

③Activation of the local community

- Hybrid BESS with coordination control is the first challenge in Japan.
- Expect an increase of visitors

④Development and application of new technology

- Accumulate technical knowledge such as the EMS control logic
- Contribute to the solution of global challenges

Verification being continued aiming further penetration of RES

Acknowledgements

This project was realized with great support of the Ministry of the Environment, through the adoption of the “Storage battery demonstration project for promoting the introduction of renewable energy for remote islands“, subsidized by the ministry.

Also, we have received great cooperation from each municipals of Nishinoshima Town, Oki-Islands, and Shimane Prefecture, in the process of the construction of the substation, and the introduction of renewable energy.

We would like to express our sincere appreciation for the efforts of those concerned.

Thank you for your attention.

Nishinoshima (Nishinoshima)

Dogo (Okinoshima)