Microgrid Use Cases in Small Island in Japan
~ Hahajima Project ~

March 23, 2022

Yuki NOMOTO

Manager
Overseas Business Office
Public Relations and Corporate Communications Unit
Tokyo Electric Power Company Holdings, Inc

Technical issues for Renewable Energy Penetration

Main Topic	#	Technical issue	#	Classifications	#	Development and expected Tech
Expansion Of Distributed Energy Resources	1	Fluctuation Control "Duck Curve"	1	Sudden Fluctuation Control In output	1 2 3 4 5	Power storage facilities Demand side resources "DR/VPP" Expansion of power bidding menus Improvement of prediction Power to Gas (hydrogen)
	2	Lack of "Automatic Frequency Control"	1	Ancillary services	1 2 3 4 5	Suppression of VER Storage batteries(BMS,EV,CAES etc.) Protection control Regional interconnection Bidirectional Demand Response/VPP
	3	Transmission Network	1	Transmission reinforcement	1 2	Improvement of network planning Reinvestment
			2	Network congestion	1 2 3 4 5	System reinforcement "Connect and management" "Dynamic Rating" Flexible AC Transmission System Wire with heat resistance
	4	Distribution Network	1	Maintain distribution voltage	1	Reactive power by storage batteries EV, VPP
			2	Reverse Power	1 2 3	Storage batteries Updated measurement technology Load prediction technology
			3	System Inertia problem *Root of Outage	1 2 3	Suppression of VER Flywheels and asynchronous rotary condensers Virtual synchronous generators
			4	Complication of protection system	1 2	New PCS development Fault point estimation technology
			5	Distribution reinforcement	1 2	Reinvestment TEPCO "D-EC" Solution

TEPCO

Renewable Penetration and Its Issues

Renewable Penetration

Off Grid

Inverter-based system

50%

25%

Synchronous generator-based system

Main Island

Issue	Countermeasure	How to Implement
Short-circuit current reduction	**Protection Coordination**	**Currently under development in Hahajima PJ**
Inertia reduction	**Synthetic Inertia** **Inertia measurement**	**・Develop BESS inverter with inertia function (Currently under development in Hahajima PJ)** **・Inertia measurement using PMU**
Short-term fluctuation	countermeasures against Frequency fluctuation (BESS, GF & LFC)	Demonstrated in Niijima NEDO project
Long term fluctuation	PV output curtailment Energy storage RE forecast, Ramping forecast Supply and demand simulation	Demonstrated in Niijima NEDO project
Transmission system overload	Resource aggregation (VPP) Connect & Manage Utilizing smart meter data Dynamic Line Rating	In progress In progress PoC PoC
Islanding in event	Anti-islanding requirement for inviter	Done
Simultaneous disconnection	FRT Requirement for inverter	Done
Reverse power flow in substation	Add vector factor to substation 90Ry	Done
Voltage swell	Transformer separation/SVR PF control requirement for inverter	Done Done

Project Objective

Achieve a Sustainable Island in Harmony with Nature

Purpose of 100% Renewable Electricity Supply

Energy Independence

- Reduce dependence on fuel from outside the island for power generation
- Expand local production and consumption of energy

Use of Renewable Energy

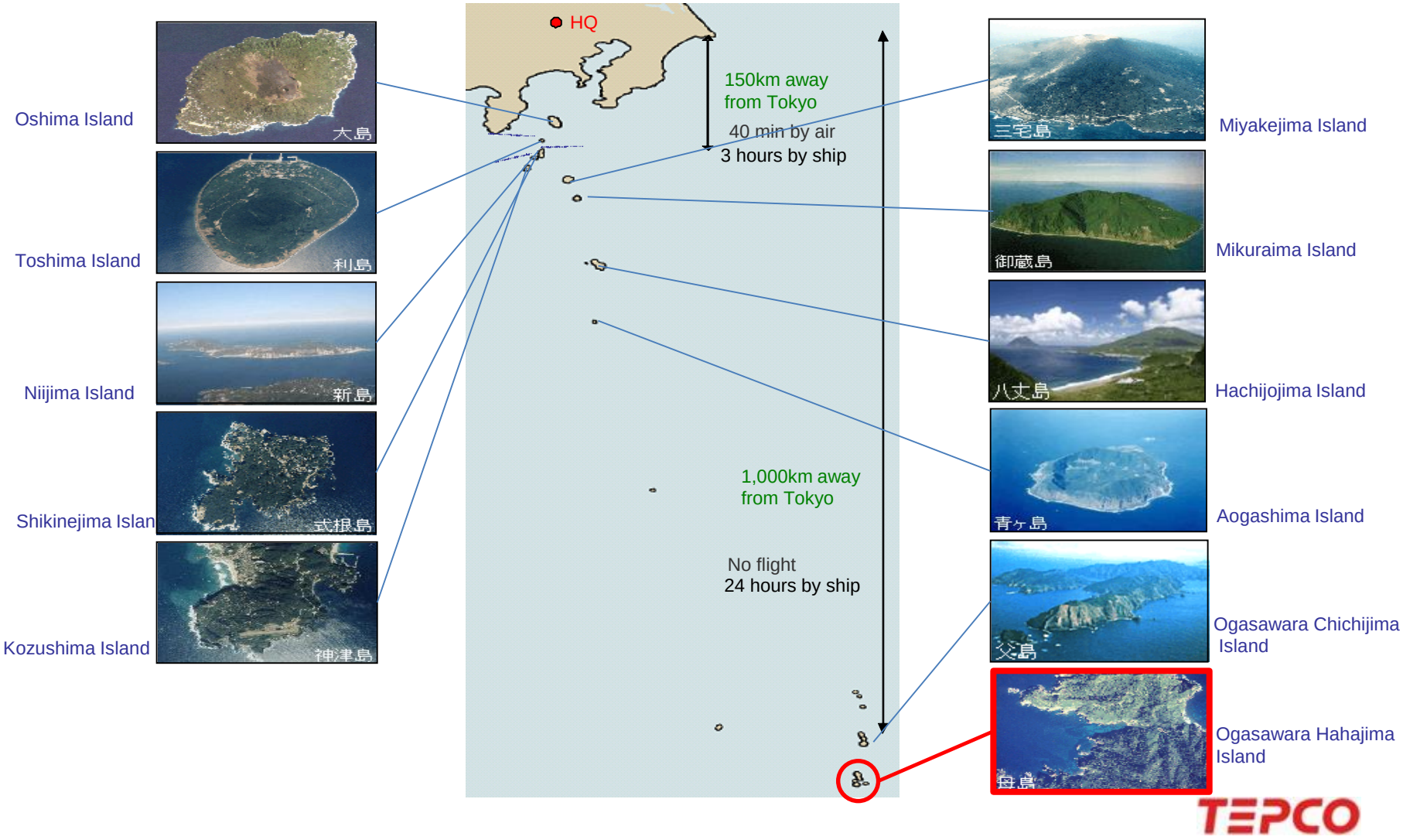
- Reduce CO2 emissions by reducing diesel generator usage
- Expand energy use by taking advantage of abundant sunlight

*** Hahajima is a World Natural Heritage island, 1000 km away from Tokyo**

TEPCO

Location of Hahajima Island

- The energy-supplied area includes 11 islands.
- Ogasawara-islands are the farthest:,1,000km south from Tokyo with no flights.



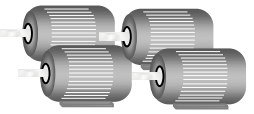
Overview of Power Supply on Hahajima

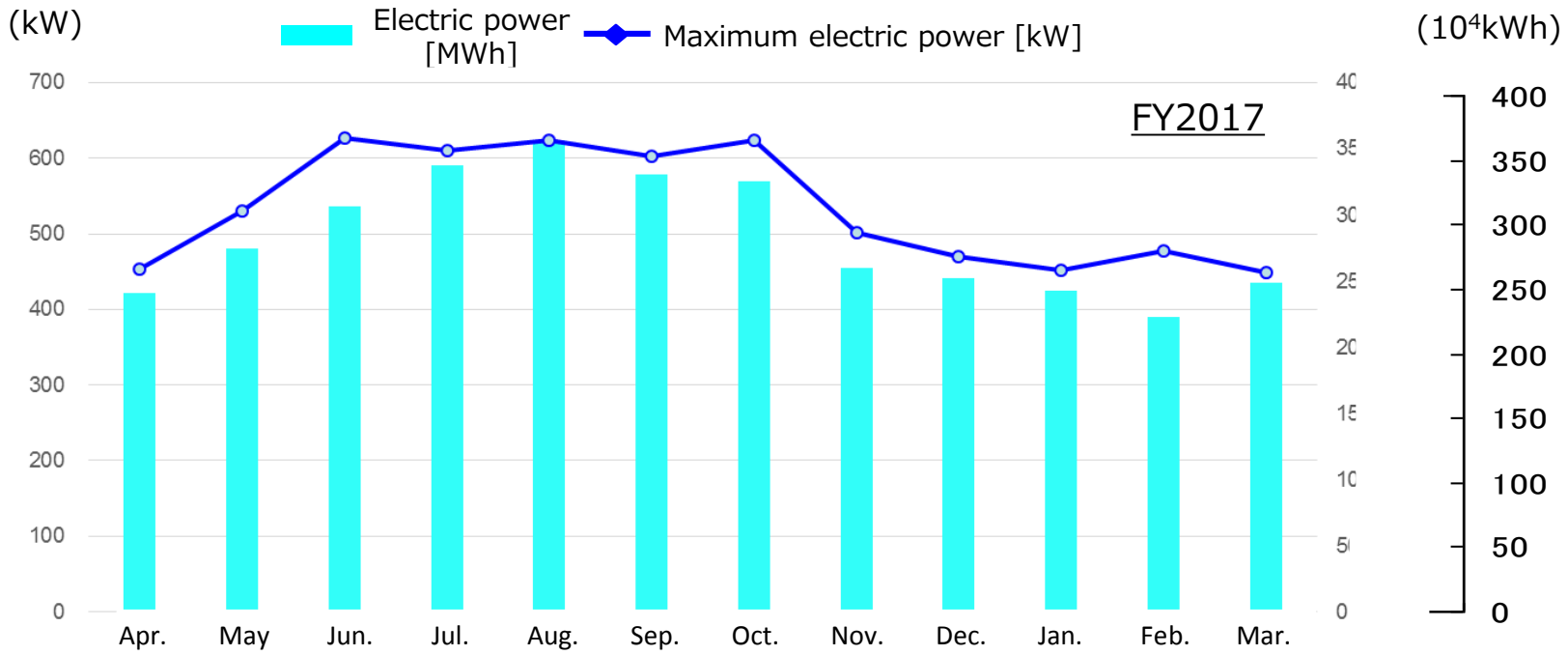
✓ Electric power is supplied by diesel power generation at Hahajima's internal combustion power plant.

Peak Demand : Approx. 630 kW

Total amount of Power Consumption
: Approx. 3 million kWh

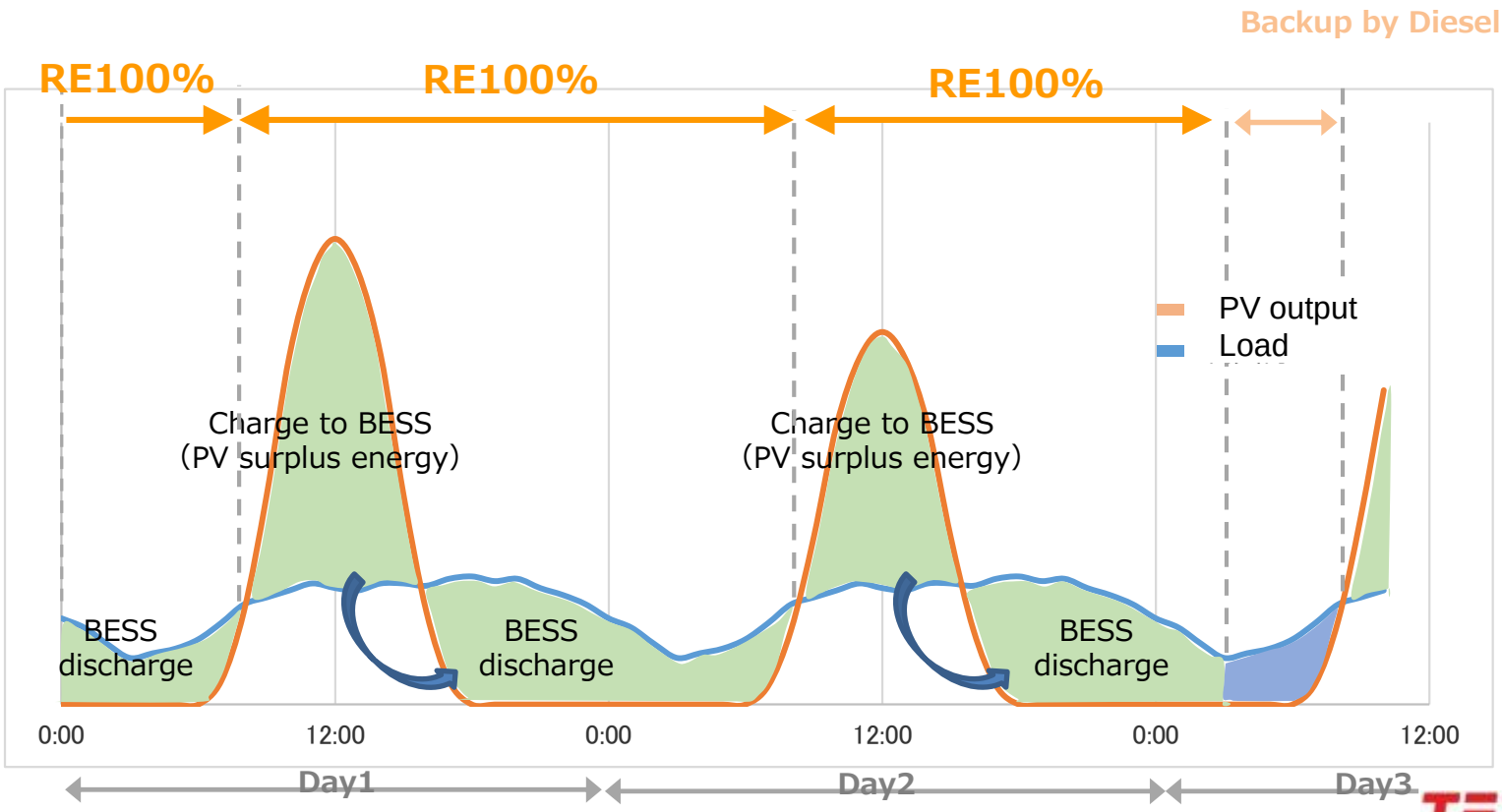
Diesel generators
240 kW x 4 units





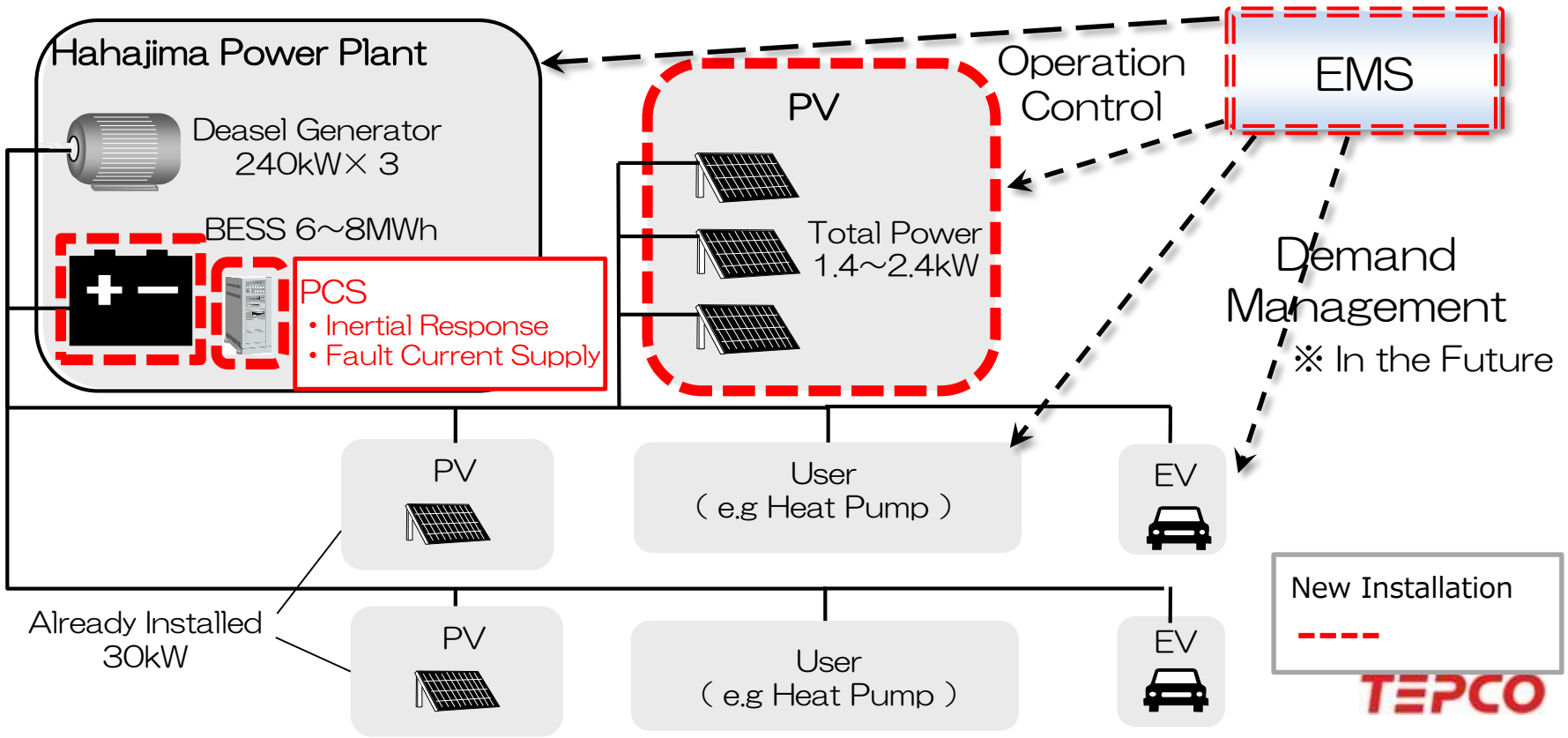
100% RE Supply

- ✓ Combine PV and batteries to supply electricity
- ✓ Supply electricity by PV during the daytime and charge the surplus PV energy to batteries
- ✓ During hours when the PV system does not generate electricity, supply electricity by discharging from batteries.
- ✓ In case of shortage, use backup electricity from a diesel generator



Overview of the Demonstration Project

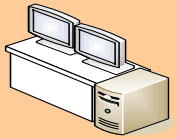
- ✓ Location : Ogasawara Hahajima Island
- ✓ Target : 100% RE Supply for over half a Year
- ✓ Peak Demand : 640kW
- ✓ Facilities : **PV** : 1.4～2.4MW、**BESS** : 6～8MWh ※ **DG** : 240kW×3(1Unit Reduction)
  PCS : Inertial Response・Fault Current Supply、**EMS** : Operation Control



Locations for Related Facilities

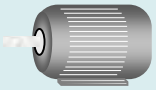
Hahajima Power Plant

EMS

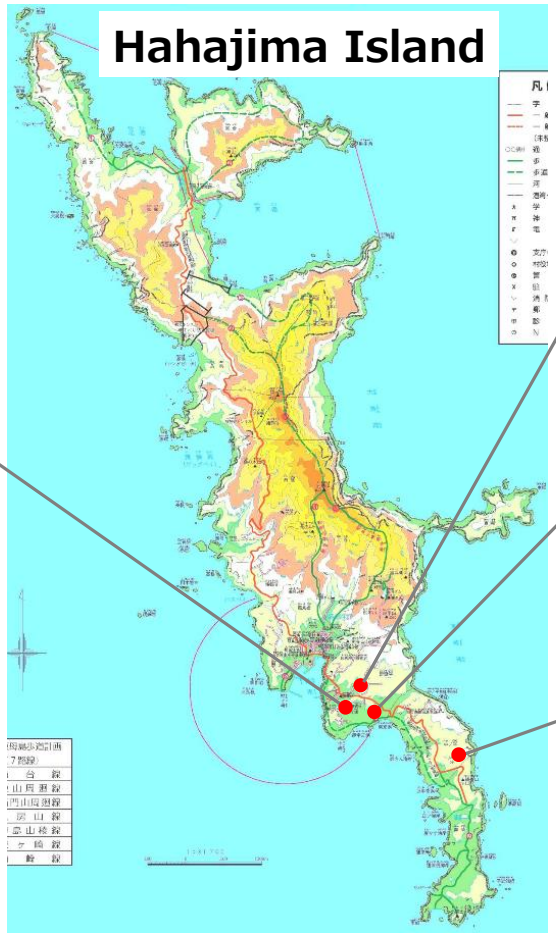


Storage Batteries

Diesel Generator

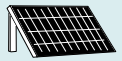


Hahajima Island

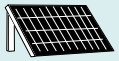


PV

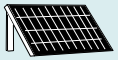
【Site A】



【Site B】



【Site C】



Solar Power Area:
Approx. 23,000m2 in total

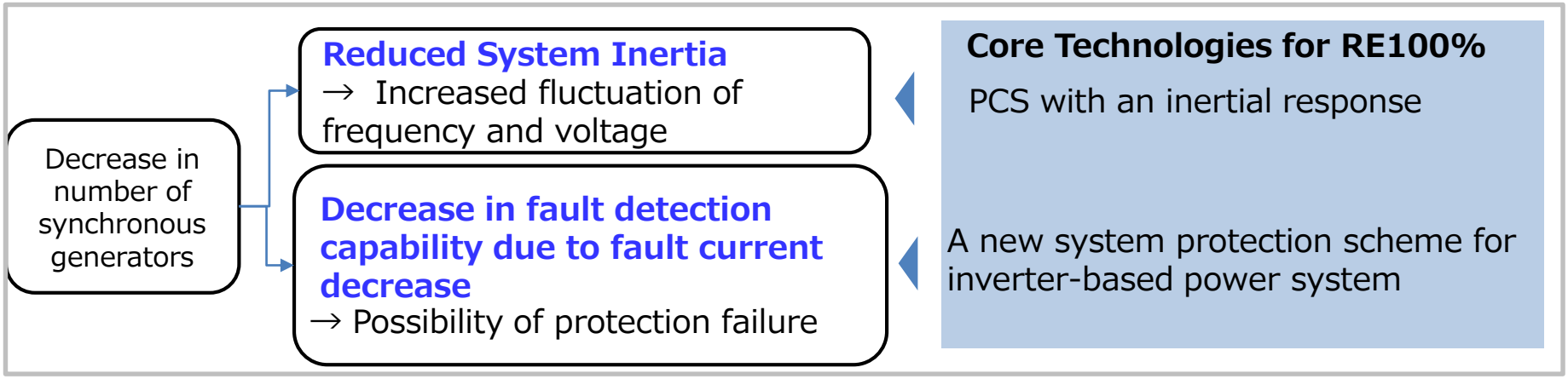
* The installation scale for PV panels will be reviewed based on natural environment survey results, measurements, and other research results.

TEPCO

PCS Development

- ✓ Core technologies for RE100% are Inverters with inertial response ability and System protection scheme for inverter-based power system
- ✓ Basic control logic development and Mini model verification have been completed.

Two Technologies

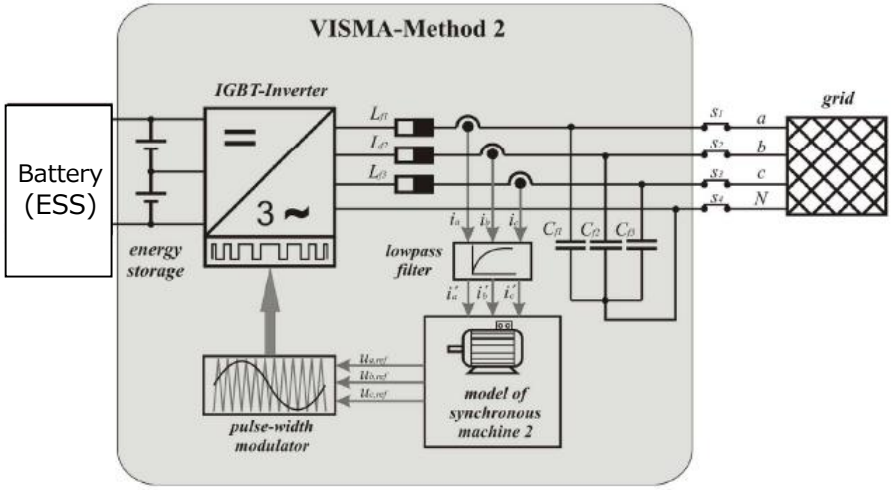


Development of core logic –inverter with inertia function-

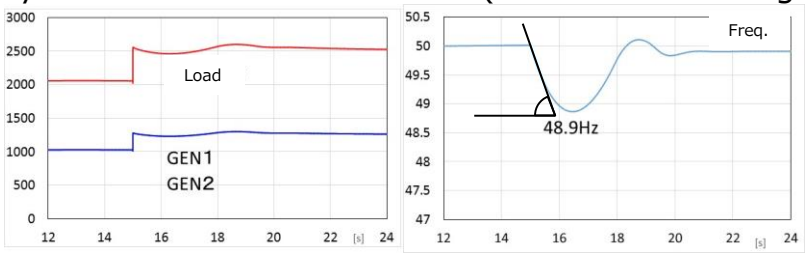
- ✓ Formulate the synchronous generator model and implement it with real time simulator.
- ✓ As a VSG function, an inverter is controlled so as to realize the I/O quantities of an internal synchronous generator model.
- ✓ Frequency fluctuation at sudden load change can be maintained at the same level as synchronous generator operation.

Inertia effect of VSG on step change in load has been confirmed

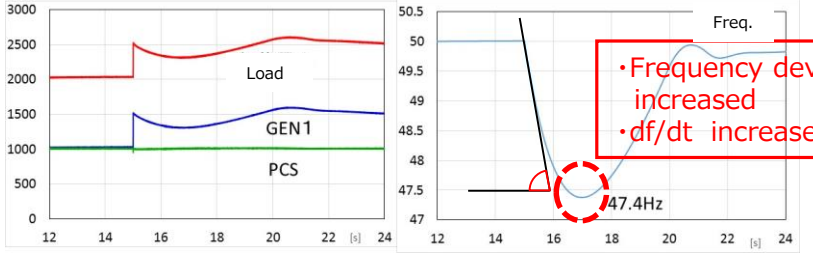
BESS with the similar characteristic as a synchronous generator



① Synchronous Gen 1000kW× 2 (500kW Load change)

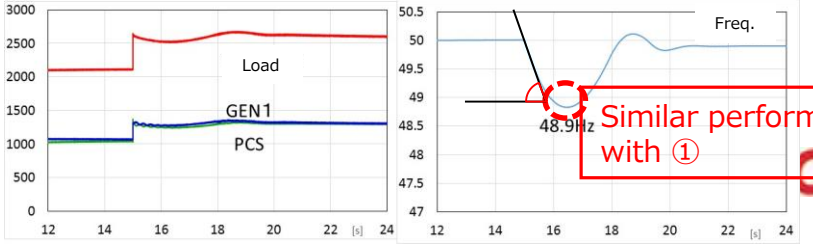


② Synchronous Gen 1000kW, Inverter without inertia 1000kW



・Frequency deviation increased
・df/dt increased

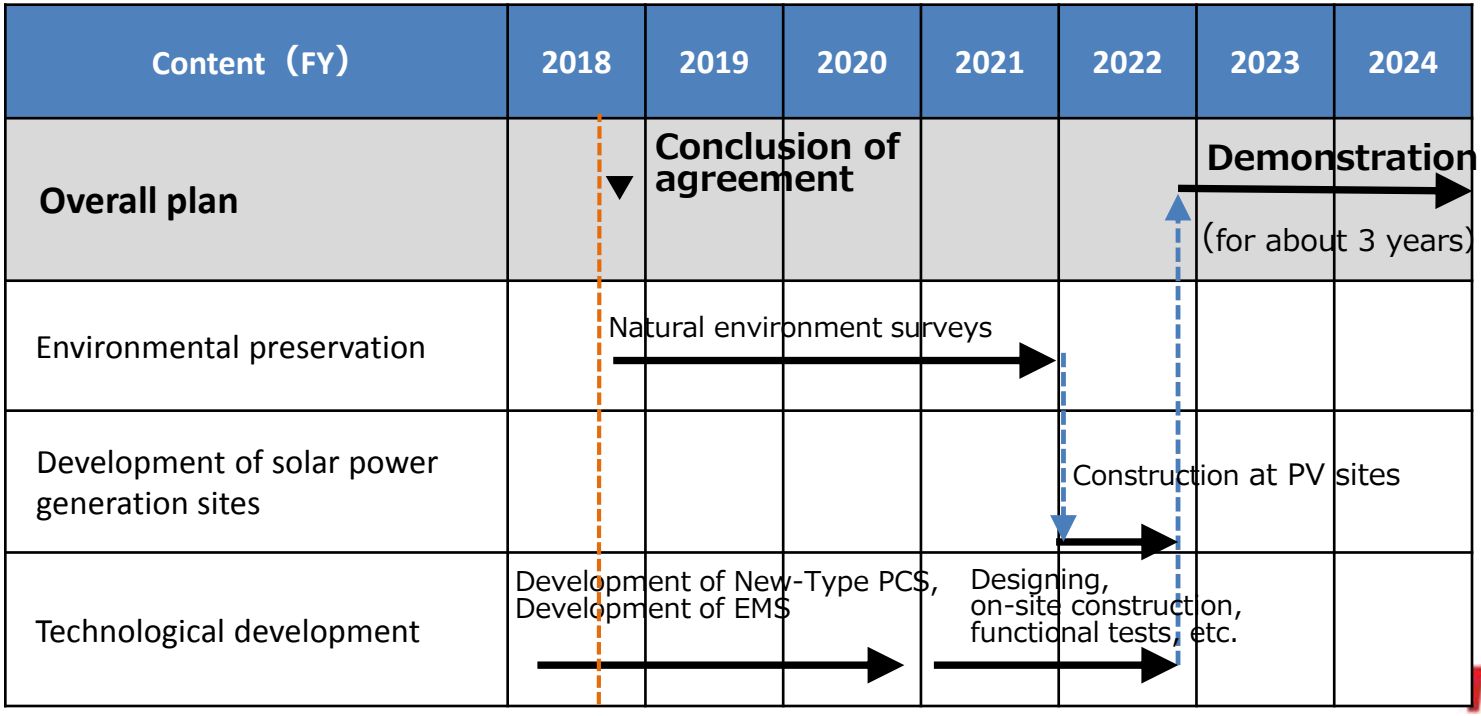
③ Synchronous Gen 1000kW, Inverter with inertia1000kW



Similar performance with ①

Project Schedule

- ✓ The Tokyo Metropolitan Government, the Ogasawara Village Office and TEPCO Power Grid, Inc. concluded the agreement to conduct the project (December 2018).
- ✓ At candidate sites, natural environment surveys are being conducted to investigate potential impact on the environments. (from January 2019).
- ✓ Technologies necessary to supply electricity only from renewable energy are being developed. (in progress)
- ✓ Installation of solar PV facilities (from 2022)
- ✓ Start of the project demonstration (from the end of FY 2022-)



Sustainable energy for a happy future!

TEPCO