Field Test Project for RES Penetration in Niijima Island Grid

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1 .R&D Project on Grid Integration of Variable Renewable Energy

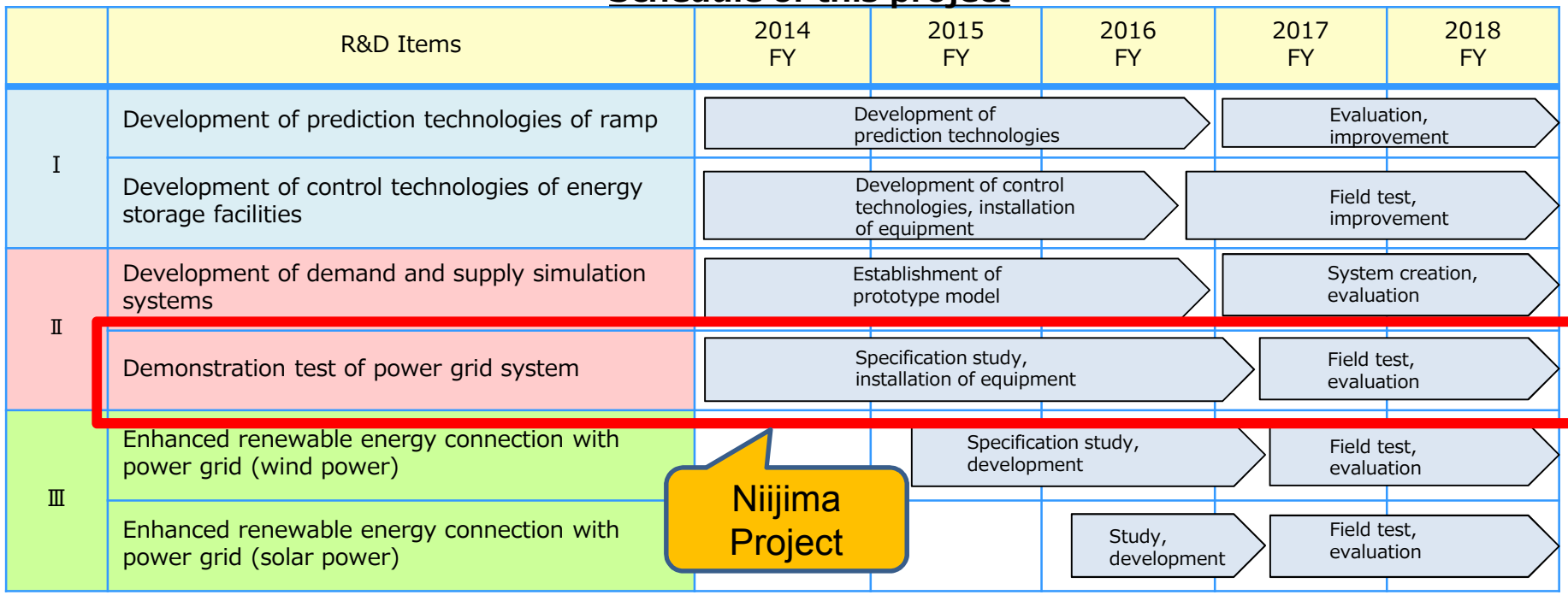
Mitigation Technologies on Output Fluctuations of Renewable Energy Generations in Power Grid ～Improving technologies on prediction, control, and operation for addressing the output fluctuations～

Development Items:

Item (I): Wind power output forecast and enhanced control technology
Item (II): Power system simulation with the forecast technology
Item (III): Enhanced renewable energy connection with power grid

Purpose: By focusing on variable output (ramp) of wind power generation which affects power system operation, proper forecast and appropriate control technologies will be developed, and appropriate operation method with these technologies will be established. In addition, a remote output control system, which is obligated to be installed, will be developed and established for stable and maximum use of renewable energy.

Schedule of this project

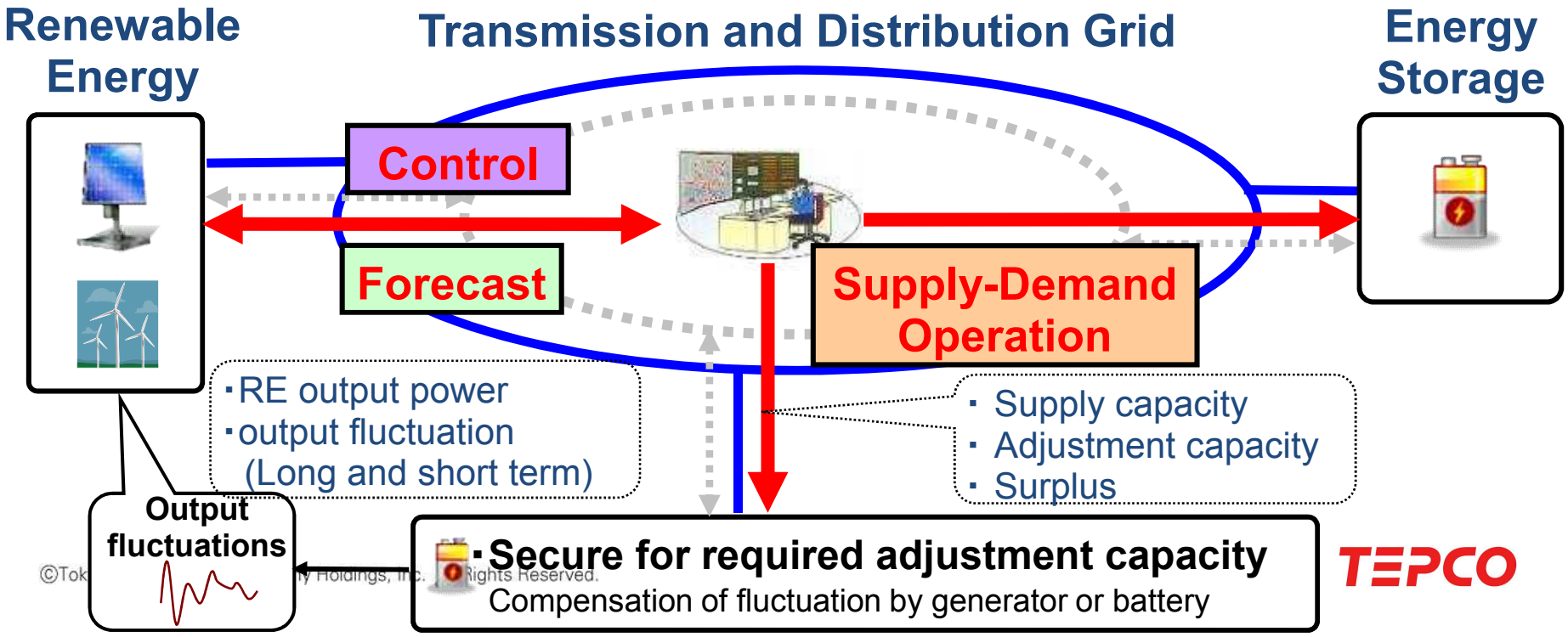


2. Outline of Niijima Project

To demonstrate massive introduction of renewable energy sources (RES), field tests in the grid in an island were performed.
Main study items are as follows:

- 'Output power prediction' and 'Output power control' of RES

- 'Supply-Demand Operation' in coordination with RES, energy storage, and existing power generations.



3. Overview of Niijima Island

◆ Population
approx. 2,800

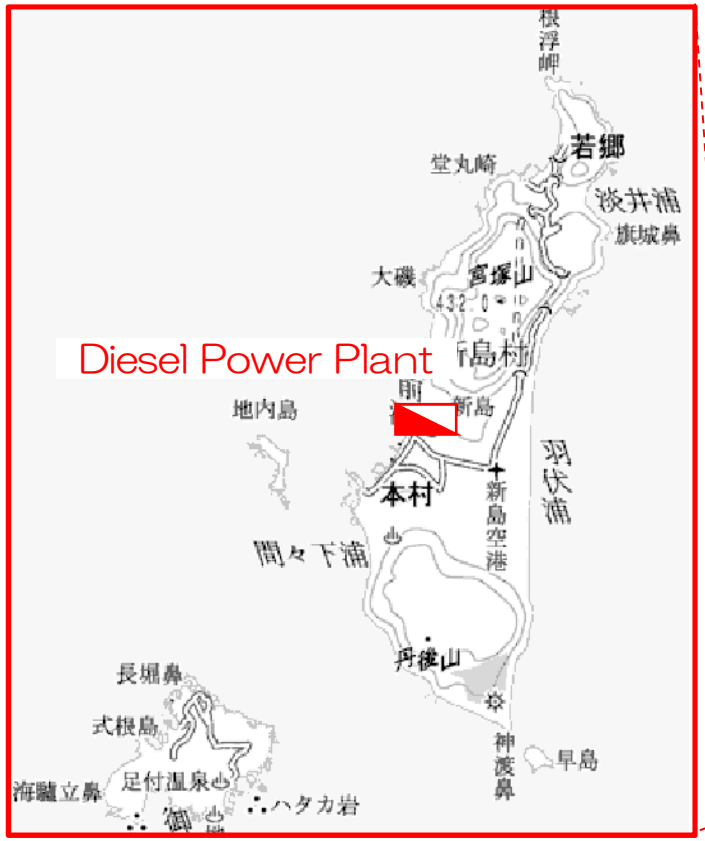
◆Geographical features
Location

34:22	North latitude
139:16	East longitude
Land area	approx. 24km^2
Altitude	approx. 432m

◆Environmental restrictions
Special zone of
Natural Park Law

◆Major Industries
Agriculture, Fisheries,
Tourism

◆Total demand
1,900kW～4,400kW



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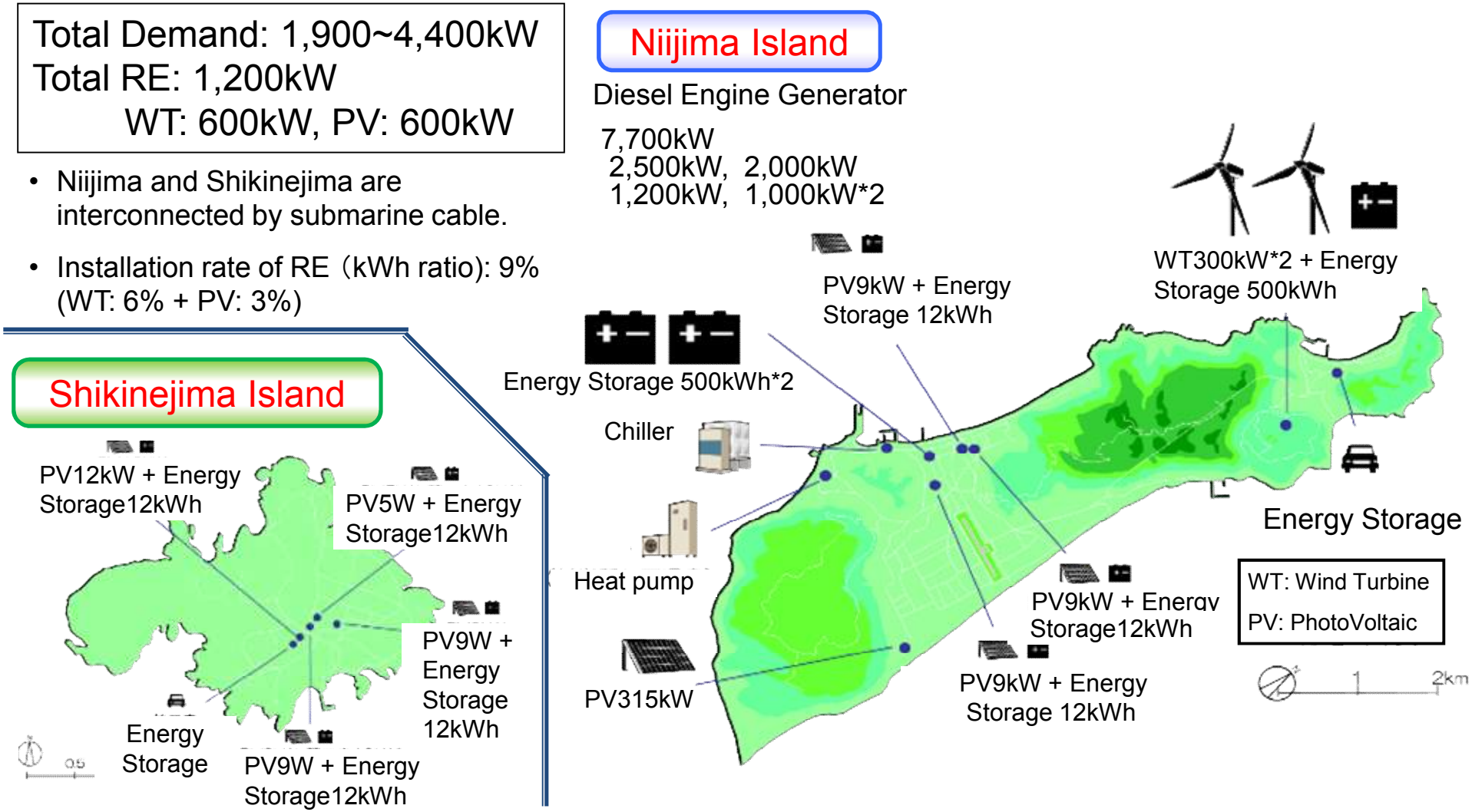
4. Layout of Facilities

Total Demand: 1,900~4,400kW
Total RE: 1,200kW
WT: 600kW, PV: 600kW

- Niijima and Shikinejima are interconnected by submarine cable.
- Installation rate of RE（kWh ratio): 9% (WT: 6% + PV: 3%)



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5. Project Organization

Project Leader
Pro. Yokoyama
The University of Tokyo

The University of Tokyo
・Demonstration for heat storage system

TEPCO HD/PG
・Summary

NEDO

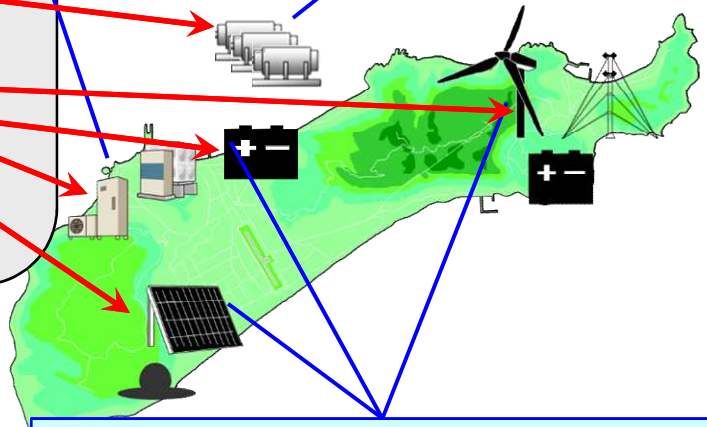
CRIEPI
・Creation of generator governor model

DG control system

Power prediction system for renewable energy

EMS

Distributed Coordinated Control System



Japan Weather Association
・Study for power prediction method of renewable energy

NRI secure technologies
・Countermeasure for system security

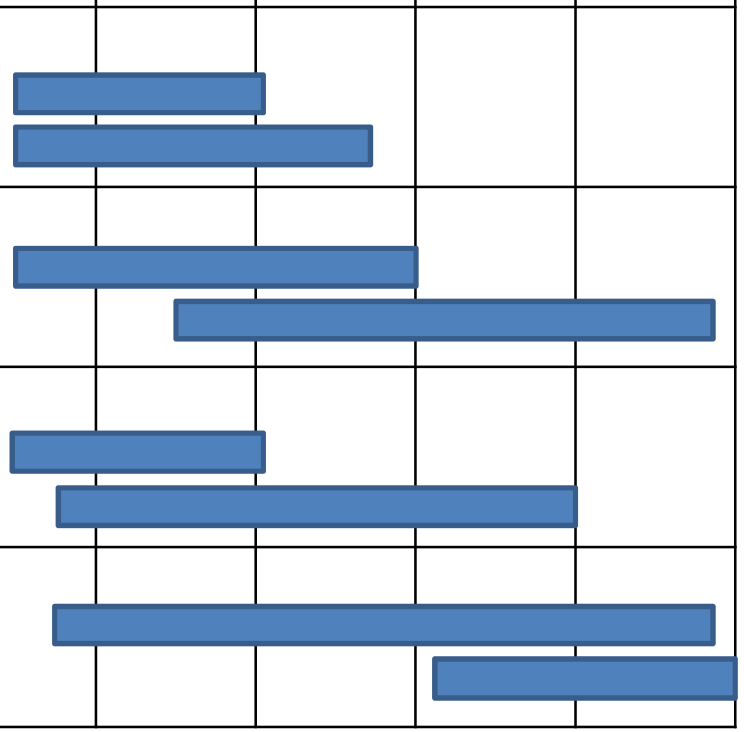
Takaoka Toko Co., Ltd.
・Construction of test field
・Development of integrated control system
・Field test

6. Schedule

- **Investigation, pre-study and construction of facilities (2014 – 2017)**
- **Combination test of each facility and function (2017 – 2018)**

Fiscal year

Action Items	2014	2015	2016	2017	2018
1. Investigation (1) Amount of insolation and wind condition (2) Characteristics of demand and power supply					
2. Pre-study (1) Development of simulation model (2) Pre-study by simulator system					
3. Facility construction (1) Design of test facilities, control system (2) Construction of facilities, control system					
4. Field test (1)Testing and adjustment of test facilities (2) Evaluation					



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7．Overview of Facilities(1)

(1) Wind Power Generation

< Connection to grid: Nov. 2016 >
- WT: 300kW * 2
- Battery: Lithium ion battery (500kWh)
- Inverter: 500kW

(2) Photovoltaic Power Generation

< Connection to grid: Dec. 2015 >
- PV: 318kW
  (255W Polycrystalline module, 1,440 panels)
- Inverter: 315kW

(3) Large-scale Storage Battery

< Connection to grid: Oct. 2015 >
- Battery: Lithium ion battery (500kWh * 2)
- Converter: 1,000kW * 2

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8. Overview of Facilities(2)

(4) Small-type PV and Storage Battery

(9 sites; elementary school, junior high school, and clinic and so on)

- PV: 5kW – 12kW
- Lithium ion battery: 12kWh (Capacity)
- Converter: 10kW


(4) Small-type PV and Storage Battery

(5) Heat Pump (Mamashita hot springs)

- Heat capability: 56kW
- Power consumption: 16kW

(6) Cooling Facility (Fish port)

- Cooling capability: 78kW
- Power consumption: 35kW


(5) Heat Pump


(6) Cooling Facility

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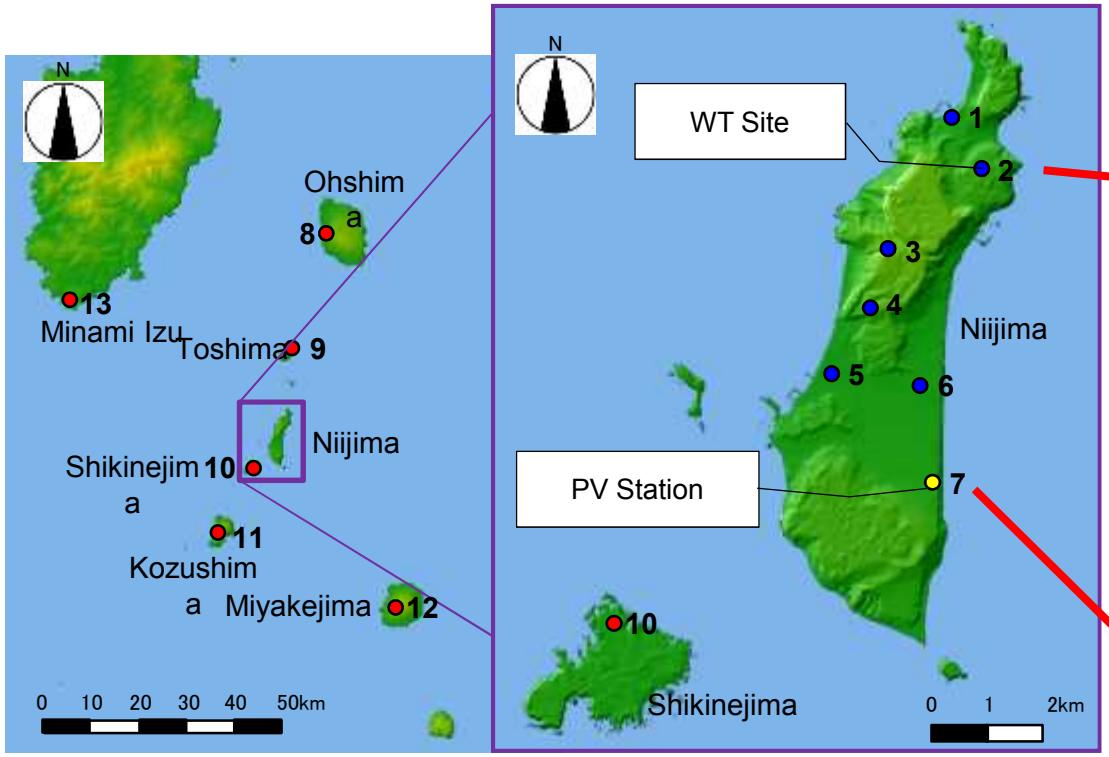
9. Output Prediction of RES

Weather Observation Equipment



site2. Aduchiyama (Niiima)

site7. Ohara (Niijima)

Weather observation spot ;
- wind direction, wind speed, global solar radiation, temperature, omnidirectional camera
- wind direction, wind speed
- wind direction, wind speed, global solar radiation

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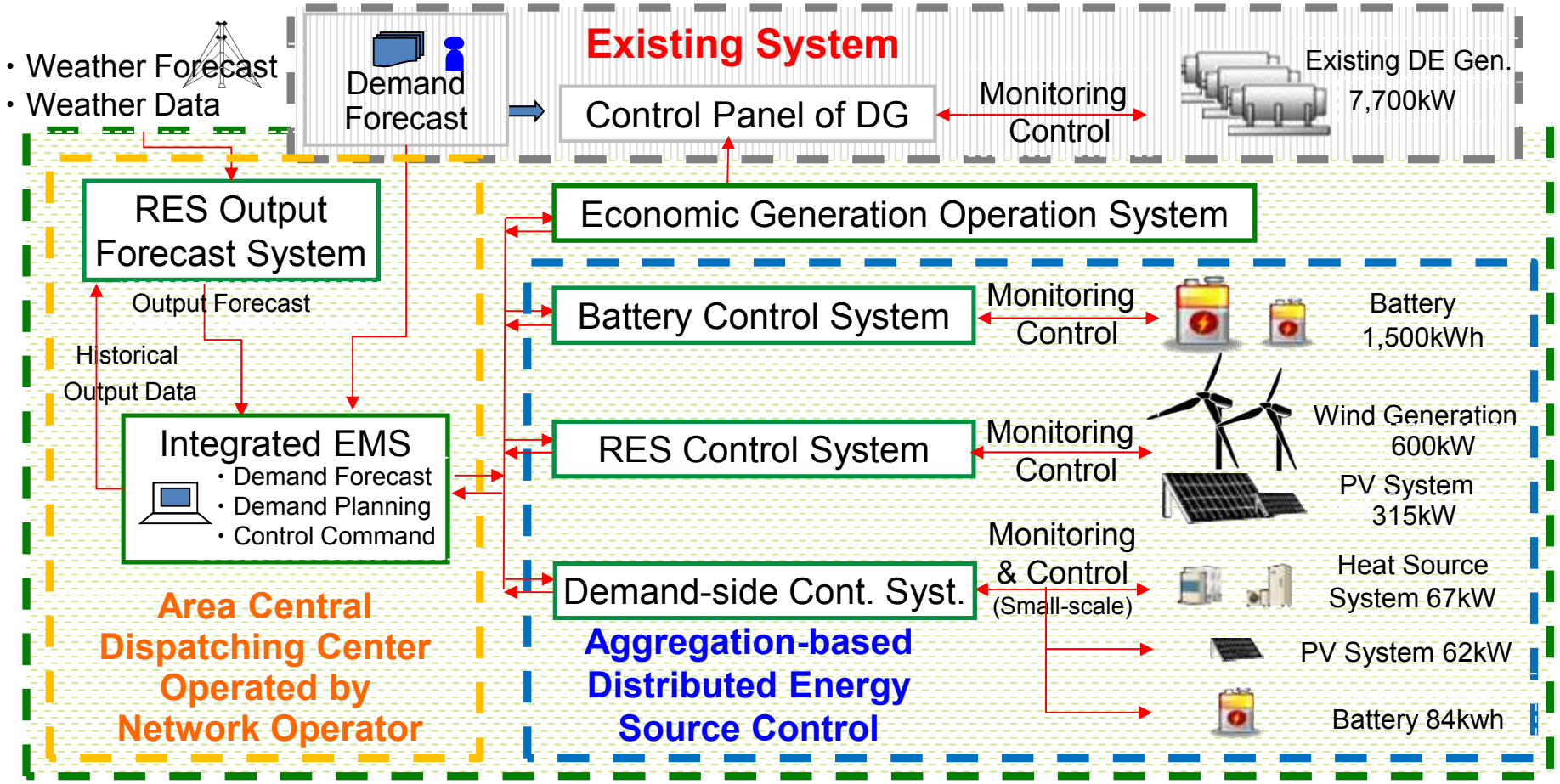
10. Distributed Coordinated Control System (1)

■ Demonstrating the feasibility of optimal integrated grid

* Output prediction, control, and curtailment of wind and solar power generation
* Cooperative control with existing power source and storage battery



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11. Distributed Coordinated Control System (2)

■ Outline of Control

		Purpose	Control	Control Object
Output fluctuation	Long term	Compensation of prediction error of RES generation	-Battery Control -Curtailment Control of RES -Demand-side Control	-Large-scale Battery -Wind and PV Generation -Heat Source System
		Demand-Shift Control	-Battery Control -Demand-side Control	-Large-scale Battery -Heat Source System
	Short term	Mitigation of RES Output Variation at RES Site (ΔP)	-Battery Control	-Large-scale Battery in WT site
		Mitigation of Frequency Variations (ΔF)	-Battery Control	-Large-scale Battery
		Load Frequency Control （LFC）	-Battery Control -Diesel engine Control	-Large-scale Battery -Diesel engine Control

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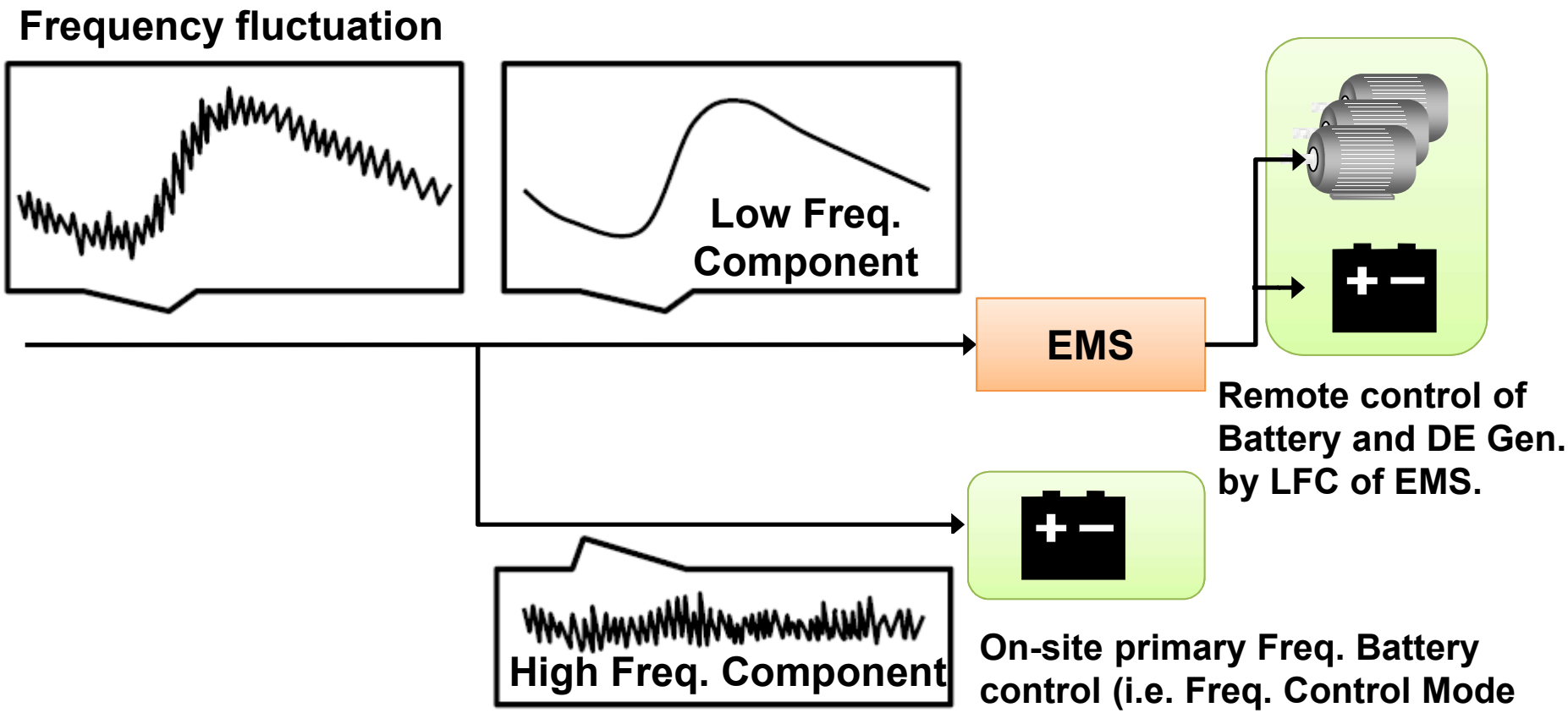
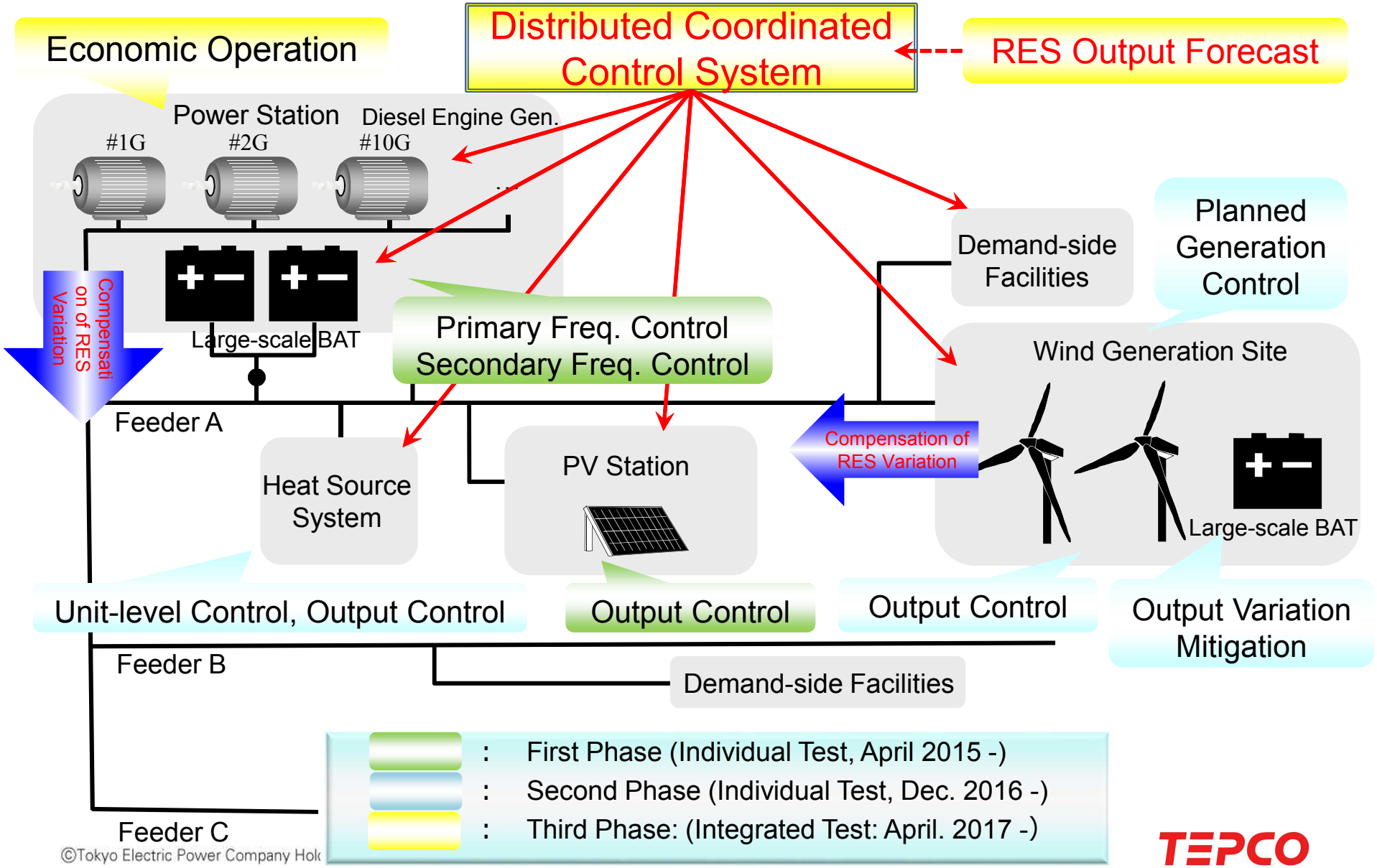
12. Distributed Coordinated Control System (3)

■ Frequency Control

- Primary Freq. Control: On-site control avoiding time-delay of controllers
- Secondary Freq. Control: Remote control based on economical control perspectives



13. Overview of Field Test



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14. Summary of the Study and the Next Step

Summary of the Study

- To demonstrate massive introduction of renewable energy, the following study items were performed in the grid of an island.
  - ✓ Output power prediction of RES
  - ✓ Output power control of RES
  - ✓ Supply-Demand Operation which can coordinate with existing power generations, RES, energy storage

The Next step

- RES penetration leads to reduction of conventional synchronous generators, which causes decrease of inertial force of the grid, and results in deterioration of power system stability.
- Technology to estimate inertial force of the grid and maintain it against RES penetration will be required.

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Danke für Ihre Aufmerksamkeit !

Moai statue of Niijima Island