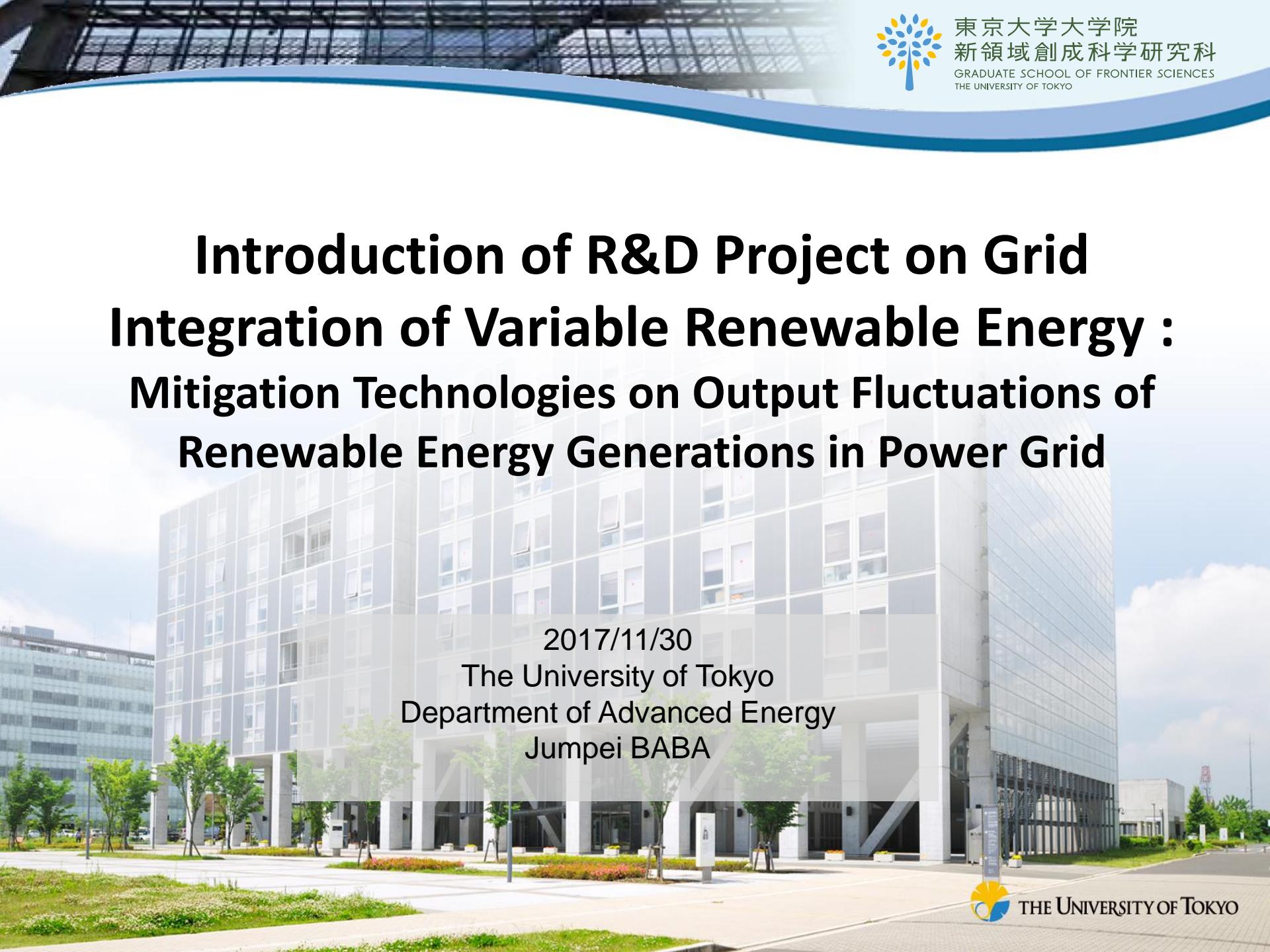


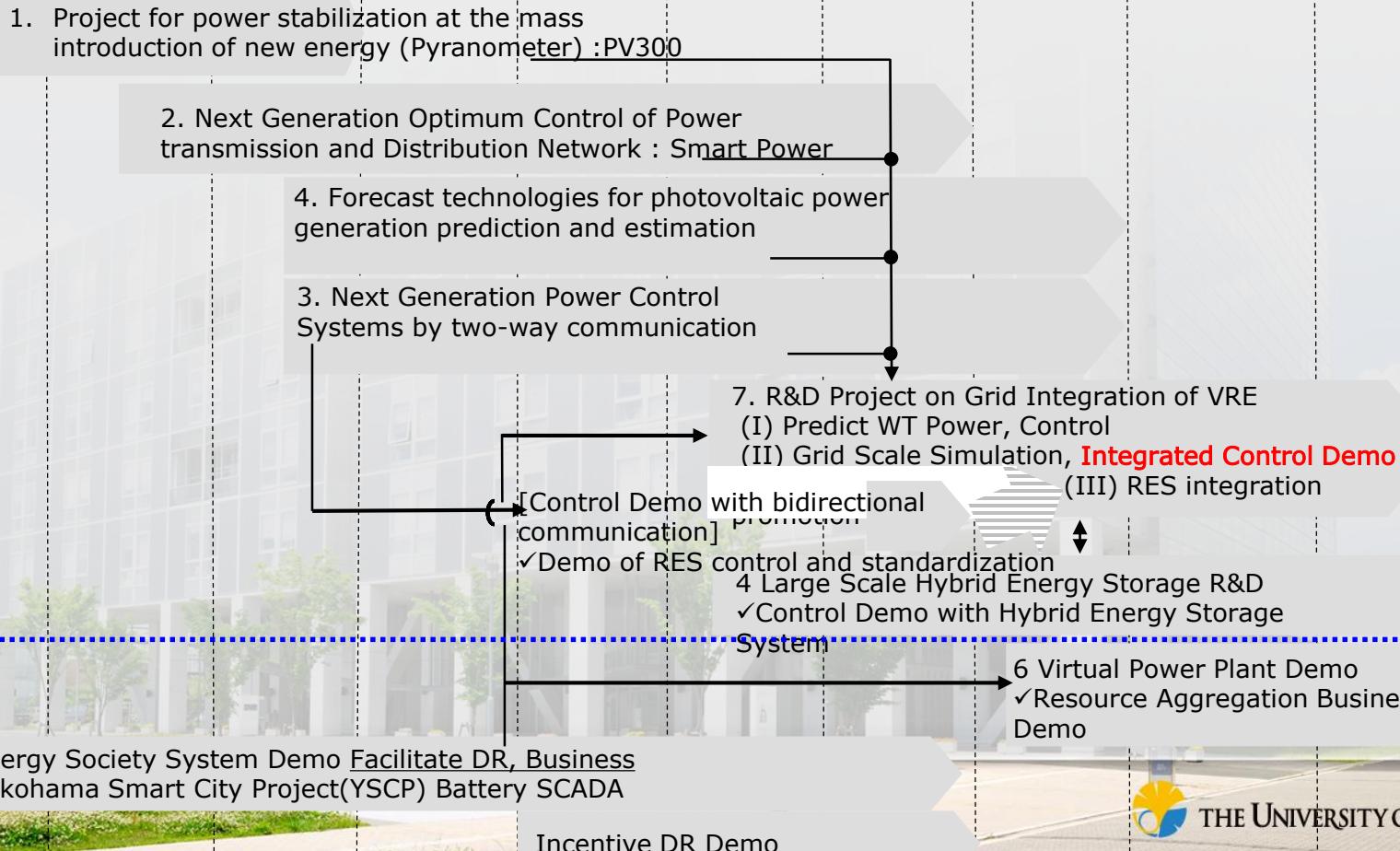
Introduction of R&D Project on Grid Integration of Variable Renewable Energy : Mitigation Technologies on Output Fluctuations of Renewable Energy Generations in Power Grid



2017/11/30
The University of Tokyo
Department of Advanced Energy
Jumpei BABA

Japanese National R&D Project on Grid Integration of VRE

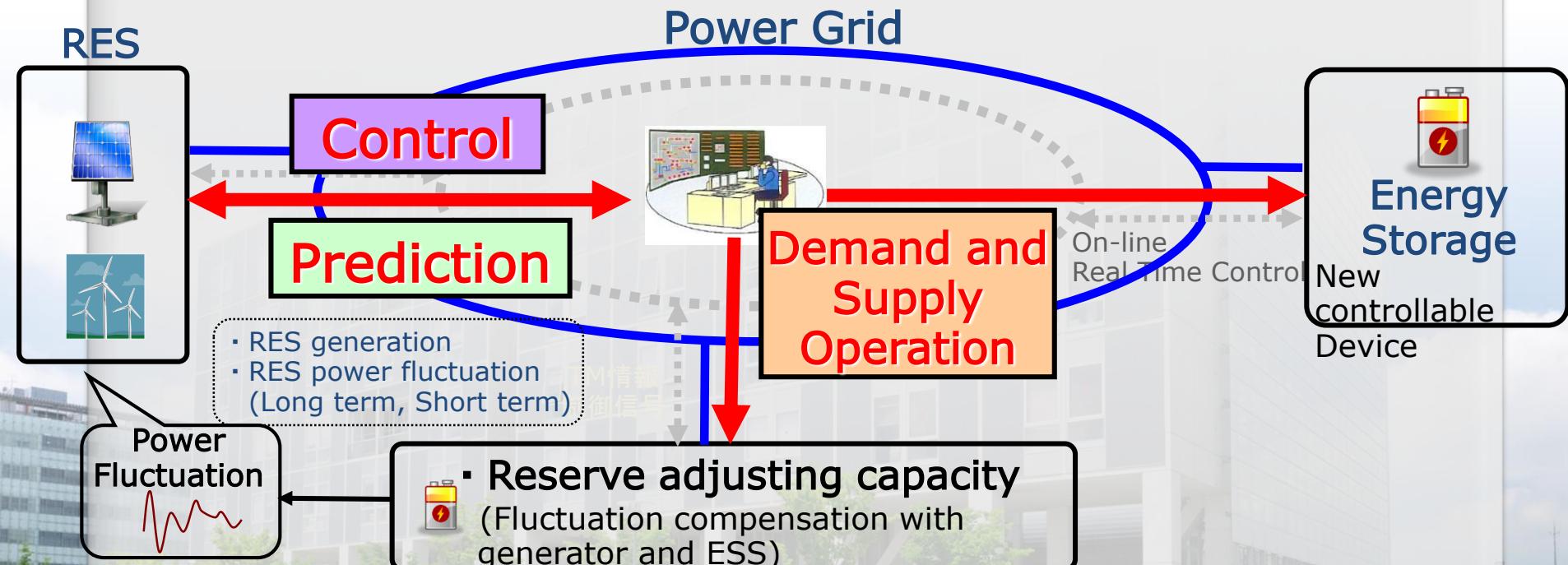
-FY2009 FY2010 FY2011 FY2012 FY2013 FY2014 FY2015 FY2016 FY2017 FY2018



Objective of Niijima Project

- R&D project to maximize the introduction of RES in 2030's power grid
 - Establish "Generation Prediction" and "Power Control" methods of RES
 - "Power Demand and Supply Operation" cooperation between diesel generator, energy storage systems and RES
- Niijima's power grid is used as test site to establish the design and operation method with minimum social cost
 - Make demonstration facility and operation test

Objective of Niijima Project



Where is Niijima?

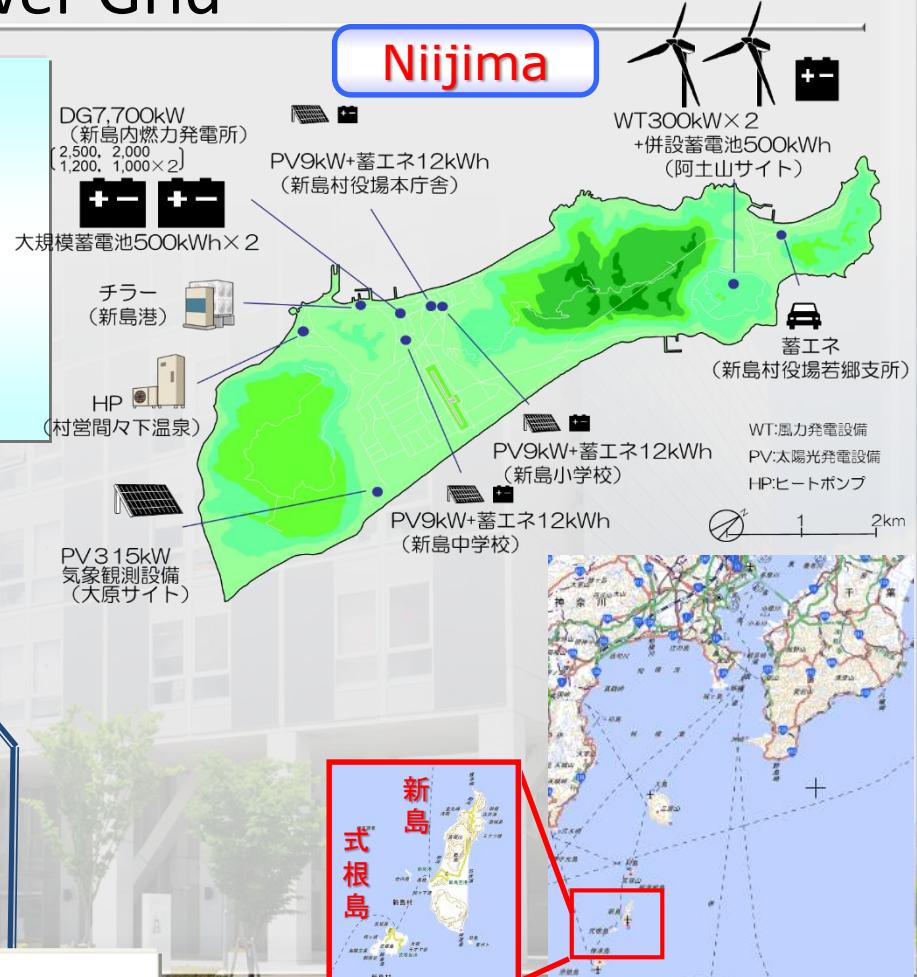
- “Jima” or “Shima” means “Island”
- 160km far from central Tokyo
- Belong to Tokyo Metropolitan
- Population : 2750
- Area : 27.5km^2



Overview of Niijima's Power Grid

- A submarine cable connects Niijima and Shikinejima power grid
- RES Energy Ratio : 9% (WT6%, PV 3%)

(Ref.) Japanese National long-term energy supply-demand outlook : 9%
(WT2%, PV7%)



1. Wind Turbine (Azuchiyama WT site)

<Operation Start 2016/11>

- WT : 300kW-2 Units
- BESS : 500kW - 500kWh

1 Azuchiyama WT site



2. Photo Voltaics (Ohara PV site)

<Operation Start 2015/12>

- PV : 318kW
 - 1440 Modules (255W Poly Silicon type)
- PCS : 315kW

2. Ohara PV site



3. Battery Storage System (Takaoka Toko Niijima site)

<Operation Start 2015/10>

- BESS : 500kWh – 1MW : 2 Units LiION

3. Takaoka Toko Niijima site



4. Small PV + BESS

(7 sites : Niijima Elementary School,
Niijima Junior High School, Shikinejima Clinic)

- PV : 5kW – 12kW
- LiION BESS : 12kWh-10kW



5. Heat Pump Water Heater (Mamashita Spa)

- Thermal Output : 56kW
- Power Rating : 16kW



6. Brine Chiller Ice Maker (Niijima Fishing Harbor)

- Thermal Output : 78kW
- Power Rating : 35kW



7. EV Quick Charger

- Power Rating : 20kW



Member of Niijima Project

Project Reader

Prof. Yokoyama

(The University of Tokyo)

TEPCO HD/PG

- Coordination
- Optimal Control



RES power output prediction system

Japan Weather Association

- Set weather observation equipment

RES power output prediction

NRI Secure Technologies

- Risk Analyses
- System Security Measures

Baba Laboratory

(The University of Tokyo)

- Heat Load, Heat pump system control

CRIEPI

- Governor model
- Classification of governor

Resource Aggregation

Distributed Control System

Integrated EMS

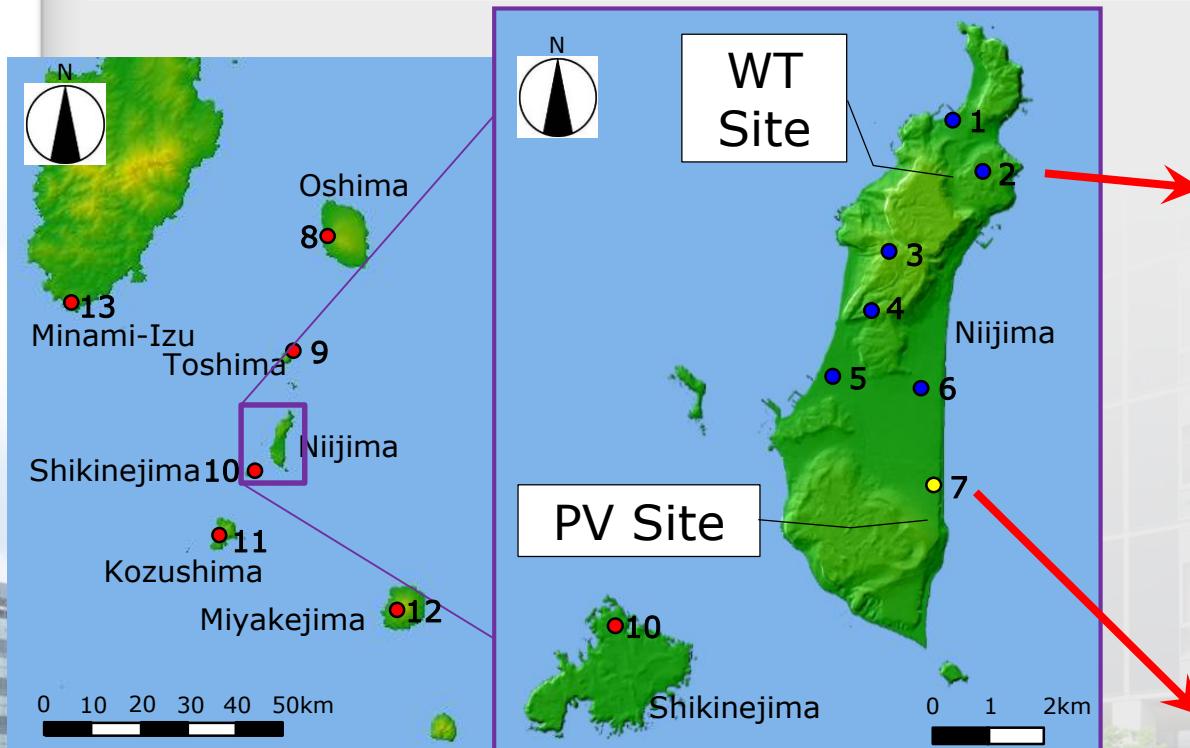
Distributed Coordinate Control System



Takaoka Toko

- Build demo setup
- Distributed Coordinate Control System
- Demonstration Test

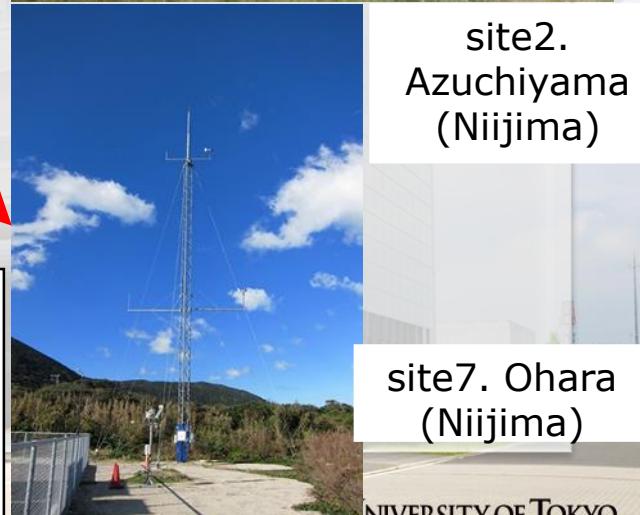
Weather observation equipment



- Weather observation point (Wind direction, Wind Velocity)
 - Global Solar Irradiance, Temperature, All-sky Camera)
 - Weather observation point (Wind direction, Wind Velocity)
- Weather observation point (Wind direction, Wind Velocity)



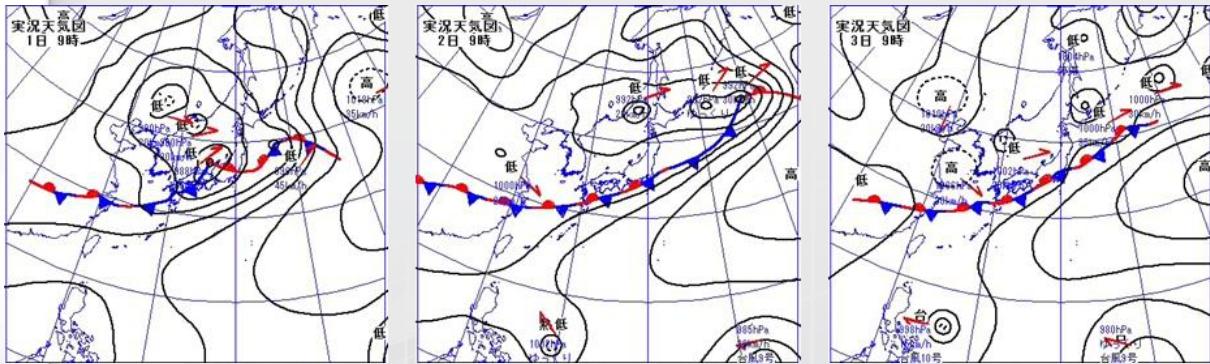
site2.
Azuchiyama
(Niijima)



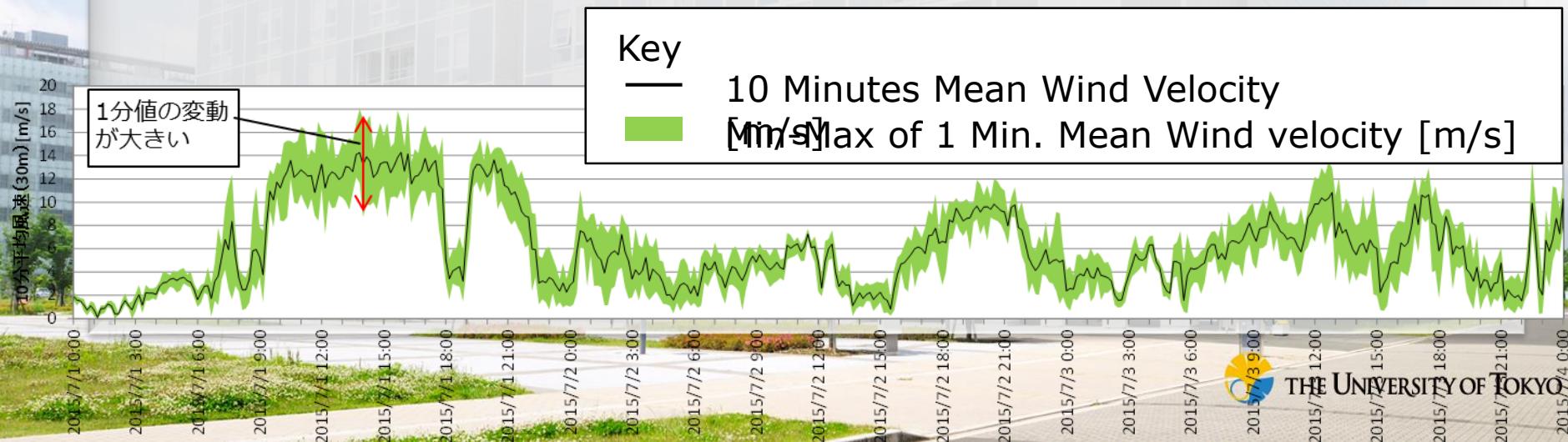
site7. Ohara
(Niijima)

Analyses of data measured by observation equipment

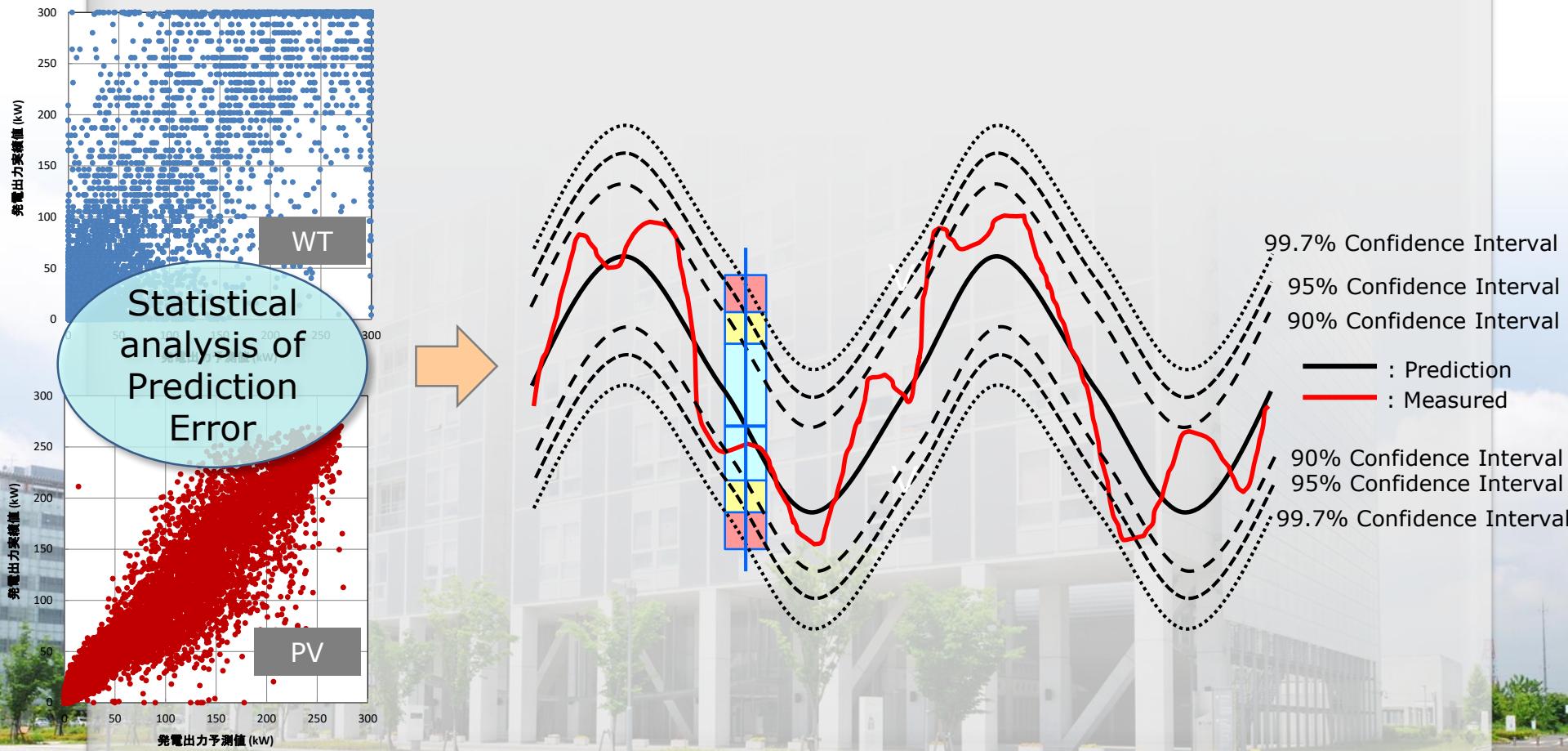
Azuchiyama Site (Niijima) : Wind Velocity (Altitude)



Low pressure with cold front move to east on Sea of Japan

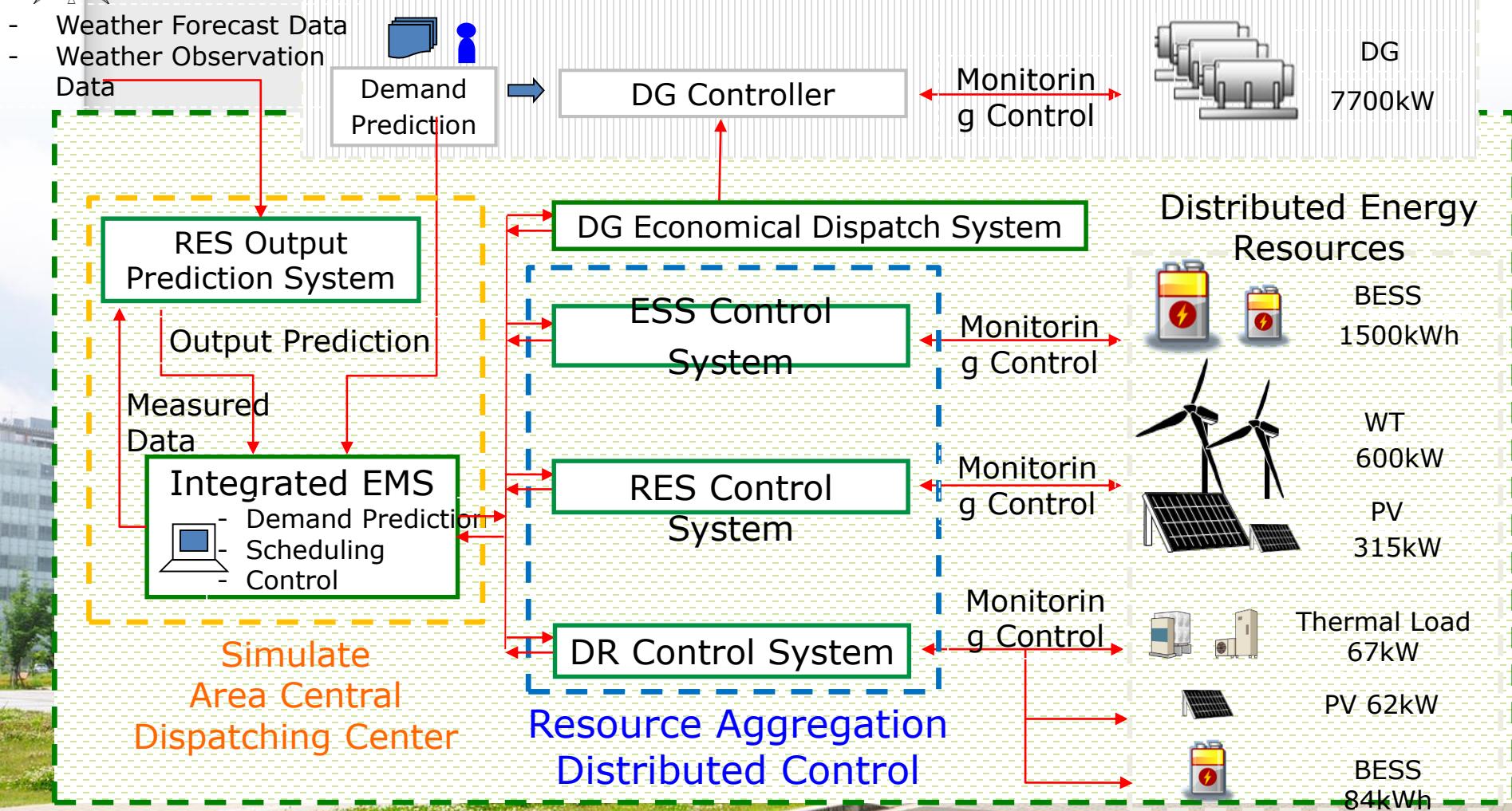


Prediction confidence interval



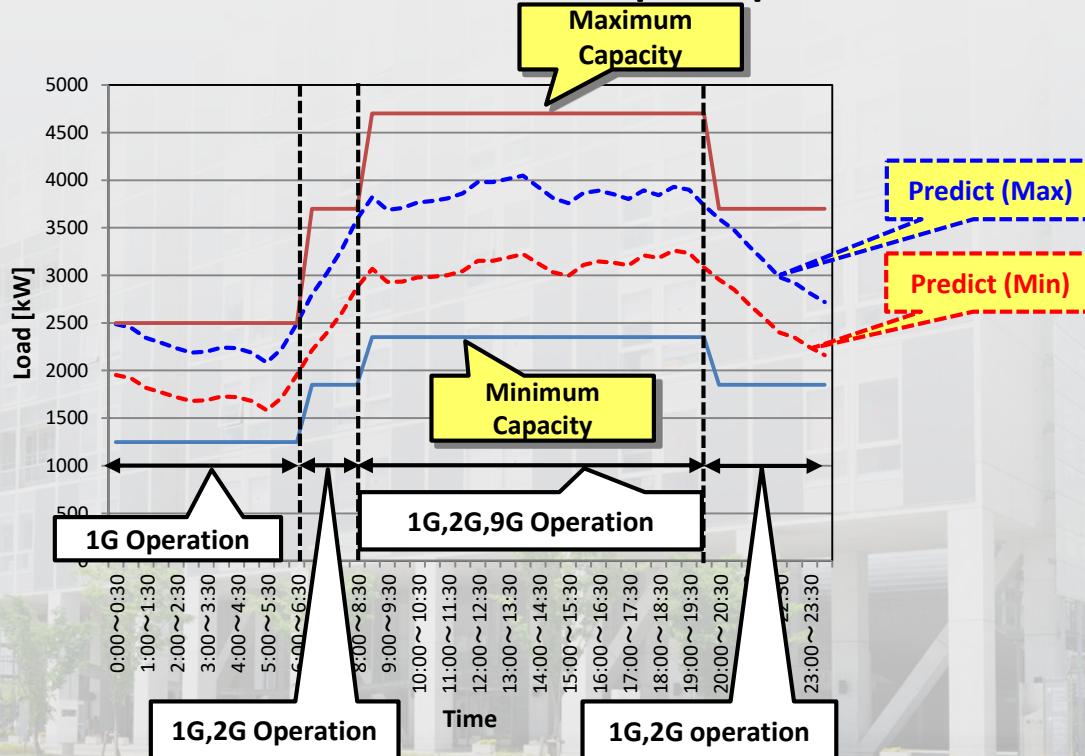


Distributed Coordinate Control System



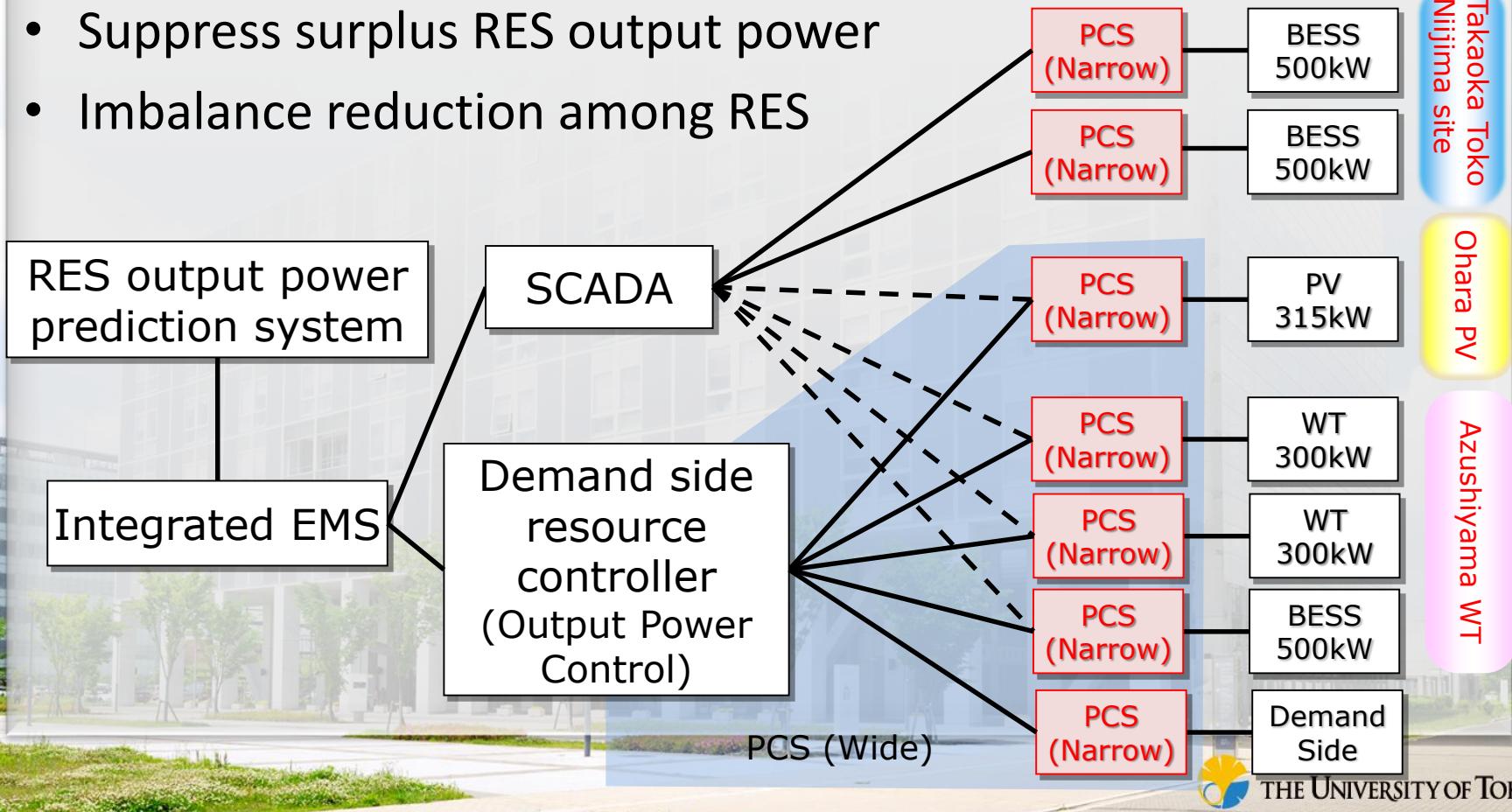
Scheduling by use of prediction confidence interval

- Unit Commitment taken into account prediction confidence interval of RES output power



Output Power Control

- Remote control system by “demand side resource controller”
- Suppress surplus RES output power
- Imbalance reduction among RES

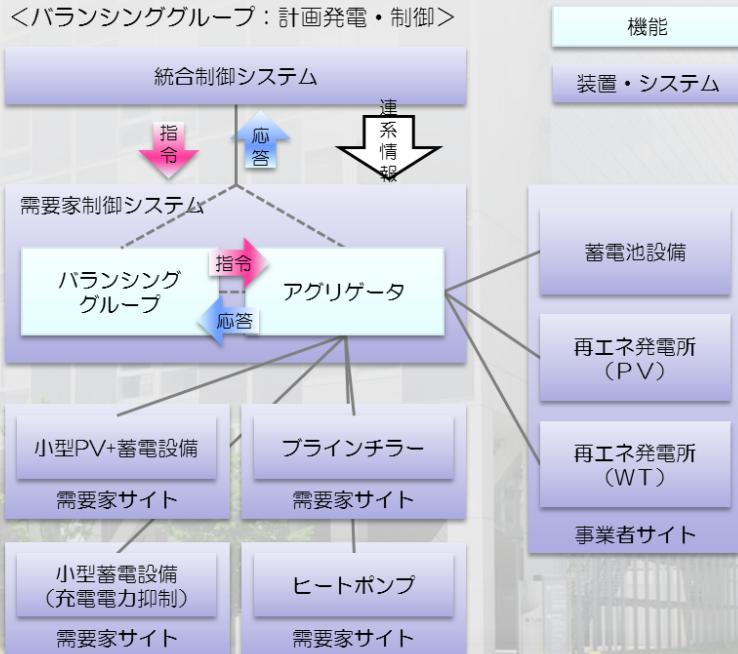
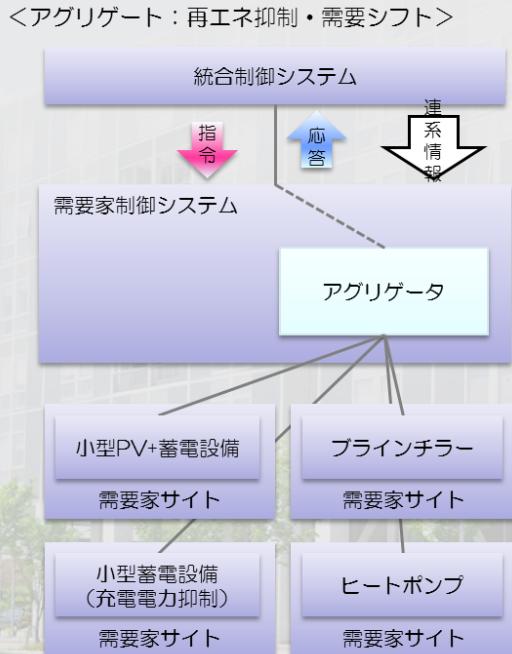


Definition of “Narrow sense” and “Wide sense” PCS

- Japanese local classification rule
- Narrow sense PCS
 - PCS with output power control input
 - Only limits PCS output by control signal
- Wide sense PCS
 - Receive control schedule from upper layer controller
 - Consists of narrow sense PCS and output control unit

Function of demand side resource controller

- Aggregation : Demand side resources control according to grid operator's request
- Balancing Group : Imbalance reduction among PPS



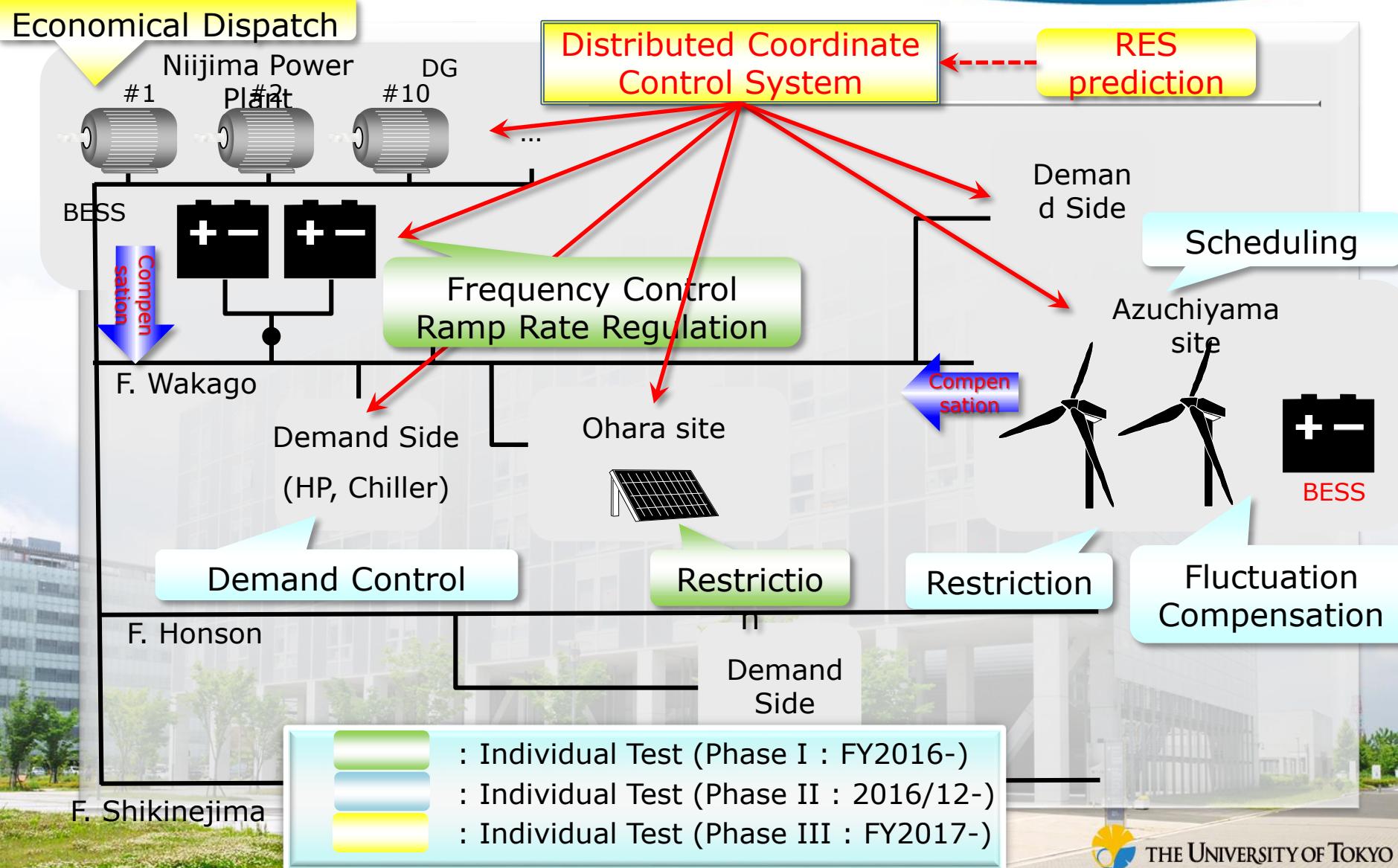
Examples of use cases

	Objective	Control	Target
Surplus Power	Direct RES and ESS control from area central dispatching center in case of surplus RES output	RES output restriction ESS charge control to reduce surplus output	RES + Grid side ESS ESS located by RES
	Demand shift by RES owner in case of RES output restriction	RES output restriction ESS discharge control	RES + ESS located by RES HP, Brine Chiller
Fluctuation Mitigation	Fluctuation mitigation by RES side	ESS charge control	WT,PV + ESS located by WT
	Frequency regulation control by mitigating fluctuation caused by RES and demands	Demand Control	ESS (HP, Brine Chiller)
Schedule	Reduce imbalance from planned generation	ESS charge control	WT,PV + ESS located by WT

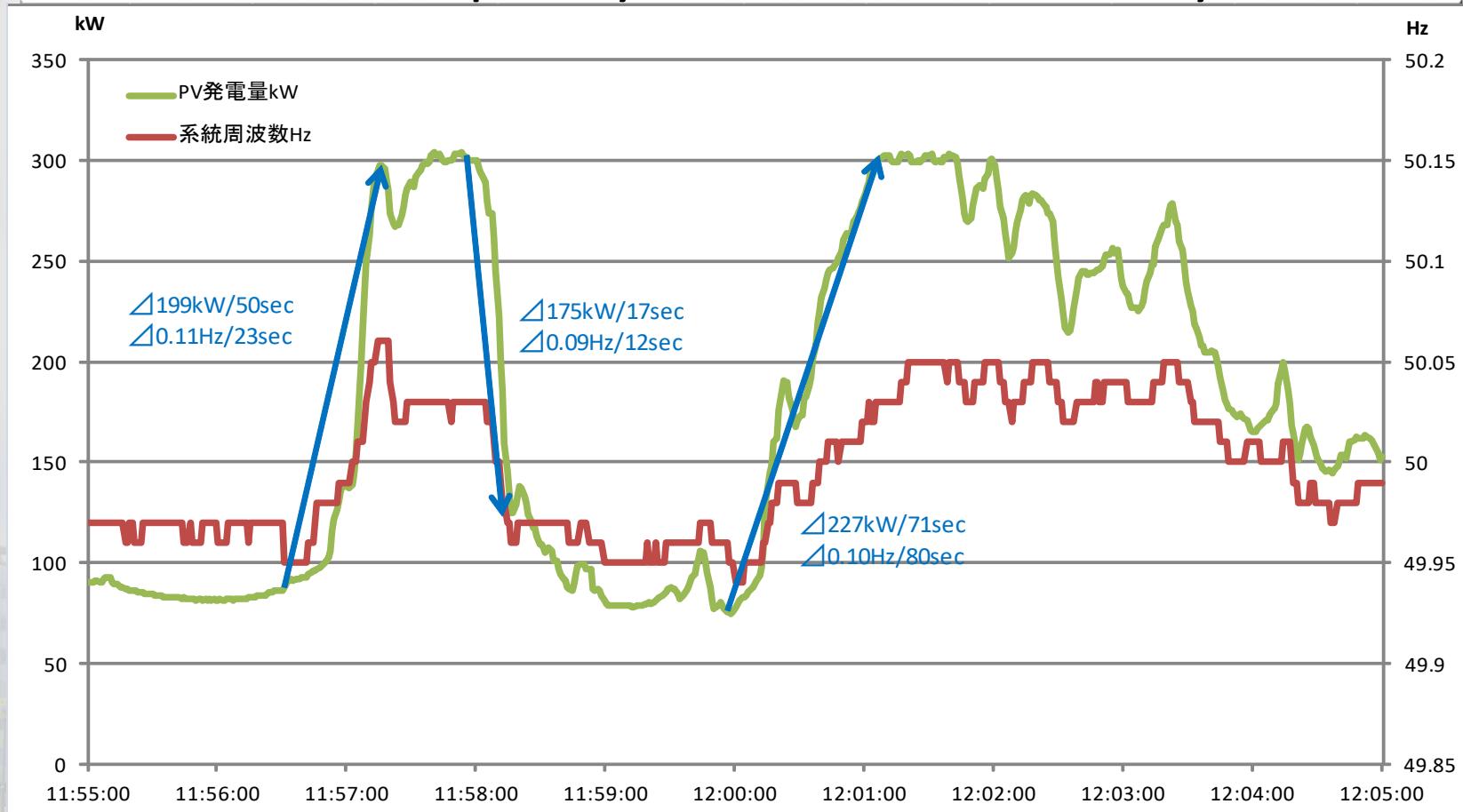
Function of test equipment

Player	Test Location	Test Equipment	Function	Controller
Area central dispatch center		Integrated ESS RES output prediction system	Generation schedule taken into account RES prediction <ul style="list-style-type: none"> - Economical dispatch - Reserve capacity reduction - Load frequency control Dispatch control signal	ACDC (Remote)
Power producer	Niijima Power Plant	Diesel Generator, Controller	Economical scheduling Power control by reference	ASDC(Remote)
BESS aggregator	Takaoka Toko Niijima site	BESS 500kWh x 2	ESS charge in case of surplus power Frequency and power flow fluctuation compensation	ASDC, Aggregator, Local
RES owner	Azushiyama site	WT 300kW x 2, BESS 500kWh	WT control Frequency regulation by ESS Fluctuation compensation by ESS Ramp change mitigation by ESS	Local Aggregator Remote
	Ohara site	PV 315kW		
Retailers	Village office, school etc.	PV, ESS, HP etc.	Power restriction in case of surplus ESS charge incase of surplus	ASDC(Remote), Local

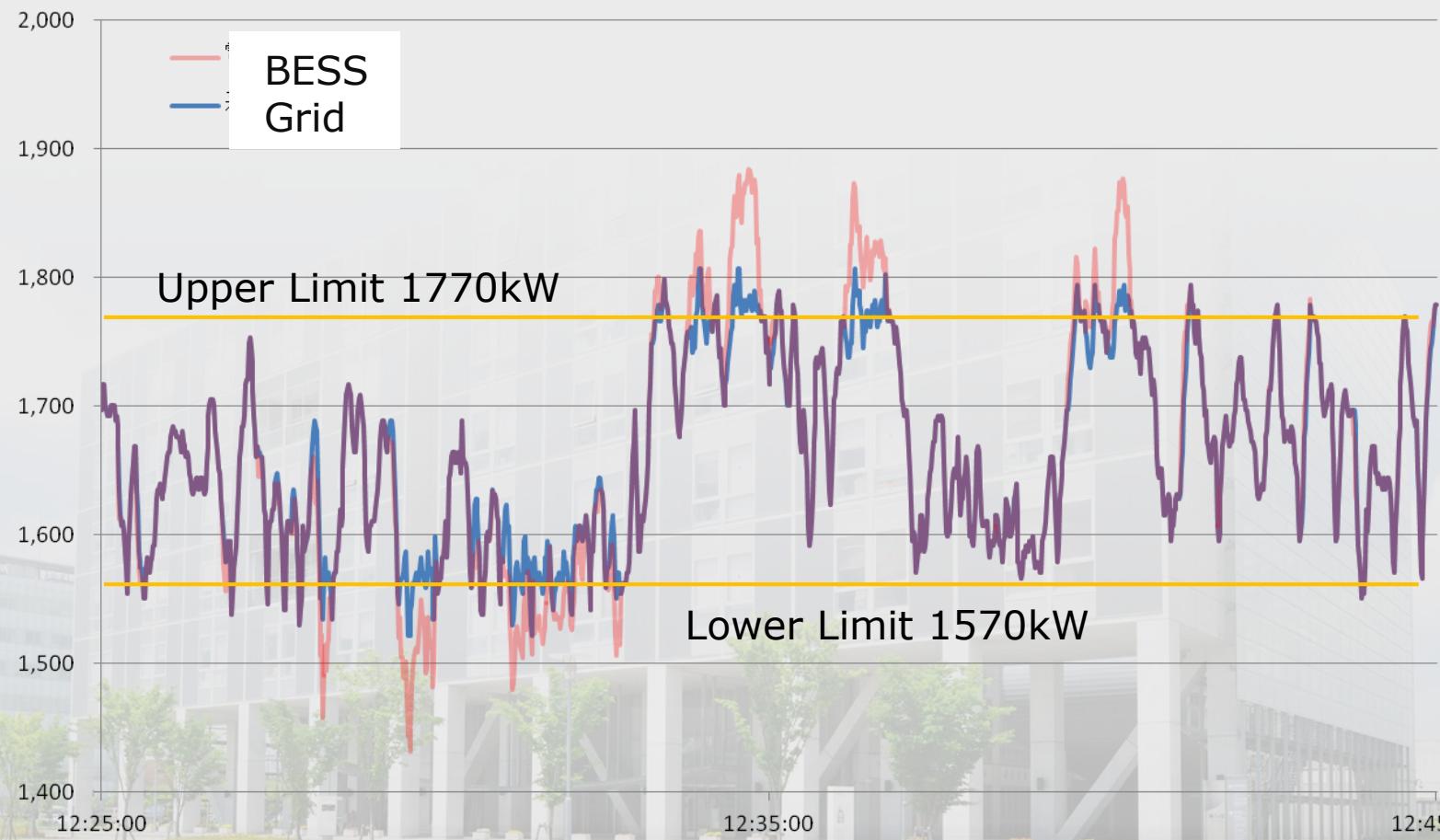
Test schedule



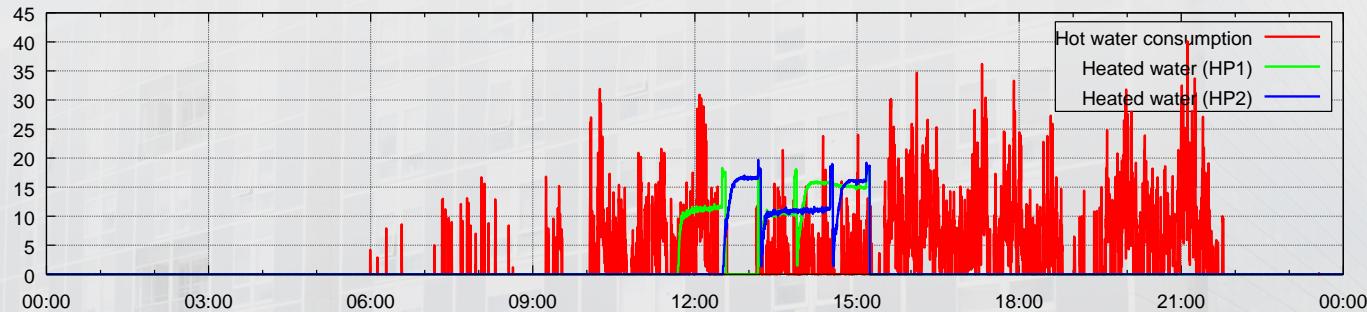
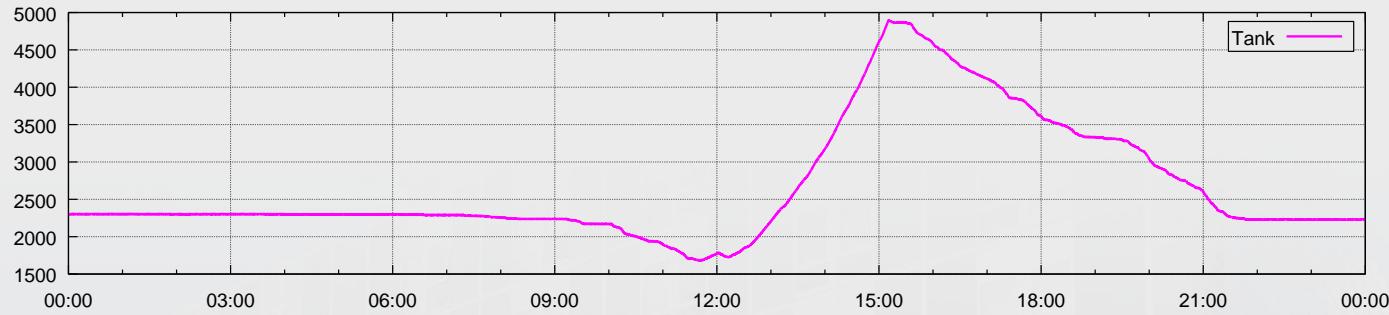
Evaluation of frequency fluctuation caused by PV



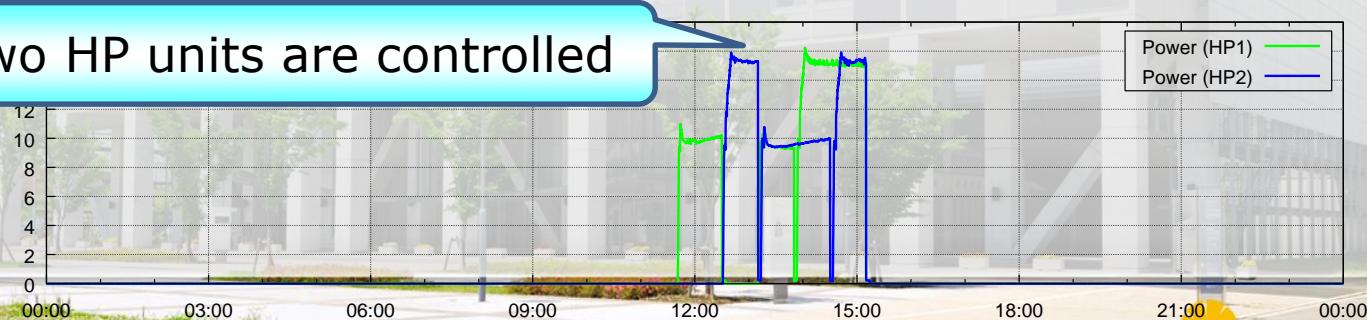
Demand fluctuation compensation by BESS



Heat Pump Control Test



Two HP units are controlled



Integrated Test (Phase III)

- Introduce RES output power prediction to integrated EMS
- Enhance DG controllability
- Frequency control and surplus power reduction by grid side BESS
- Frequency control and surplus power charge by local BESS
- RES power restriction



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