

# **Advanced Challenges of Kyushu EPCO due to Rapid PV Penetration**

**Kyushu Electric Power Co., Inc.**

**May 22, 2018**

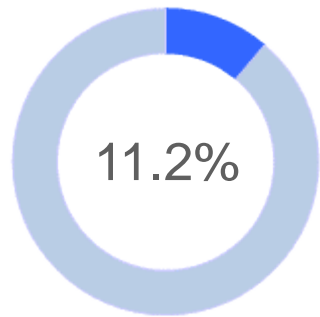
1. About Kyushu and Kyushu EPCO
  
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  - (1) Demand-Supply Balance
    - Output-Control system
    - Large-Capacity Storage Battery
  - (2) Power Quality
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3. Kyushu EPCO's Challenge

# About Kyushu and Kyushu EPCO

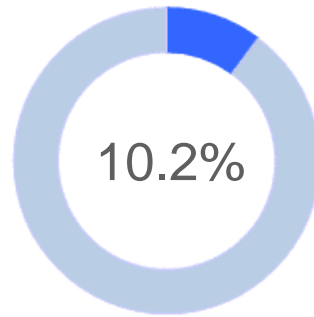
# Outline of Kyushu (principal indicators)

The economic scale, population and area of Kyushu account for approximately 10% of Japan.

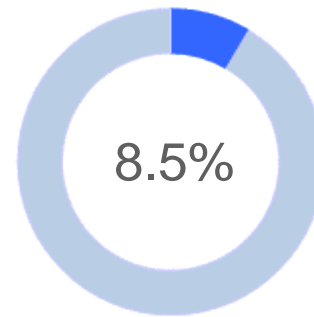
**Area**  
42,232 km<sup>2</sup>



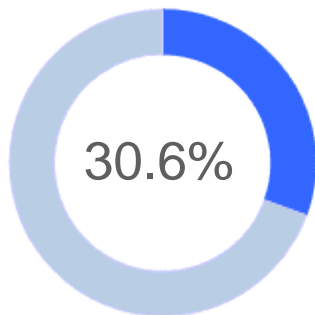
**Population**  
12.97 million



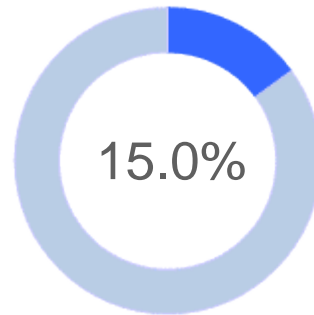
**Nominal gross product**  
\$ 392 billion



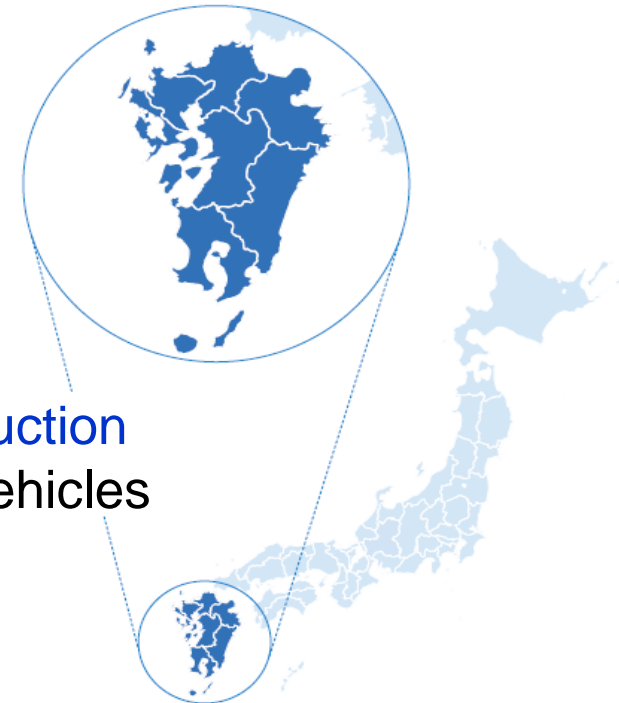
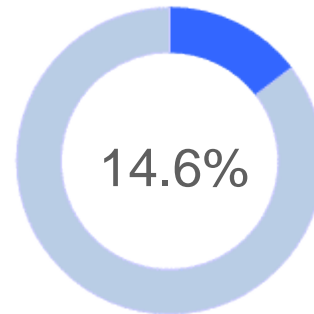
**IC production**  
\$ 6.41 billion



**Steel production**  
15.8 million tons



**Vehicle production**  
1.37 million Vehicles



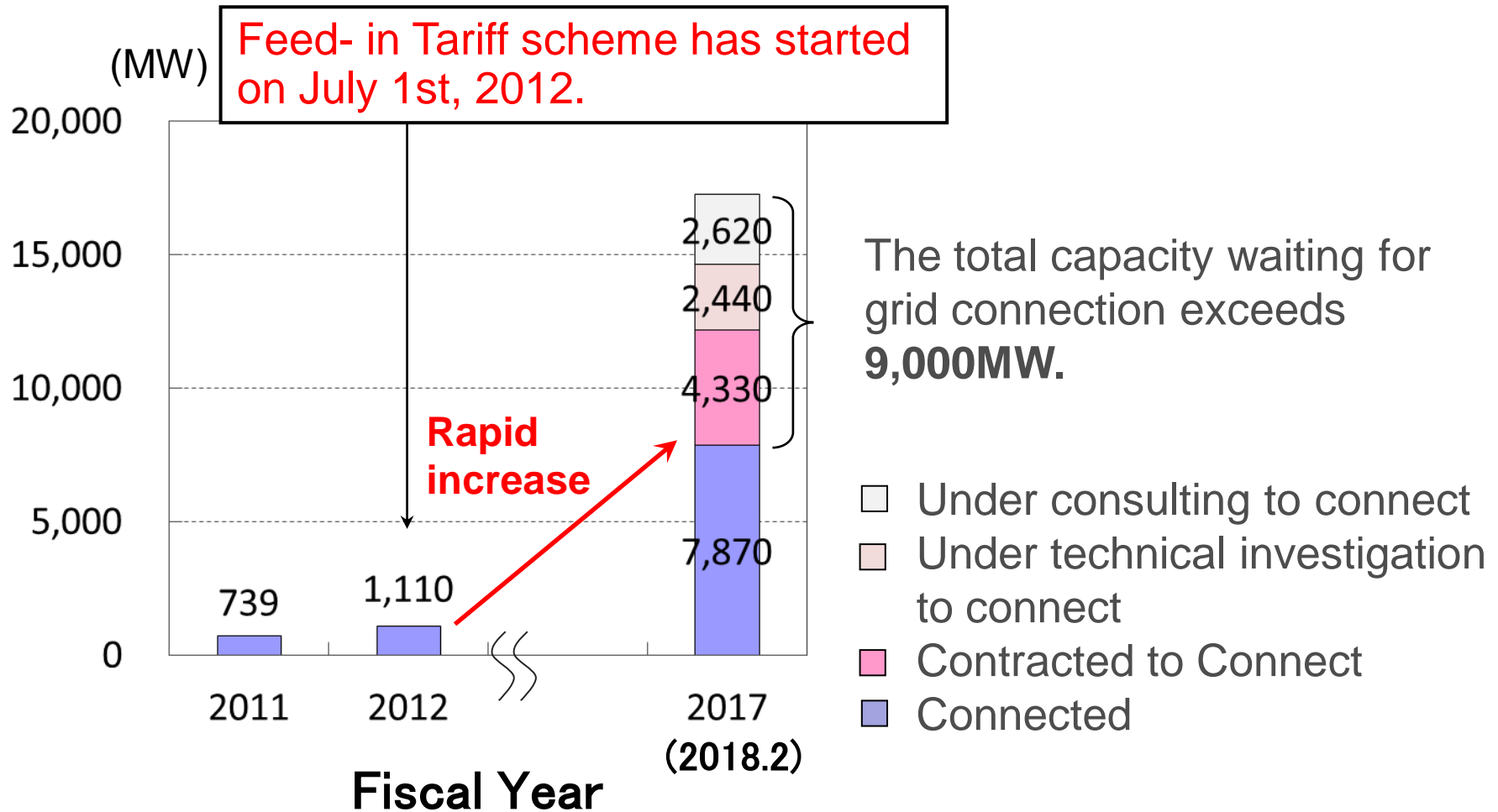
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Amount of Sales	\$ 15.1 billion	(1,696.3 billion JPY )
Total Asset	\$ 36.9 billion	(4,141.5 billion JPY )
Number of Employees	13,053	
Electric Sales Volume	78,619 millions of kWh (10% of Japan) - light: 28,535 - power: 50,084	
Date of Establishment	May 1, 1951	
Capital Fund	\$ 2.1 billion	(237.3 billion JPY)

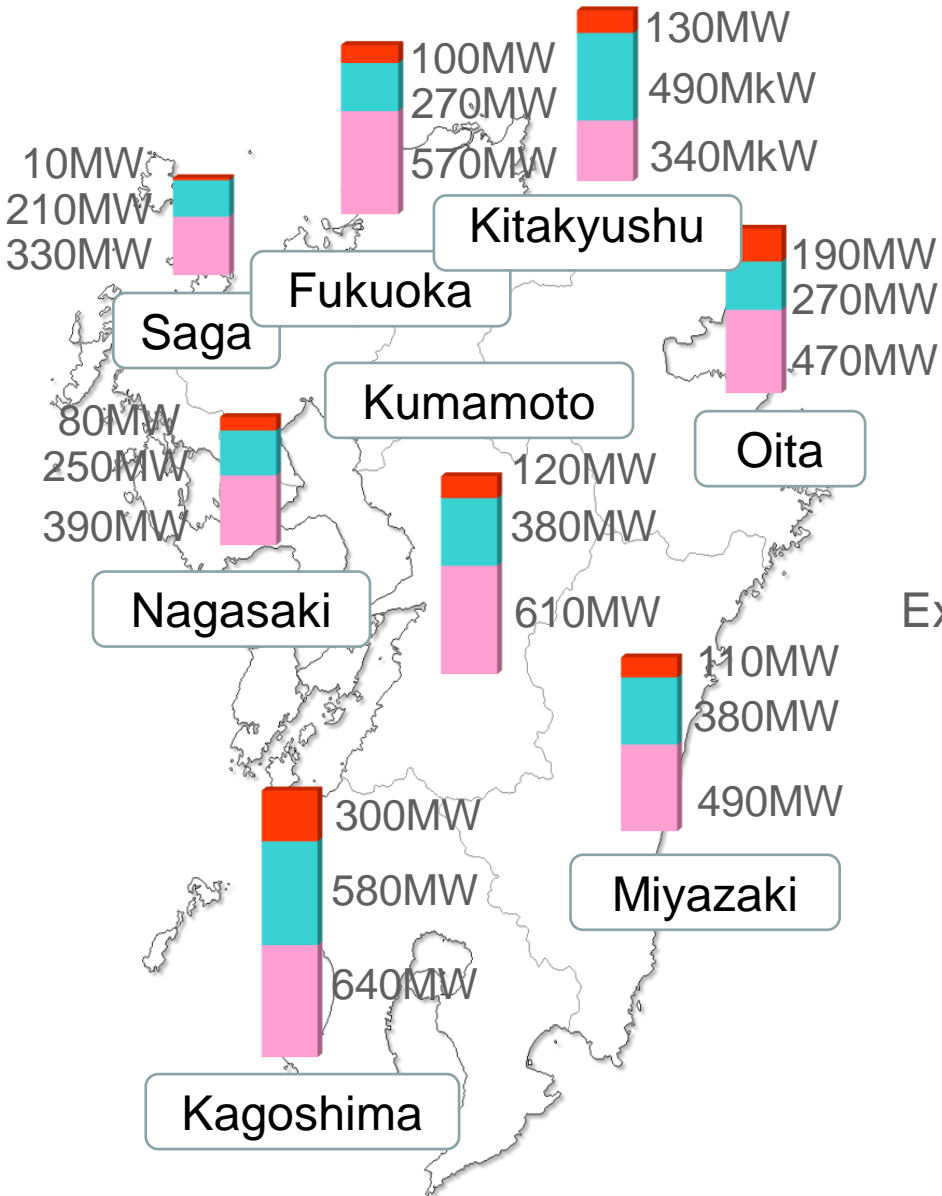
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# Many Requests for PV Connecting to Power Grid

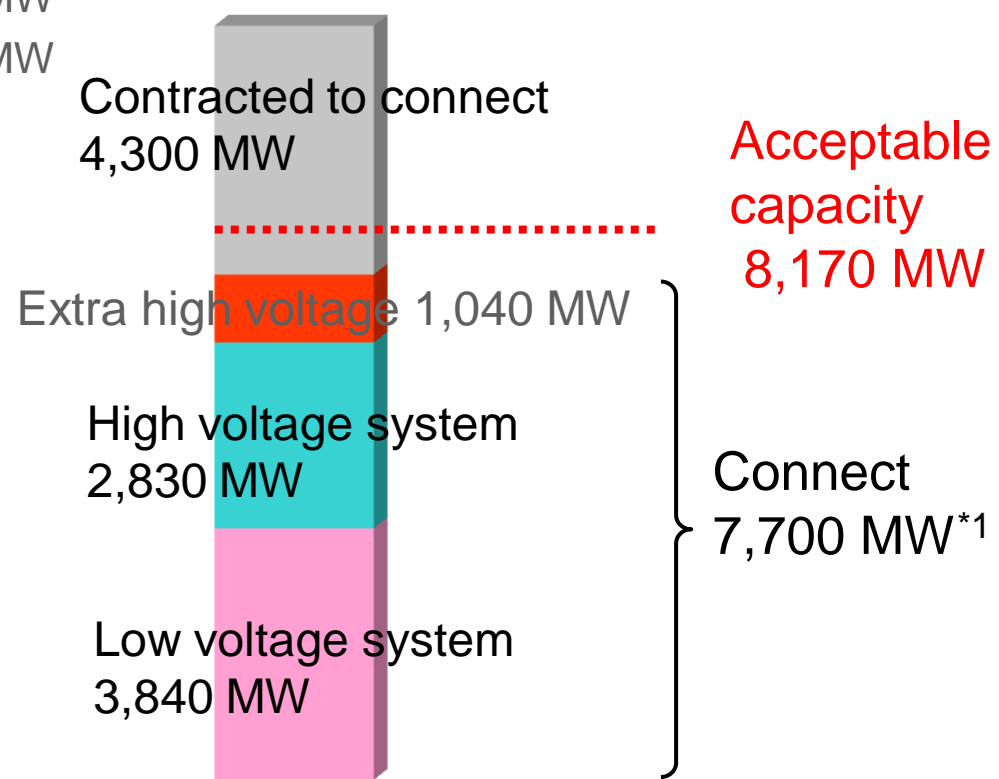
- Peak demand in summer time was about **15,500MW**. (2016)
- The capacity of connected PV was about **7,870MW**. (2018.2)



# Capacity of PV Generators in December, 2017



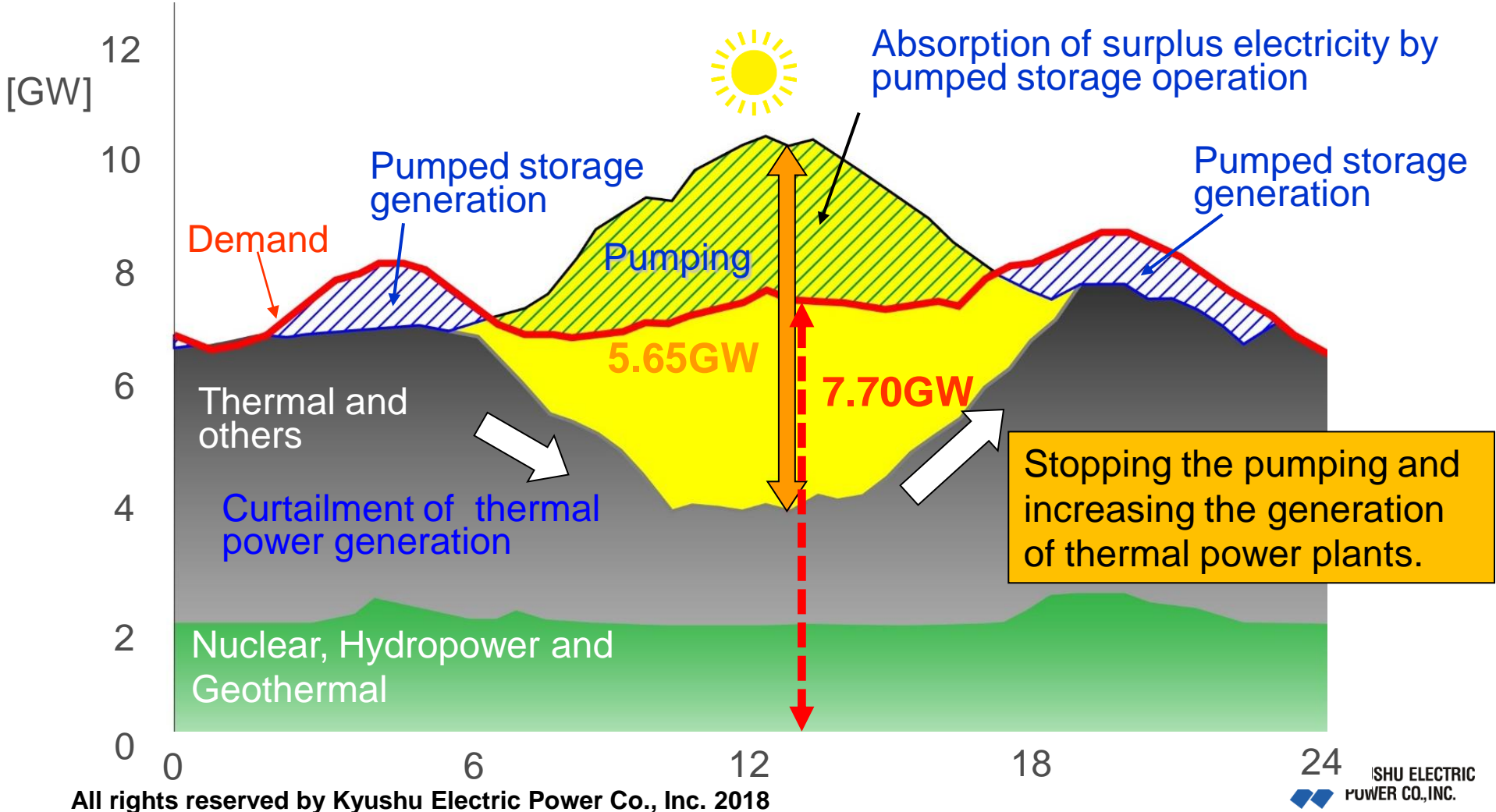
Total  
12,010 MW



\*1 18% of Japan

# Demand-Supply Balance on April 30, 2017

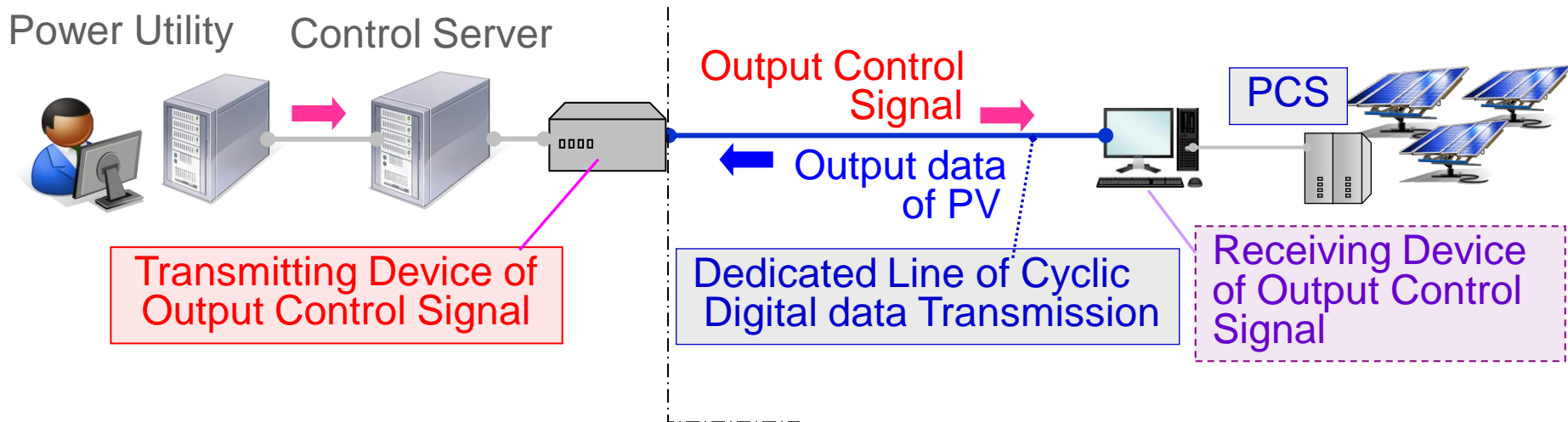
The power supplied from PV has exceeded 70% of the demand in April 30, 2017 in Kyushu area.



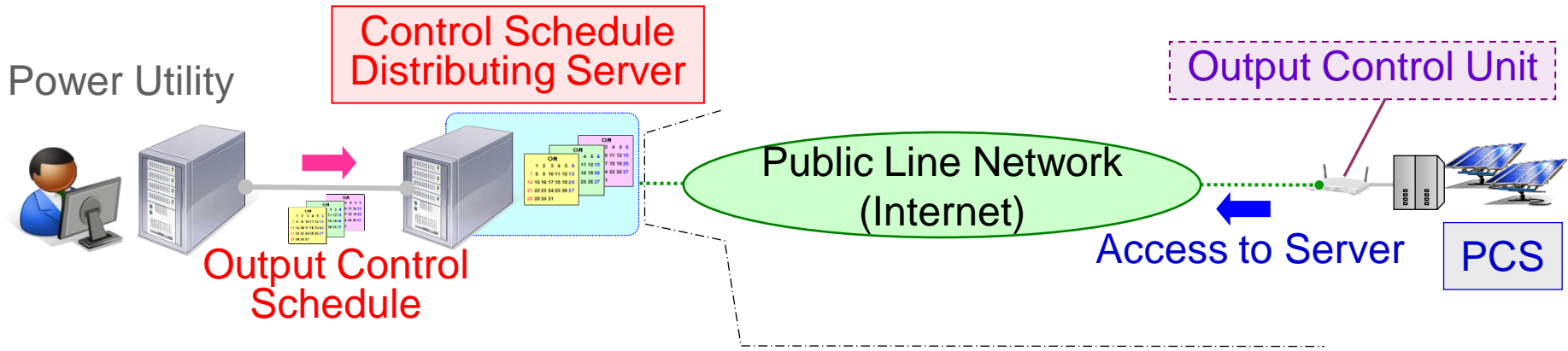
# Issues of Rapid Spread of Photovoltaics - Demand-Supply Balance

- To resolve the issue of adjusting the supply-demand balance, it is necessary to develop **the output control system of PV facilities** and introduce it quickly.
- Two types of output control system are developed to achieve the sure and precise output control.
  - Connection Voltage  $\geq 66\text{kV}$  :  
Interactive communication system ,  
via dedicated line.
  - Connection Voltage  $< 66\text{kV}$  :  
One-way communication system ,  
via the Internet.

Connection Voltage  $\geq 66\text{kV}$  : Interactive communication via dedicated line



Connection Voltage  $< 66\text{kV}$  : One-Way communication via the Internet



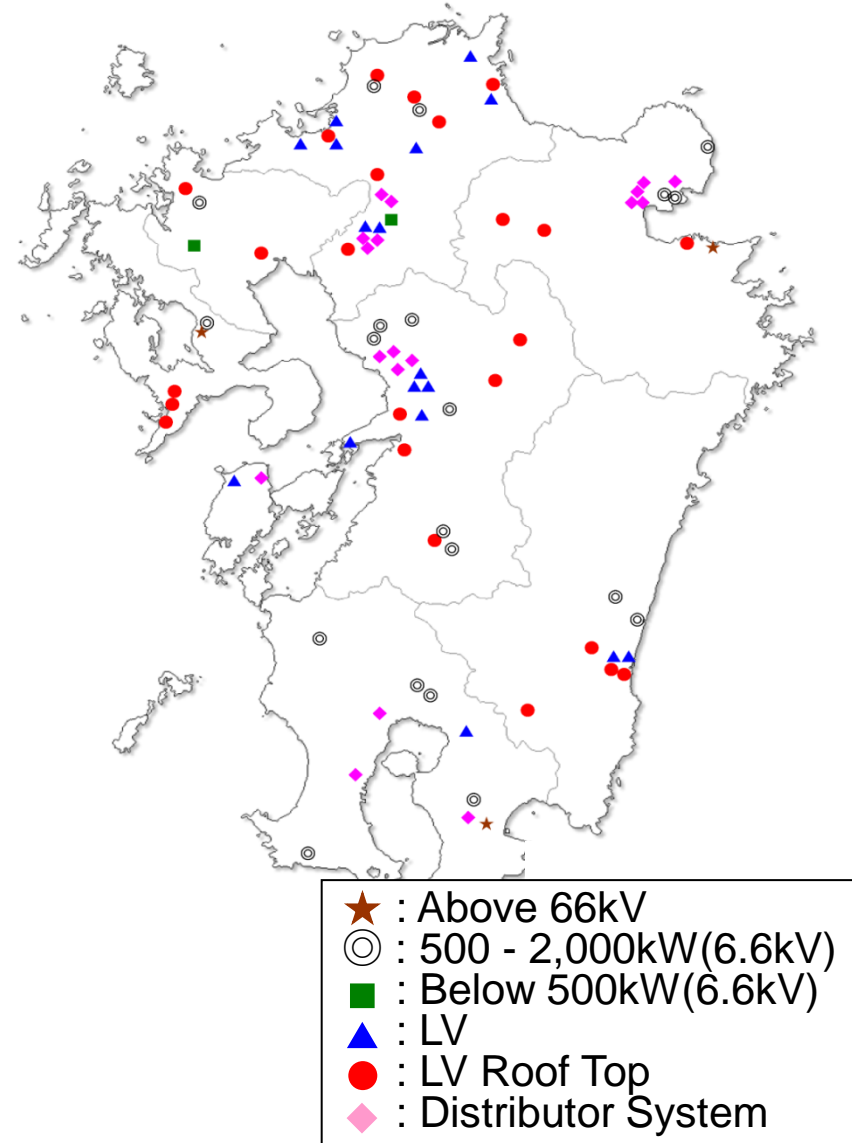
- The demonstration project to verify the reliability of output control system was started in June, 2015
- It completed successfully in February, 2016.

## <Facilities under control\*>

Connected Voltage	Number	kW
Extra High <66kV>	3	79,000
High <6.6kV>	22	27,000
Low <200V>	58	1,300
Total	83	107,300

\* Facilities were selected by public offering.

## Location of PV facilities



- ★ : Above 66kV
- ◎ : 500 - 2,000kW(6.6kV)
- : Below 500kW(6.6kV)
- ▲ : LV
- : LV Roof Top
- ◆ : Distributor System

# Result of Output-Control System Operation

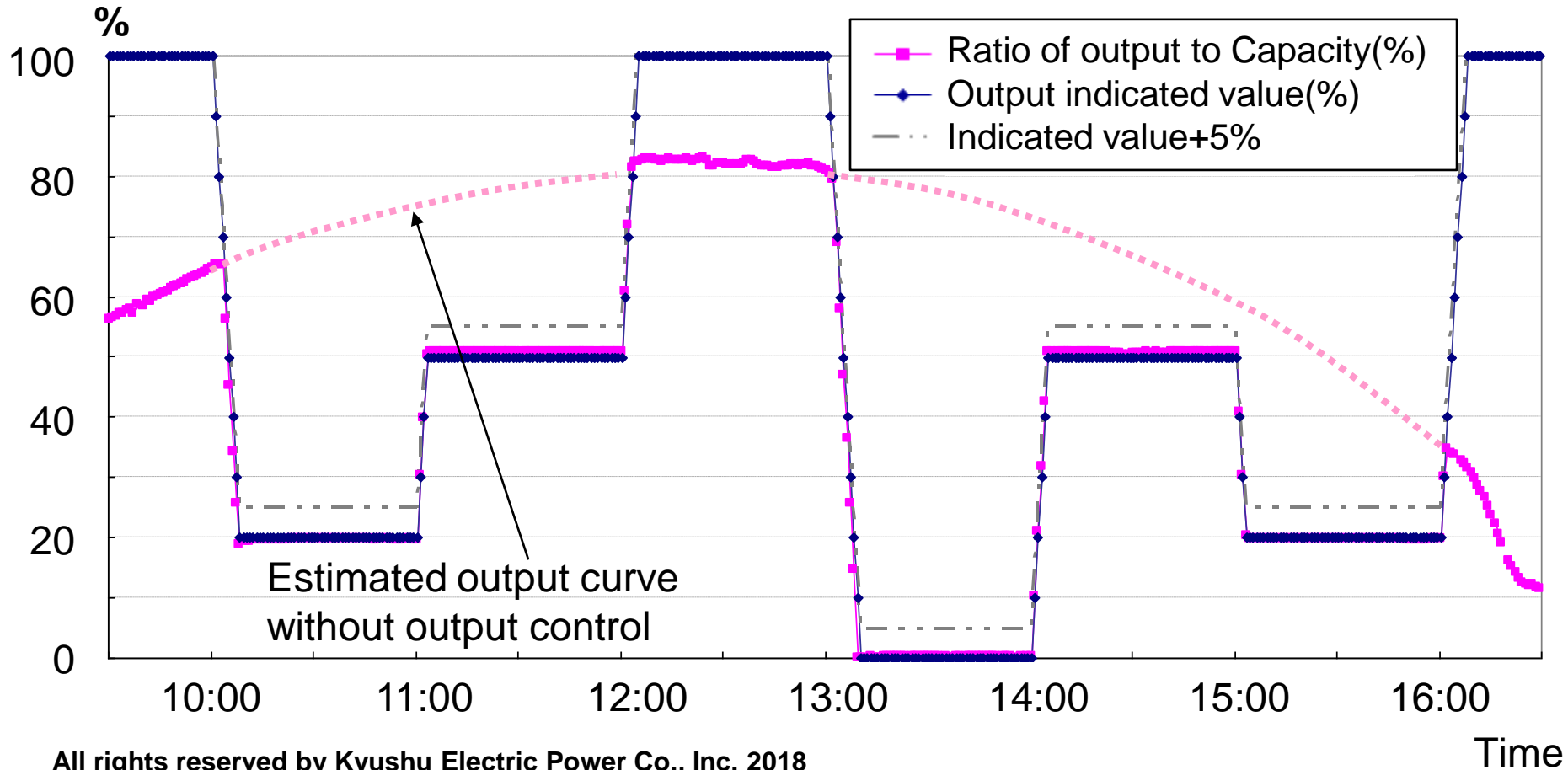
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Connected Voltage : 200V (One-way communication)

Date : January 20, 2016

Weather : fine and then cloudy

(The percentage of cloud cover is below 10%)



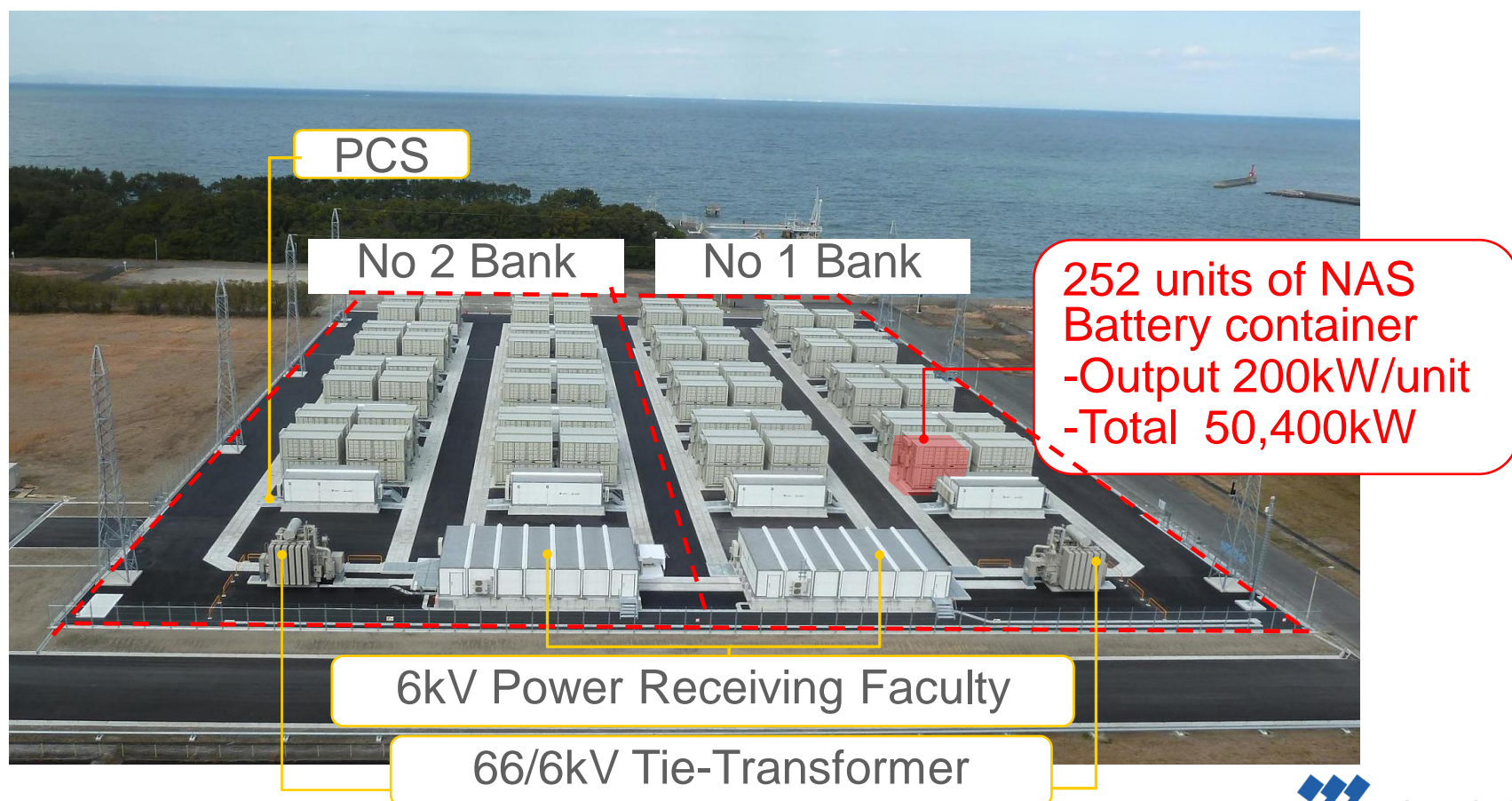
# Large-Capacity Storage Battery

Buzen Battery Substation located in Fukuoka Prefecture

- Storage battery capacity: 50,000 kW (about 300,000 kWh)

- \* One of the largest system in the world

- \* Storage battery installation area: About 14,000m<sup>2</sup>

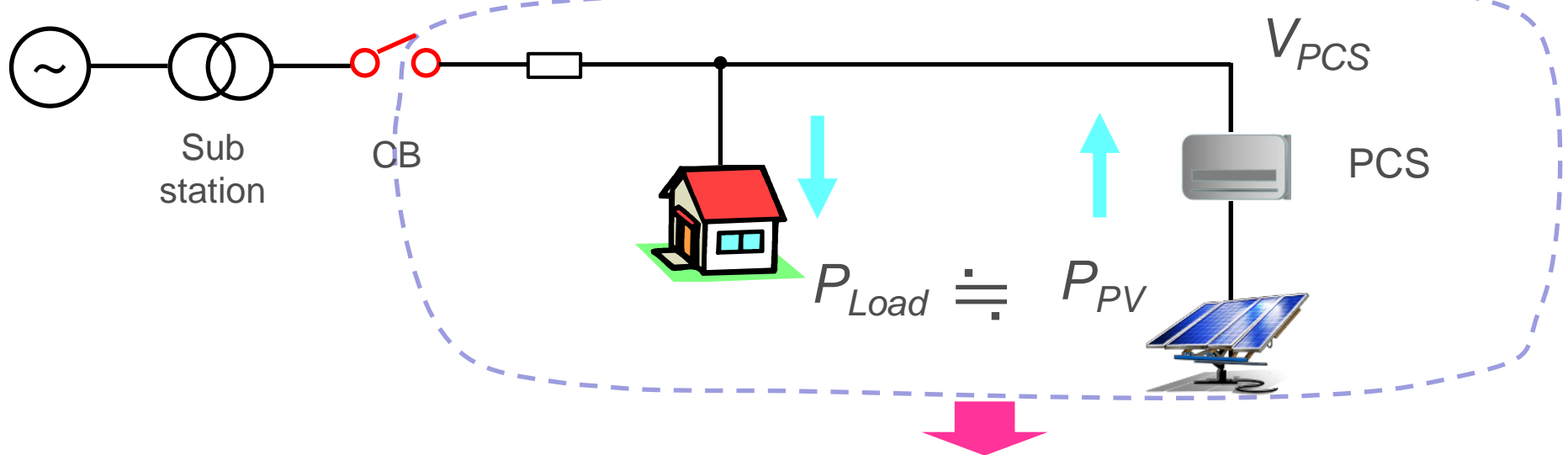


# Issues of Rapid Spread of Photovoltaics - Power Quality

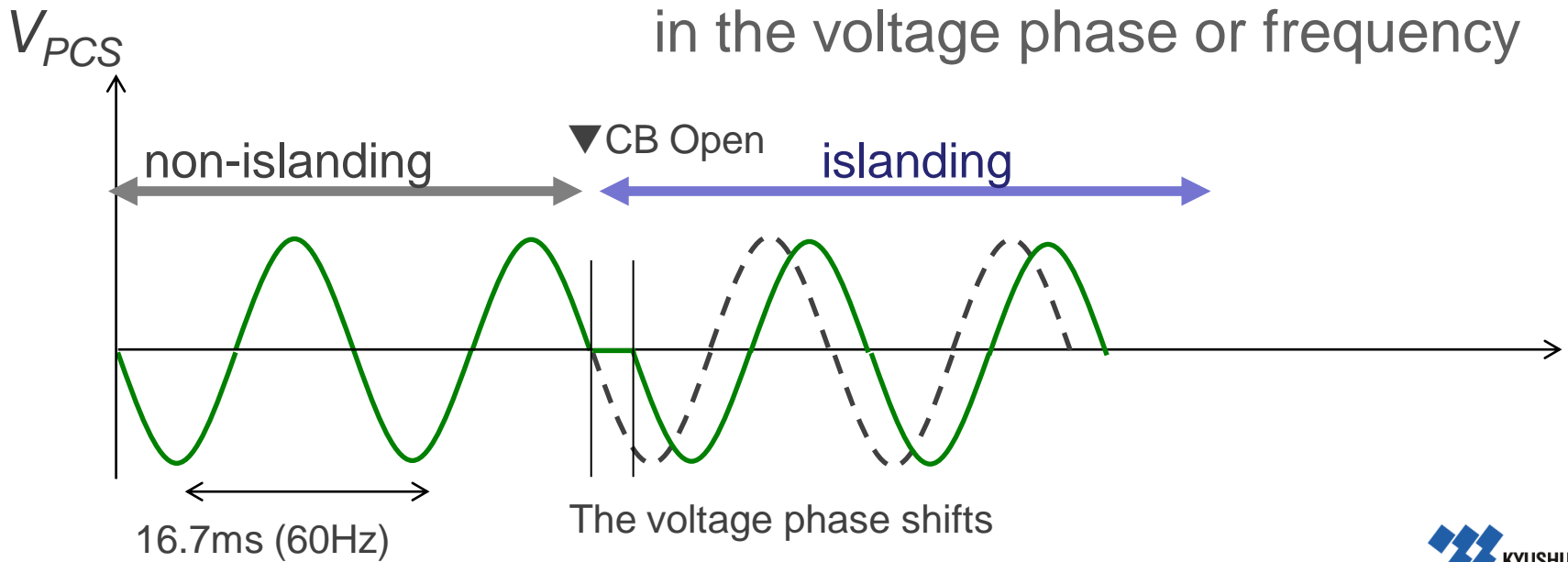
- The Grid Code in Japan requires both **Passive** and **Active Methods** for surely detecting islanding.
  - When output of PV generators and load are almost equal, deviation of a reference voltage or frequency are too small for protective relay such as OVR, UVR, OFR, UFR to detect.

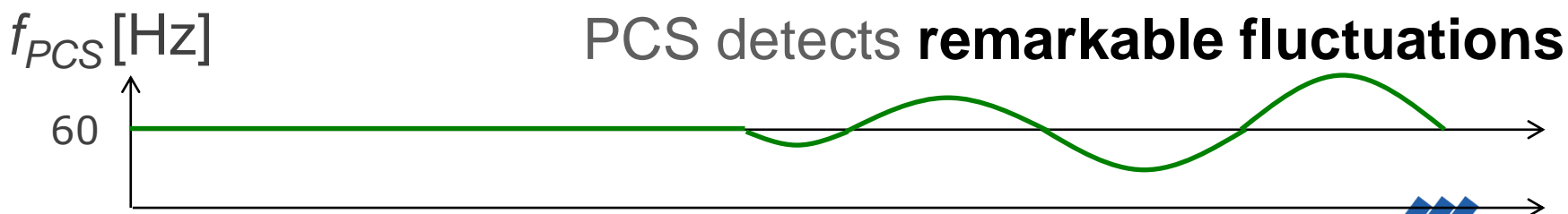
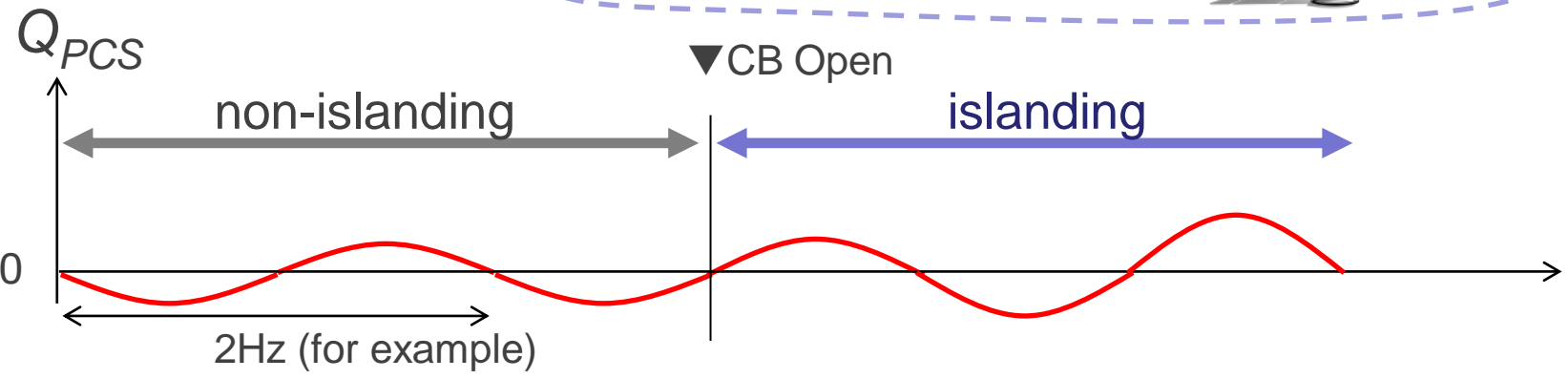
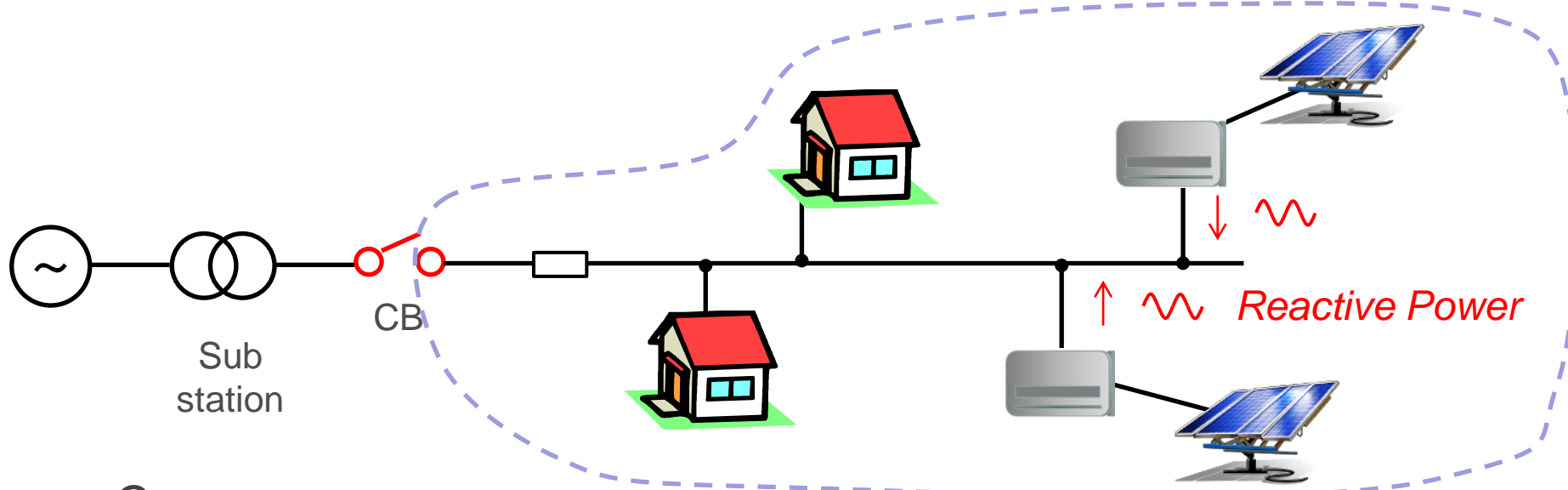


- **Reactive power** due to active method has caused **voltage flicker** in power system with rapid penetration of PV.



PCS detects **sudden changes** in the voltage phase or frequency



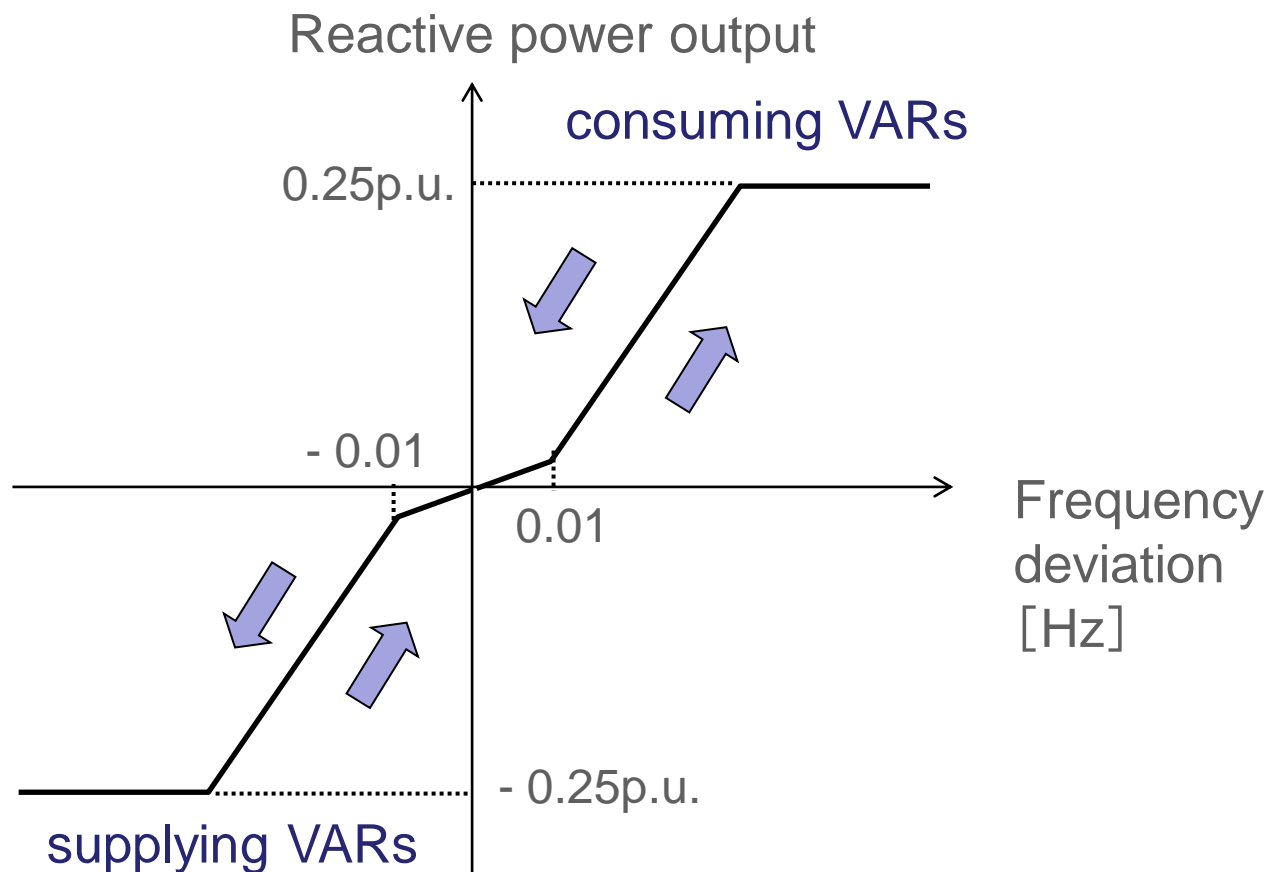


- With **increase of PV**, the detection of isolated operation will be more difficult, because the disturbance signal of PCS may interfere with each other.
- **“New Active Method”** that surely detects islanding has been introduced into low voltage PCS.



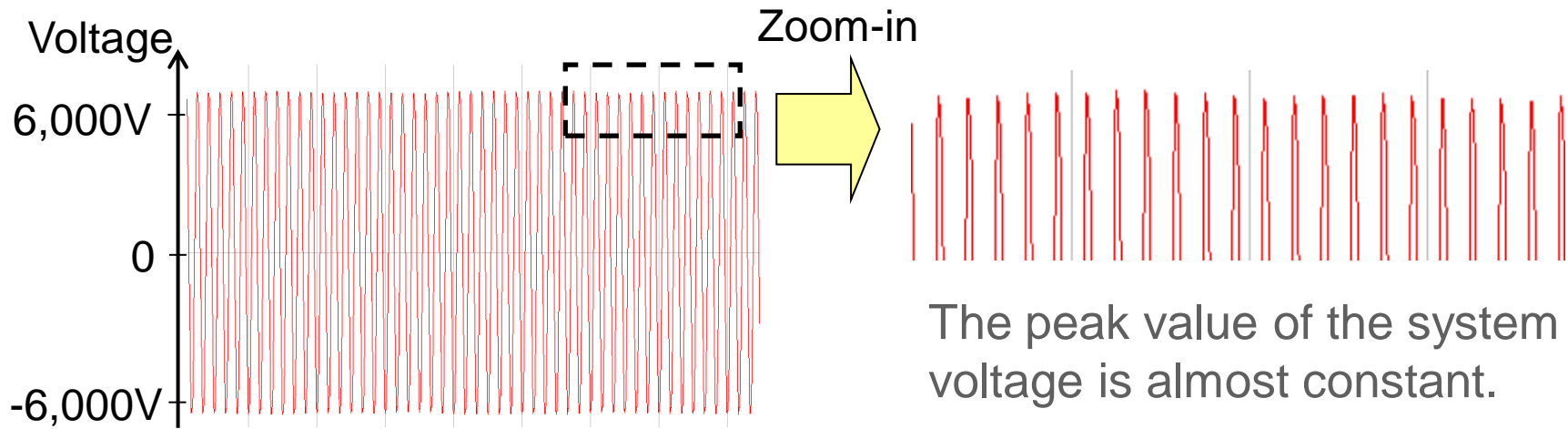
- **Voltage flicker** occurs due to reactive power from the PCS.
  - Especially, Kyushu EPCO experienced voltage fluctuations throughout Kyushu twice in 2017.
- As a countermeasure, we introduced **STATCOM** and got results.

- The specifications of the new method are regulated in JEM 1498.
- Each PCS consumes or supplies **reactive power** according to the **frequency deviation** synchronously.

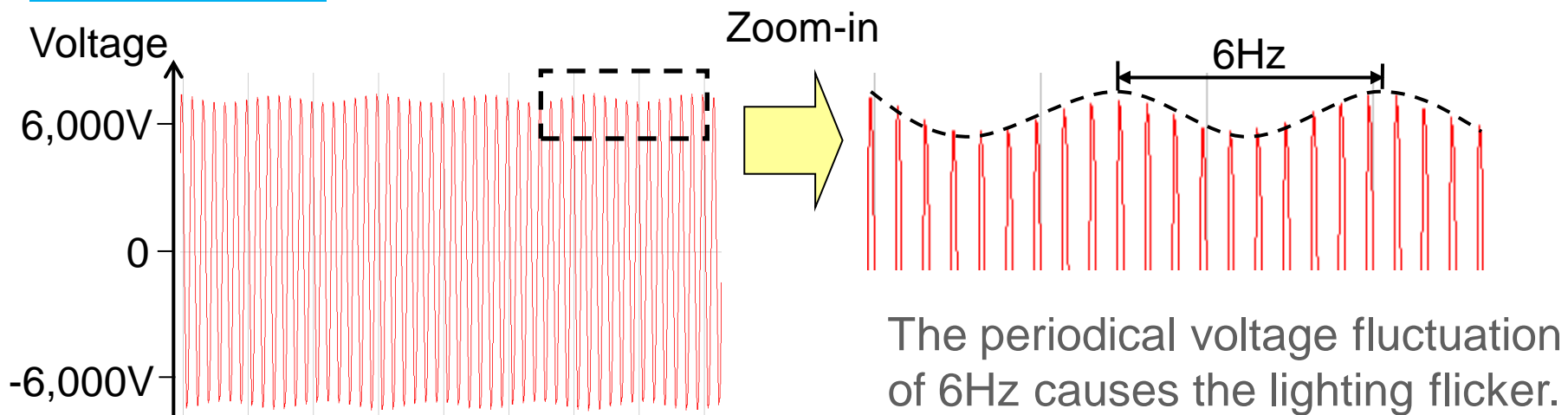


# Voltage Waveform with / without Flicker

## Without Flicker



## With Flicker



- In Japan, flicker level has been estimated by  $\Delta V_{10}$ .
- That is used for the influence of load fluctuation due to ark melting furnace (not IEC flicker meter defined by IEC61000-3-3) .

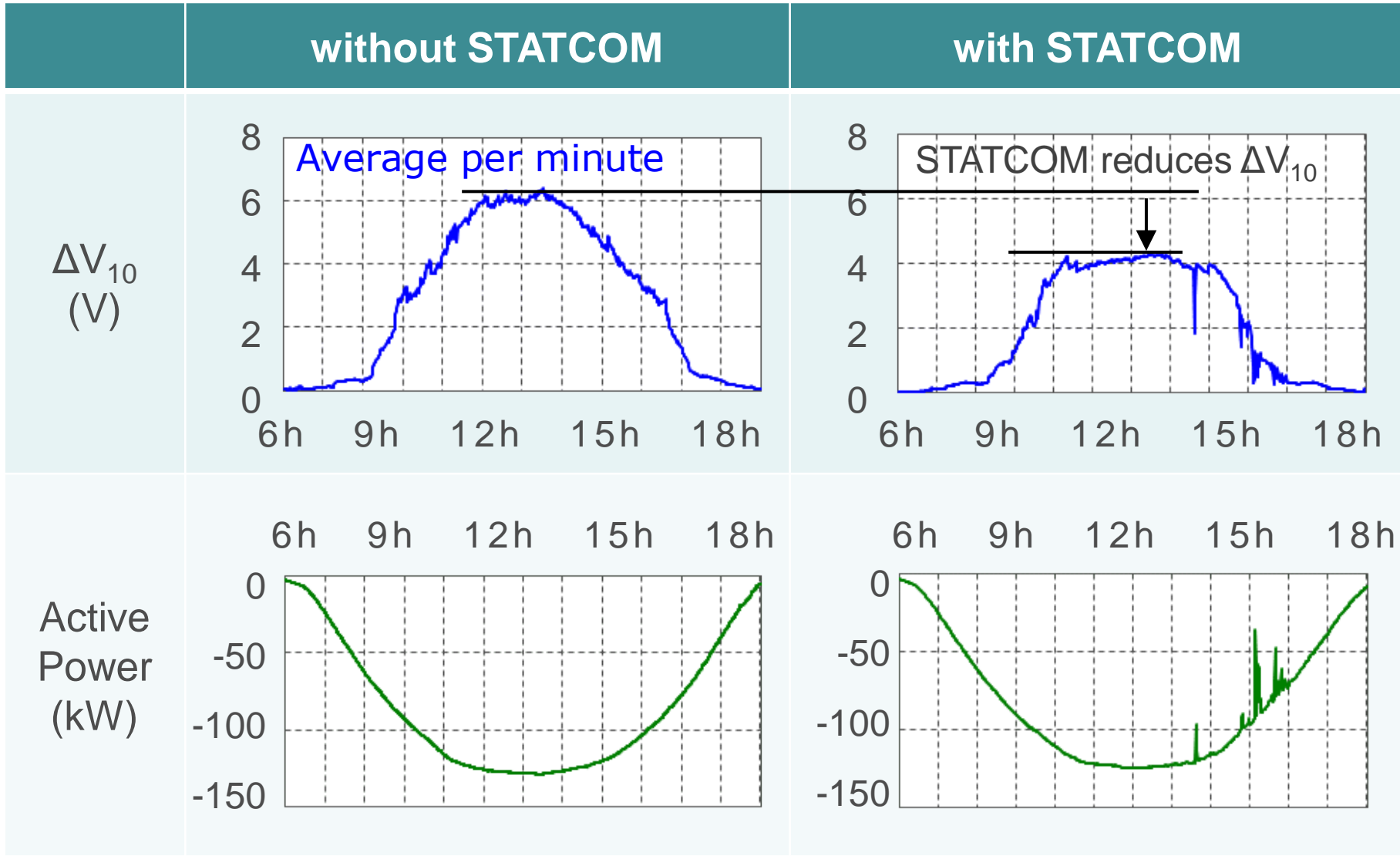
$$\Delta V_{10} = \sqrt{\sum_{n=1}^{\infty} (\alpha_n \times \Delta V_n)^2}$$

$\alpha_n$  : luminosity factor

$\Delta V_n$  : **rate of voltage fluctuation** of each order [%]

- The value of  $\Delta V_{10}$  should not exceed 0.45 .
- However,  $\Delta V_{10}$  **tends be higher** with increasing the quantity of reactive power.

STATCOM can effectively suppress the voltage flicker.



# Kyushu EPCO's Challenge



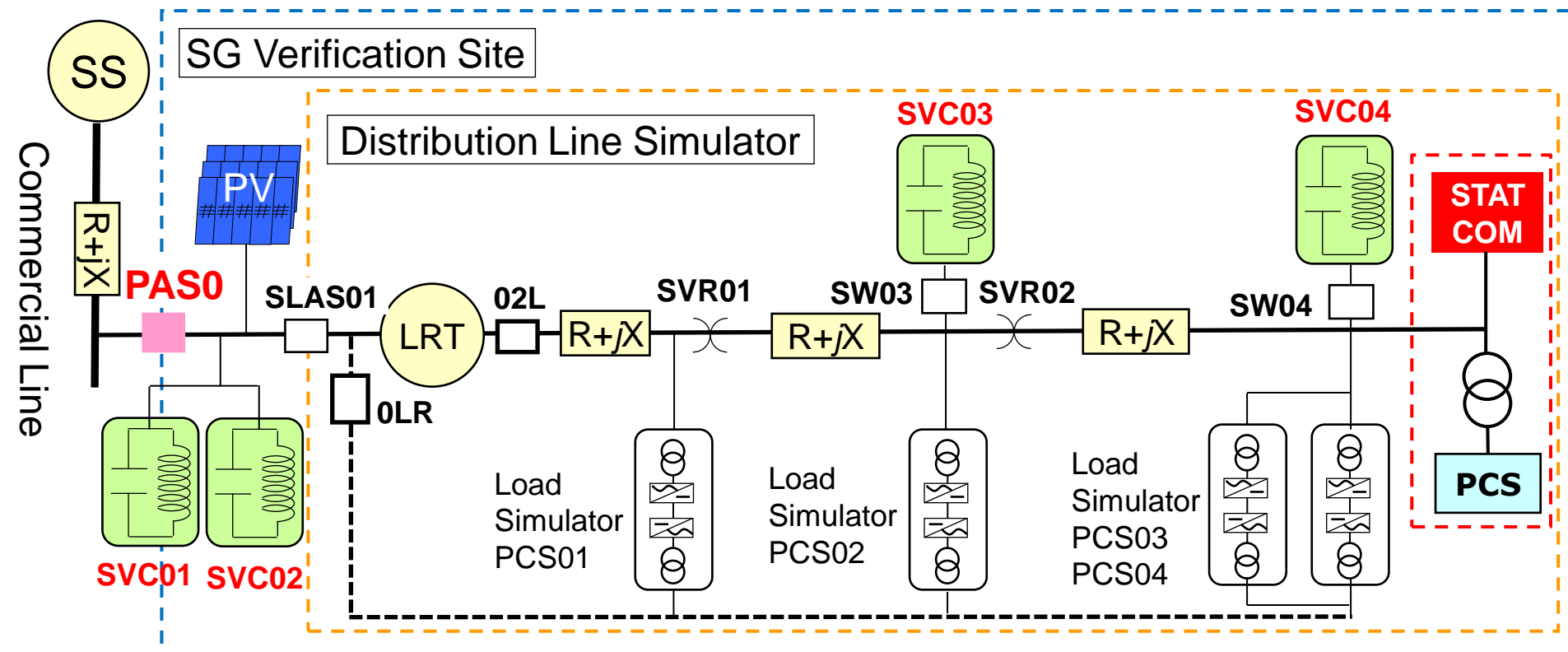
Solar Panels

## Distribution Equipment and Others

- Distribution Line Simulator
- Voltage Control Facilities
- Storage Batteries (Lithium Ion Batteries)

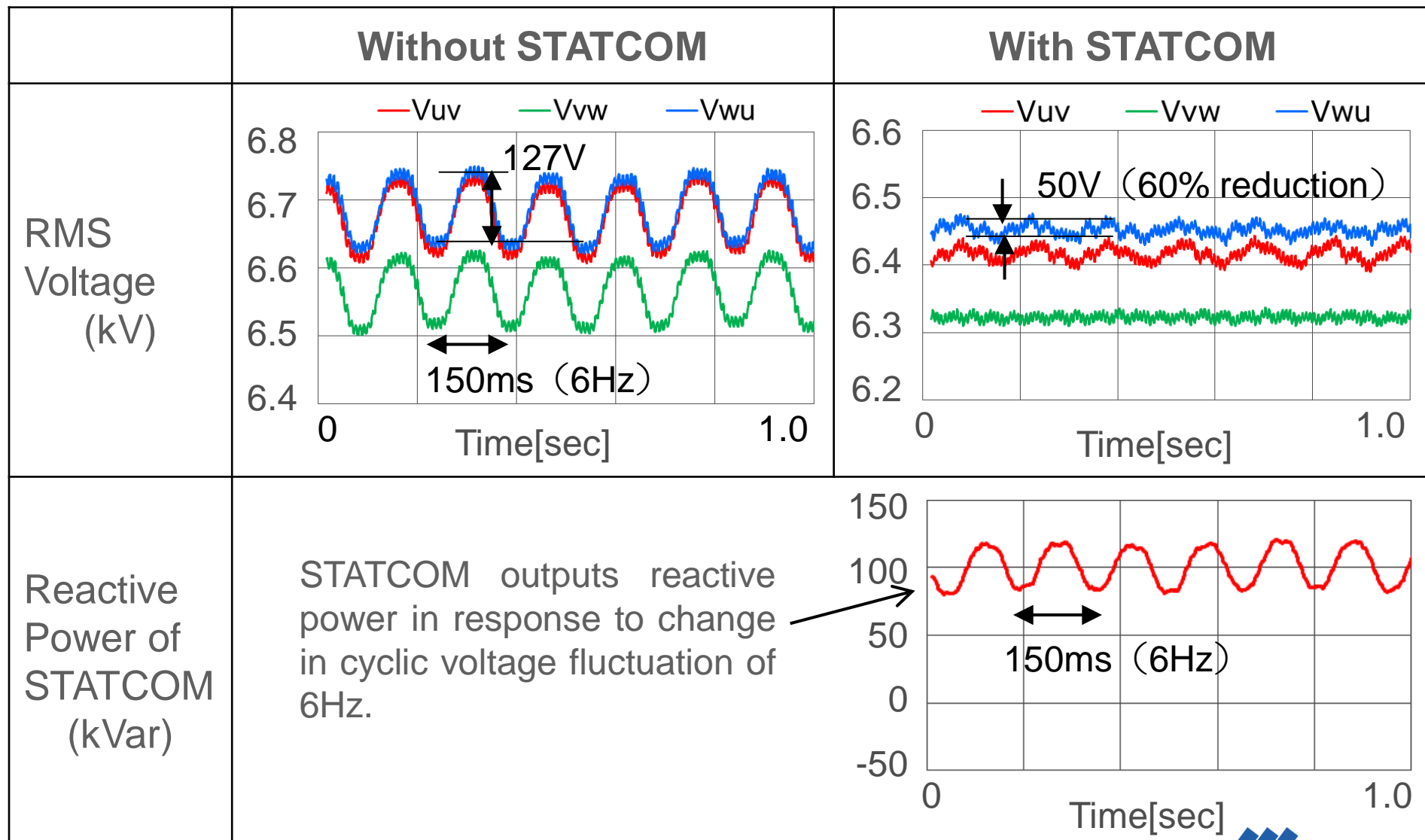
# Schematic Diagram of Test Facilities

- Adjusting **line impedance** can simulate distribution line between 3 and 40km length.
- **Load simulator** is capable of being simulated both load and generator.



# Example of Test Results

STATCOM reduced the voltage fluctuation from 127V to 50V.



**Kyushu EPCO will further pursue the improvement of power quality for expanding the introduction of renewable energy.**

