

# Large-scale PV Demonstration Projects in Japan

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Generation and Smart Grids

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# Background

**Security of energy supply**  
(Oil-alternative energy)

**Harmony with environment**  
(Lowering CO<sub>2</sub> emission)

**Promoting renewable energy is essential.**

**New energy introduction target**  
ex. PV: 4.82GW (FY2010)  
102GW (FY2030)

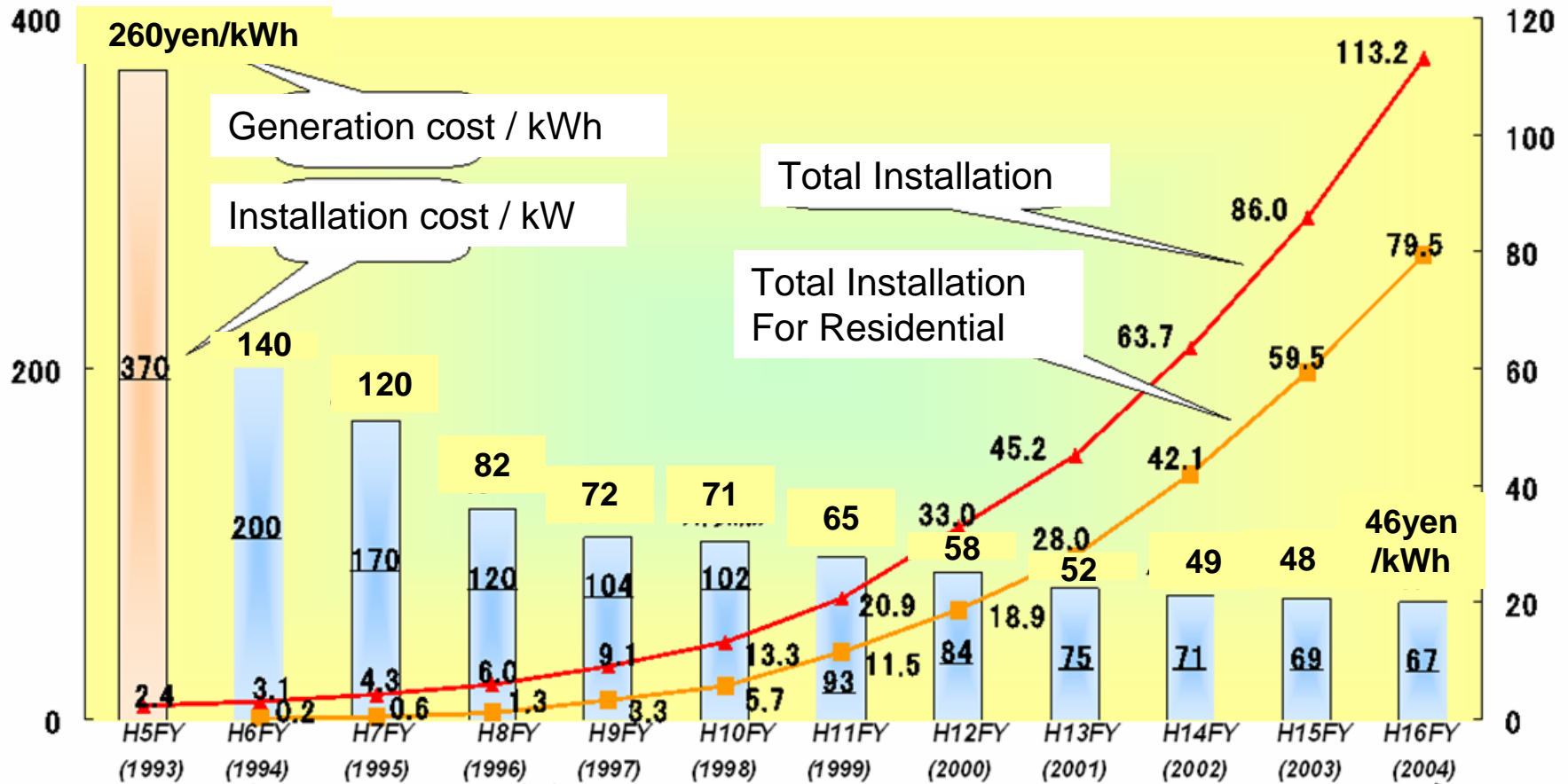
**Renewable energy resources are increasing in electric power system.**

**Power quality issues**

# Introduction of PV

Price of PV system  
(10<sup>4</sup> Yen/kW)

Installed PV capacity  
(10<sup>4</sup> kW)

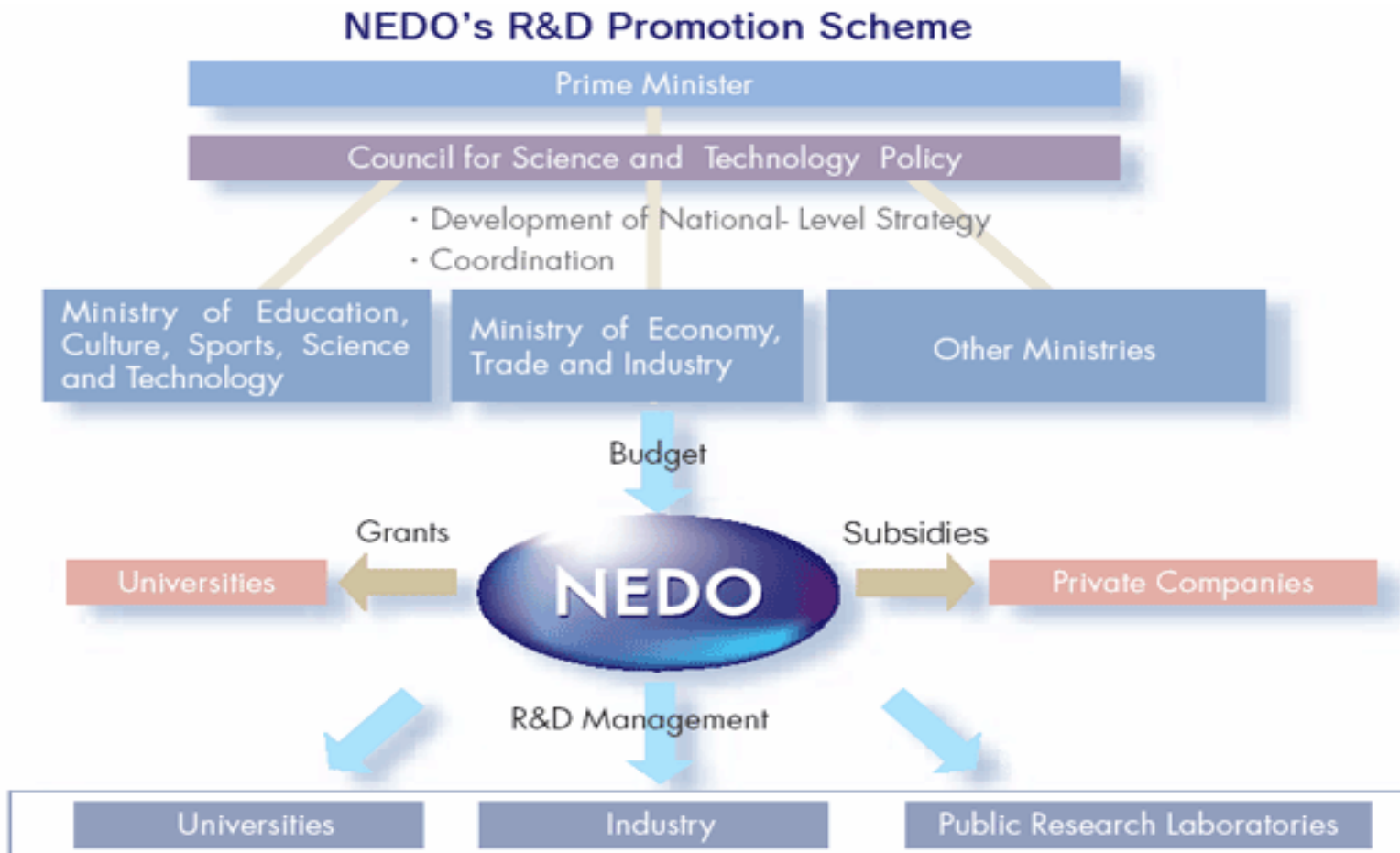


Data Source: NEF

# What is NEDO?




The New Energy and Industrial Technology Development Organization (NEDO) is Japan's largest public R&D management organization for promoting the development of advanced industrial, environmental, new energy and energy conservation technologies.



# Development and Demonstration of new energy-related grid-connecting technology

One of the important objectives of NEDO's R&D is solving problems that arise when distributed and renewable resources are connected to power grids.

These issues arise because the power output from most renewable energy resources fluctuates with weather conditions and connecting them to traditional power grids may create power quality issues.

- 
- A decorative graphic consisting of a grey rectangular block with a white shadow underneath, positioned above the list.
- 1) Frequency Stabilization
  - 2) Voltage Control
  - 3) Protection
  - 4) Other Power Quality Issues
  - 5) Technology Development

# Grid-Connection related Projects in NEDO



FY2005 and Before      FY2006      FY2007      FY2008 and After

**Voltage control technology for clustered PV systems**



**Demonstrative Project on Grid-interconnection of Clustered Photovoltaic Power Generation Systems (FY2002-2007)**

**Power Control Technology for wind farm**



**Wind Power Stabilization Technology Development Project (FY2003-2007)**

**Control of supply system with several new energy and dispersed generators**



**Demonstrative Project of Regional Power Grids with Various New Energies (FY2003-2007)**

**Interconnection technology for large scale PV generation system**



**Demonstrative Project on New Power Network Systems (FY2004-2007)**

**Voltage control technologies for distribution system when many DGs are connected  
Development of supply system with different power quality**



**Energy storage system for new energy**



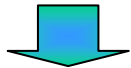
**Verification of Grid Stabilization with Large Scale PV Power Generation Systems (FY2006-2010)**

**Development of an Electric Energy Storage System for Grid-connection with New Energy Resources (FY2006-2010)**

# Demonstrative Project on Grid-interconnection of clustered Photovoltaic Power Generation (FY2002-2007)

## Background

Clustered installation of Photovoltaic on the distribution network is expected.



There are tangible problems, such as voltage swell by output from PV systems .

## Objects

- Development of the technology to avoid restriction of PV system output.
- Development of function to prevent unintentional islanding.
- Development of applied simulation technologies.

## Results

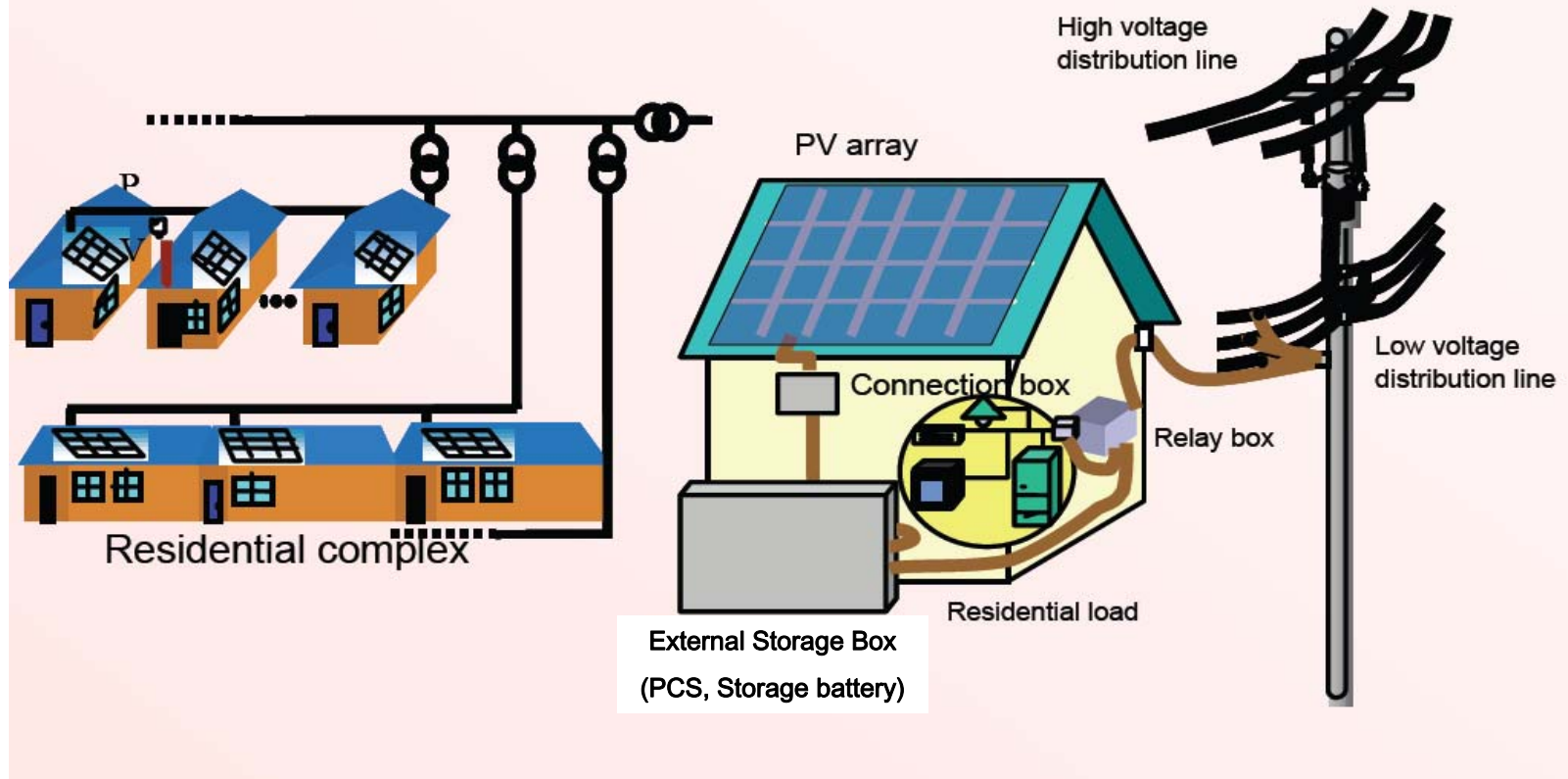
- 553 PV systems were installed.
- Effect of battery for avoiding restriction of PV output was examined.
- Possibility of interferences among the equipments for preventing islanding were detected.
- New equipment, which can avoid such interferences is now being developing.



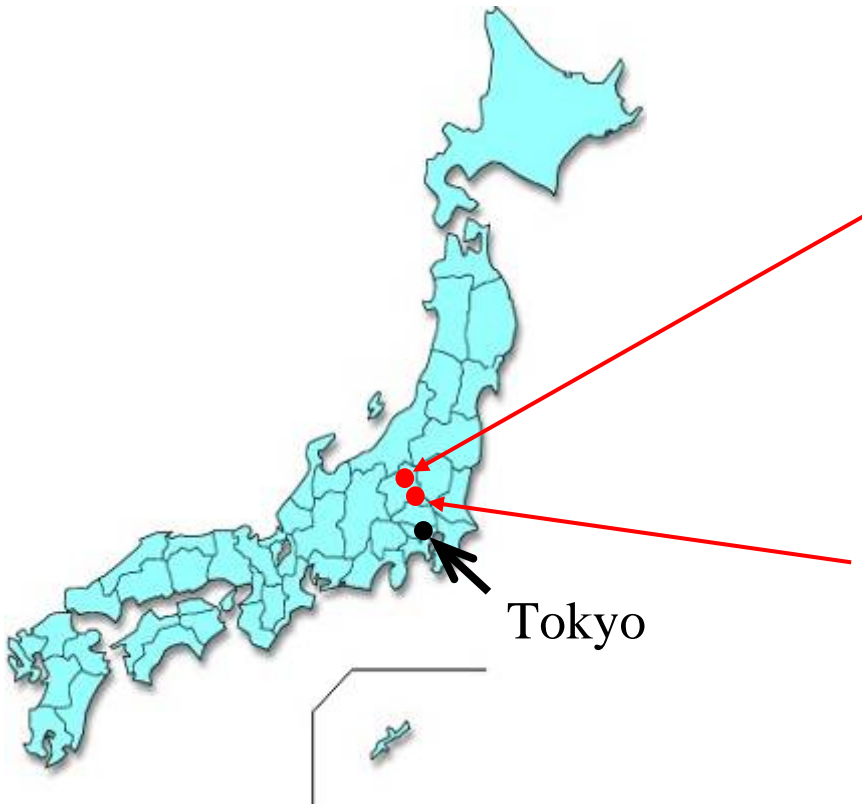
# Outline of the project

## Purpose of the project

- Development of the technology to avoid restriction of PV system output.
- Development of function to prevent unintentional islanding.
- Development of applied simulation technologies.



# Demonstration sites



Research facility in Maebashi city



Demonstration site in Ota city

# Demonstrative project site

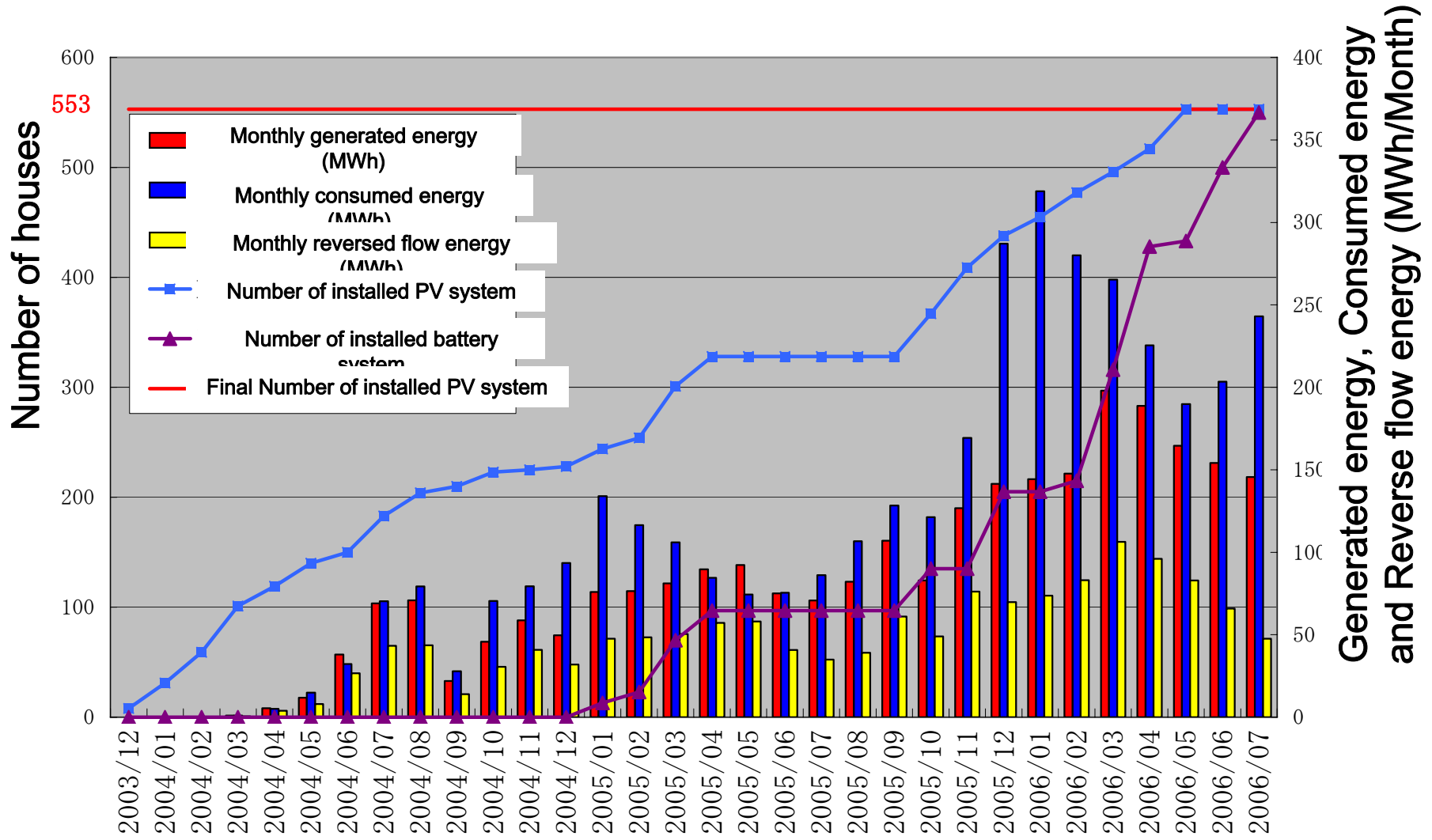


**Installed PV : 553**

**Total PV Capacity :  
2,129kW**

**Average PV Capacity : 3.85kW**

# History of installation



# A system of battery management system

## (3) Central Controller

Remotely controlling each external battery box

Central Controller

## (4) New Type islanding protection equipment

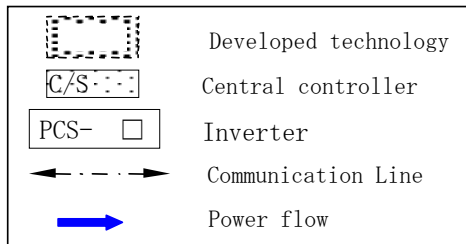
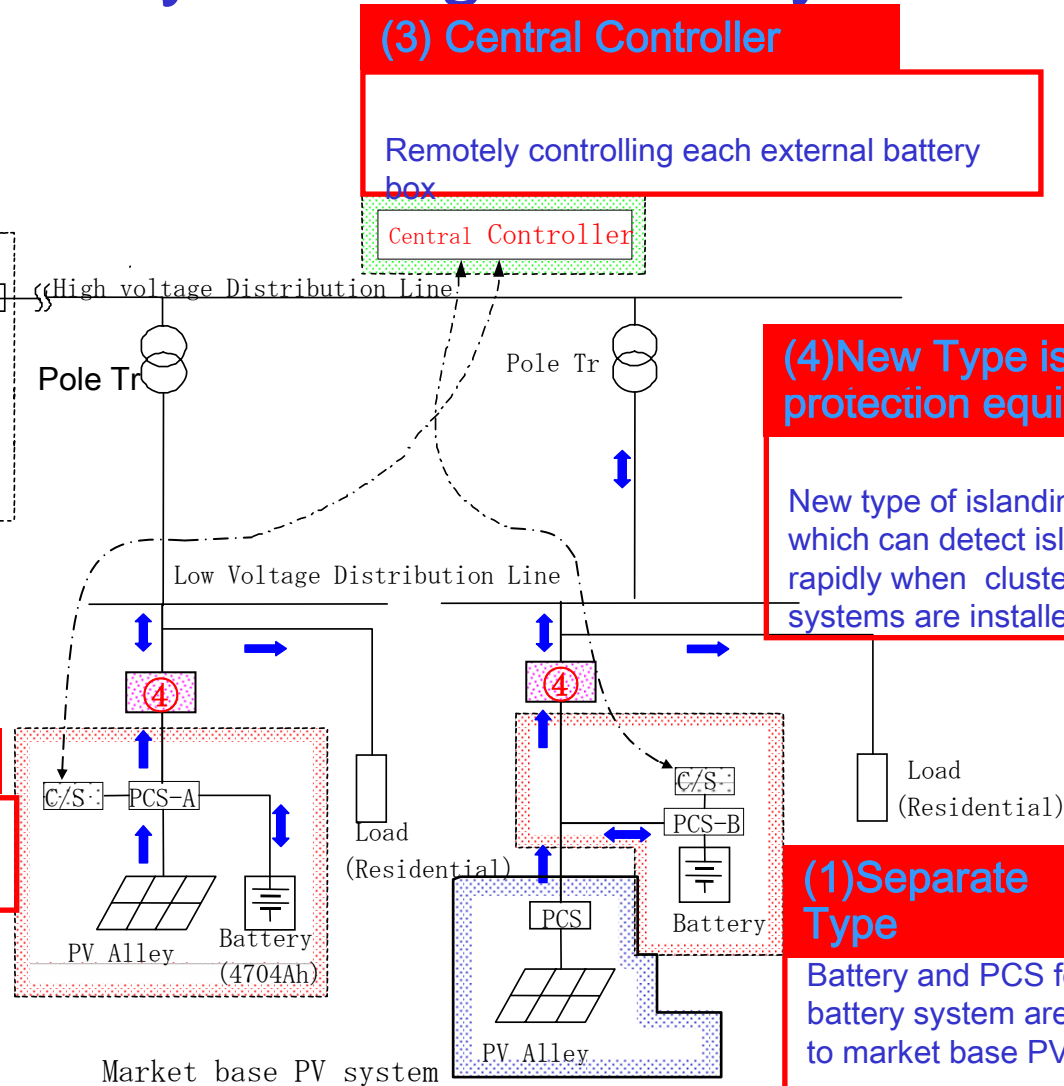
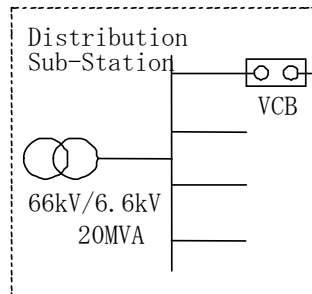
New type of islanding protection which can detect islanding rapidly when clustered PV systems are installed

## (2) All in One Type

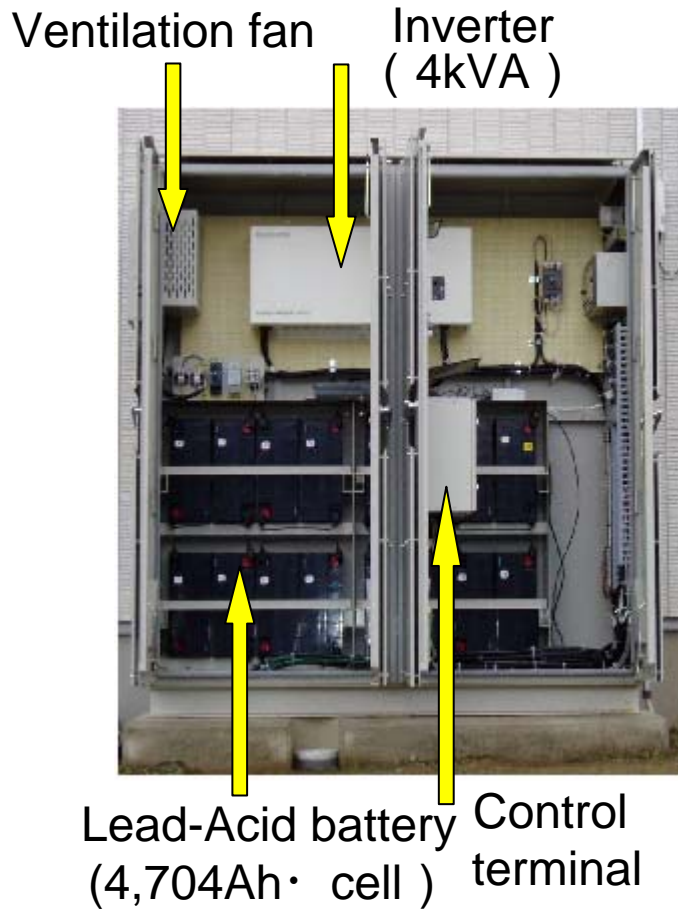
A type of system which has one PCS for PV and battery system.

## (1) Separate Type

Battery and PCS for battery system are added to market base PV system.



# External battery box

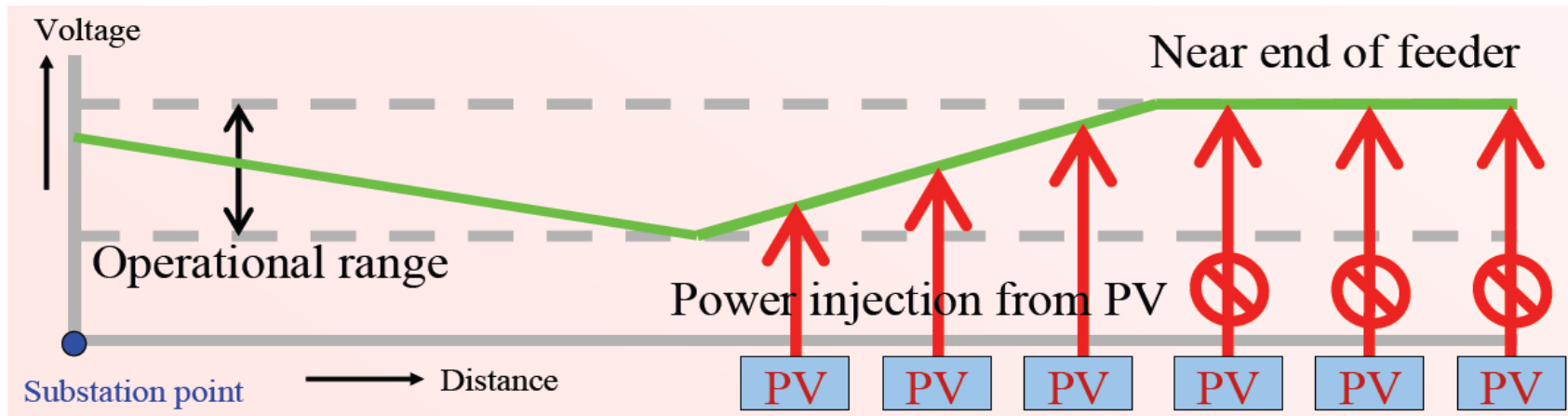


External Battery BOX

# Development of technology to avoid restriction of PV system output

The voltages in distribution line sometimes becomes higher than the maximum nominal voltage of 107V or 222V because too much power injection from PV system.

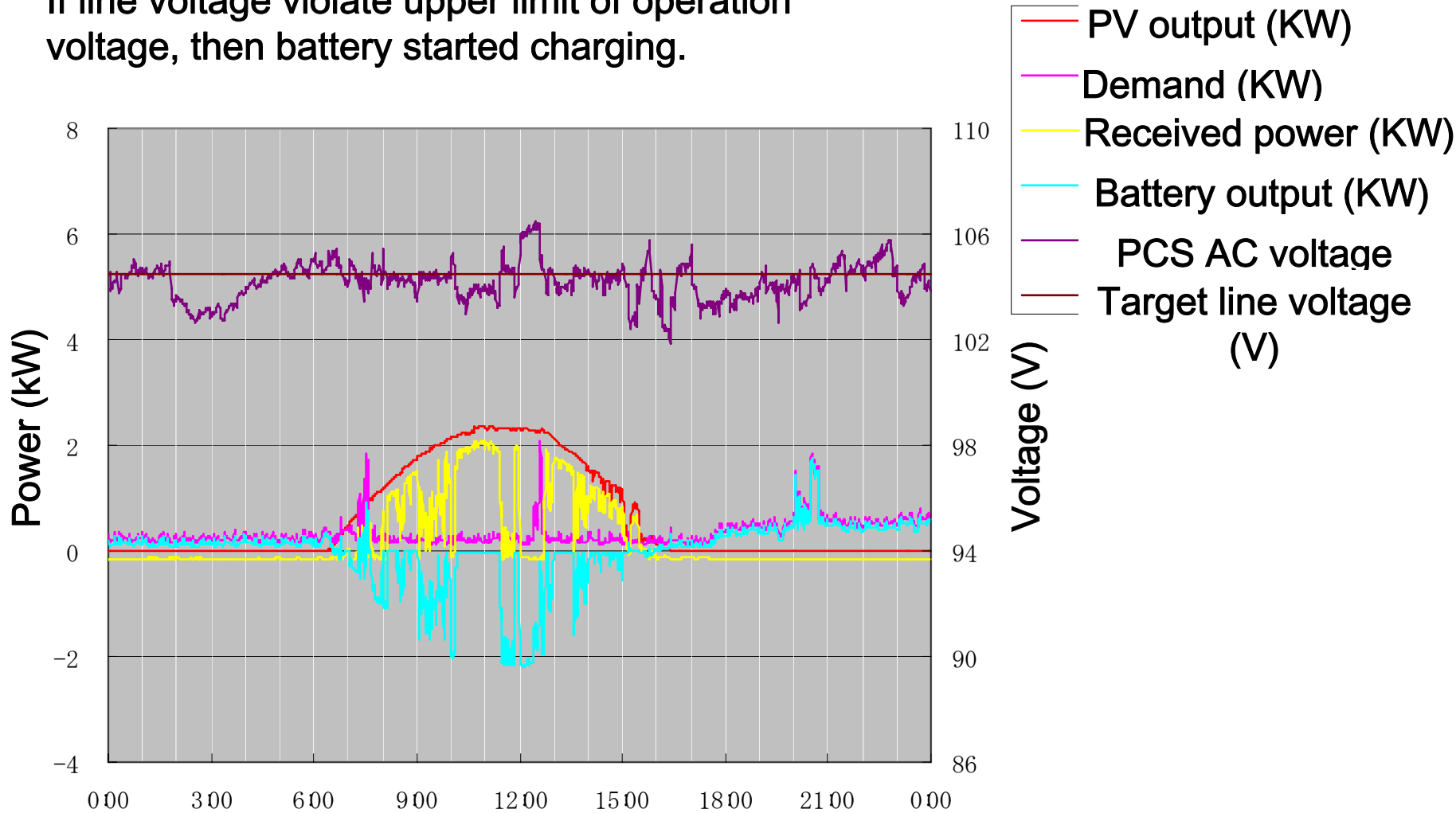
Output of PV is restricted to keep line voltage within operational range ( $101\pm 6V, 202\pm 20V$ ).



Various suppressions of the PV output are analyzed, and then several battery operation modes to reduce such suppressions are developed in this project.

# A sample of voltage control operation

If line voltage violate upper limit of operation voltage, then battery started charging.





# Development of function to prevent unintentional islanding

- A function to prevent islanding operation disconnects the PV system from the power grid in the case of service interruptions. Interferences among the equipments for preventing islanding are induced when the clustered PV systems are installed.
- Methods to avoid mis-actuations of such function in the clustered PV systems are developed, the methods will be verified through demonstration.

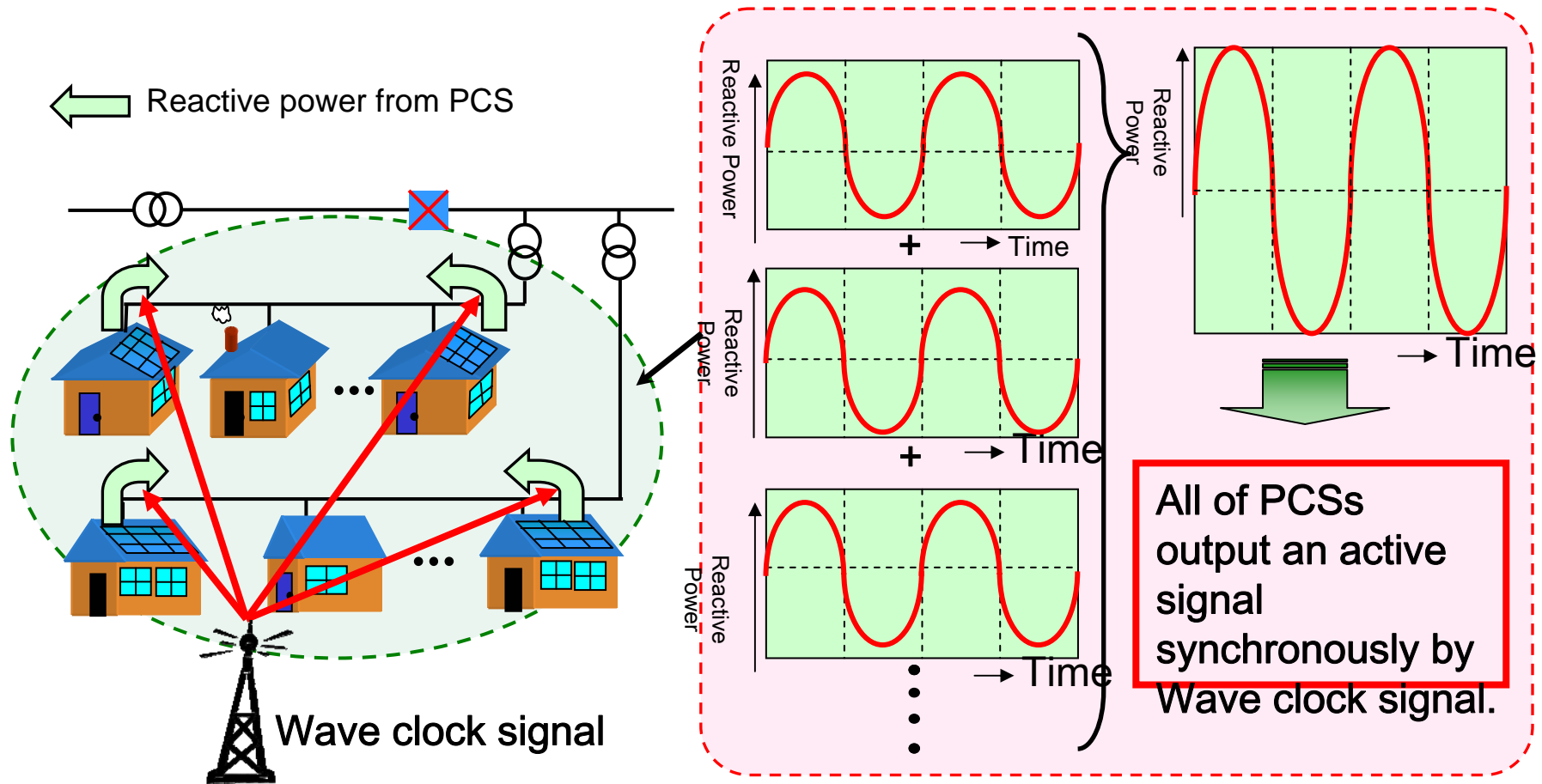


- ✓ Developing new islanding detection method.
- ✓ Testing this method at the test facility in Maebashi City.
- ✓ Installing field-test equipment at the demonstrative site in Ota city
- ✓ Installing quality improved facility at the demonstrative site in Ota city



Test facility in  
Maebashi

# New method of prevent islanding



# Verification of Grid Stabilization with large-scale PV Power Generation Systems (FY2006-2010)

## Background

If PV becomes popular in future, large scale (MW level) PV power station will be introduced to power system.



It is possible that such large scale PV power station may influence voltage and frequency in the utility system.

## Objects

(1) Technology for reduction of fluctuation of voltage and frequency using battery storage will be demonstrated. Also, countermeasure of harmonic will be developed and demonstrated.

(2) Developing simulation method related technologies mentioned above.

# Demonstrative projects site



Wakkanai Site completion forecast figure



Hokuto Site completion forecast figure

The first Japanese  
Mega-Solar

# Comparative table

	Wakkanai City	Hokuto City
PV capacity	~5MW	~2MW
Module type	crystal type	advanced type
Energy storage	NaS :1.5MW - 11.8MWh EDLC :1.5MW - 25kWh	-
PCS	250kW (commercialized product)	400kW (developing )
Grid connection	33kV transmission line	66kV transmission line
Forecast	solar radiation forecast	-

# Schedule

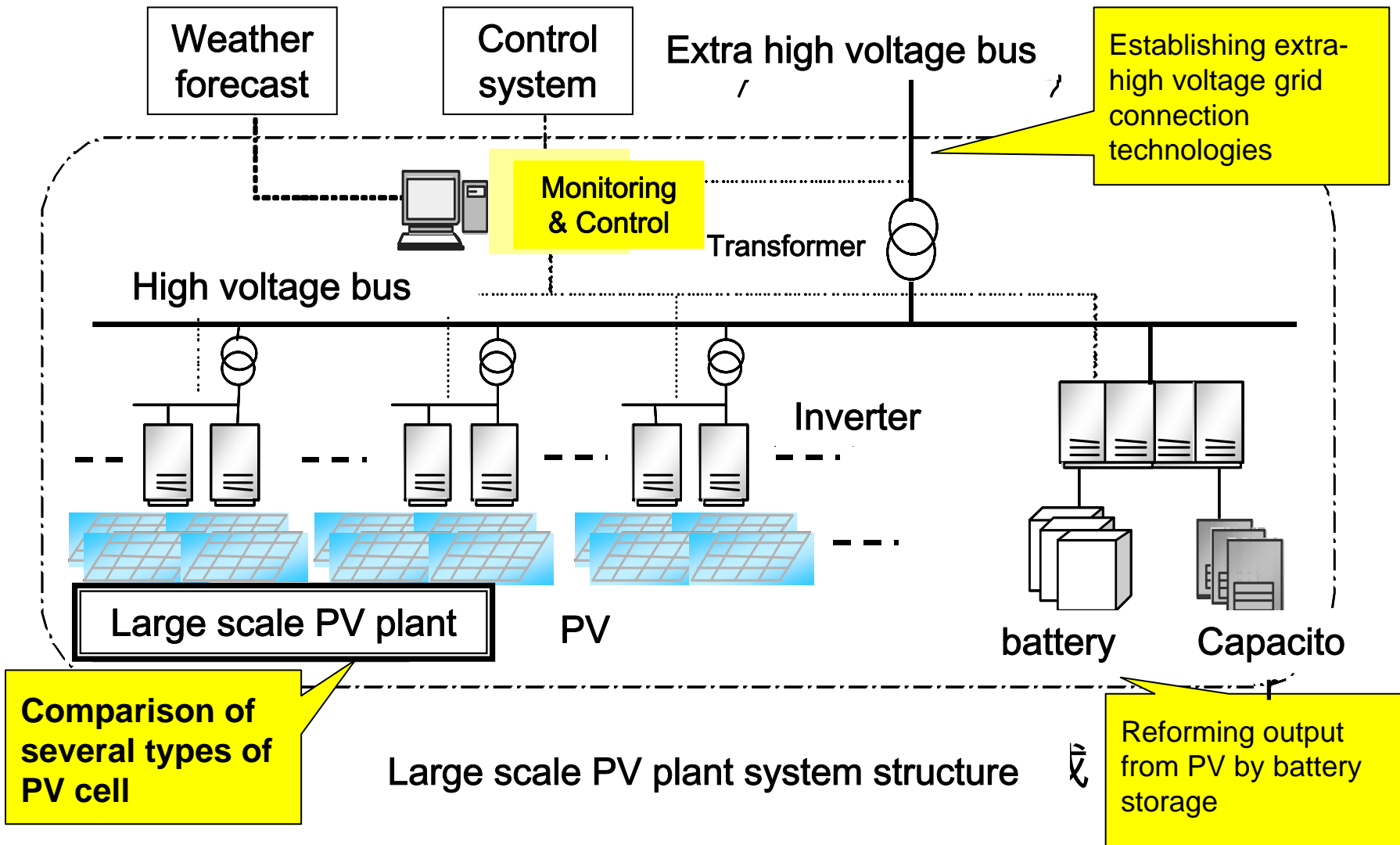
## Wakkanai site

FY	2006	2007	2008	2009	2010
PV capacity (MW)		Mar. 80kW	Nov. 1.7MW	Oct. 4.0MW	Oct. 5.0MW
NaS battery (MW)			Nov. 0.5MW	Oct. 1.5MW	
EDLC (MW)				Oct. 0.5MW	Oct. 1.5MW
Grid connection		Mar. 6.6kV	Nov. 33kV		

## Hokuto site

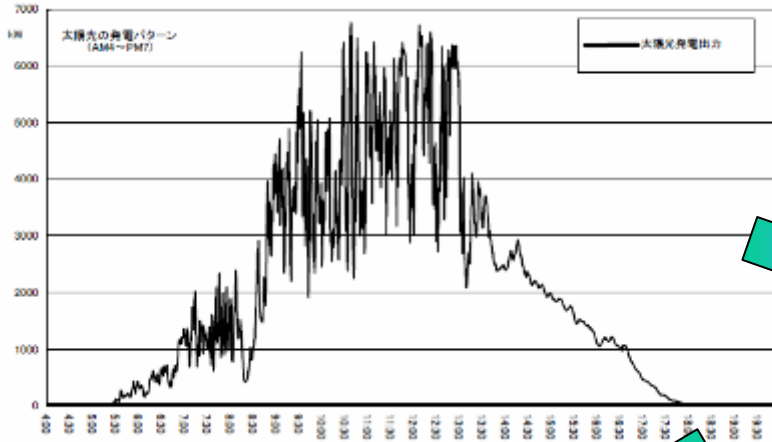
FY	2006	2007	2008	2009	2010
PV capacity (MW)			Feb. 0.6MW	Nov. 2.0MW	
Grid connection			Feb. 6.6kV	Nov. 33kV	

# Configuration of Wakkanai site

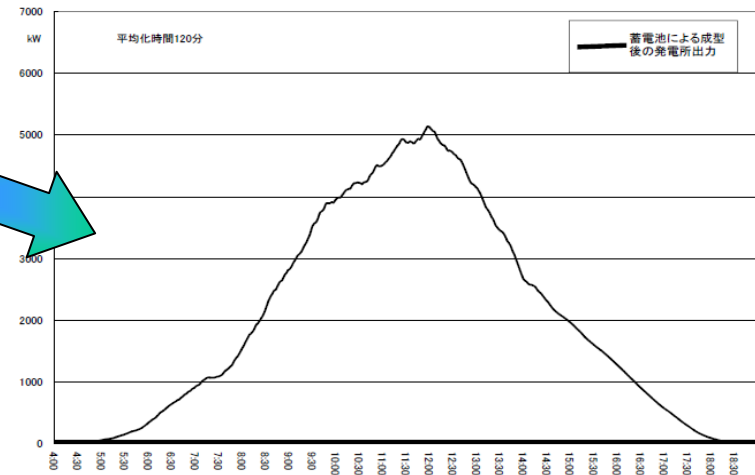


# How battery system operates

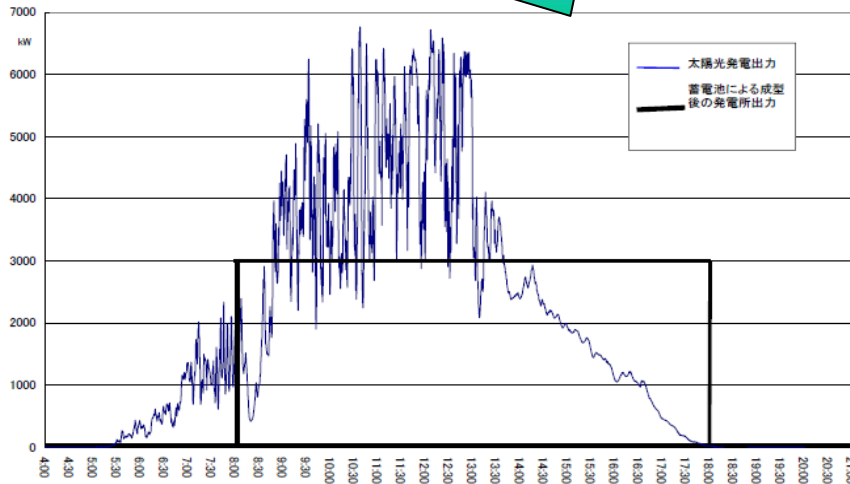
## Output from Mega-solar Plant



## Smoothing by battery

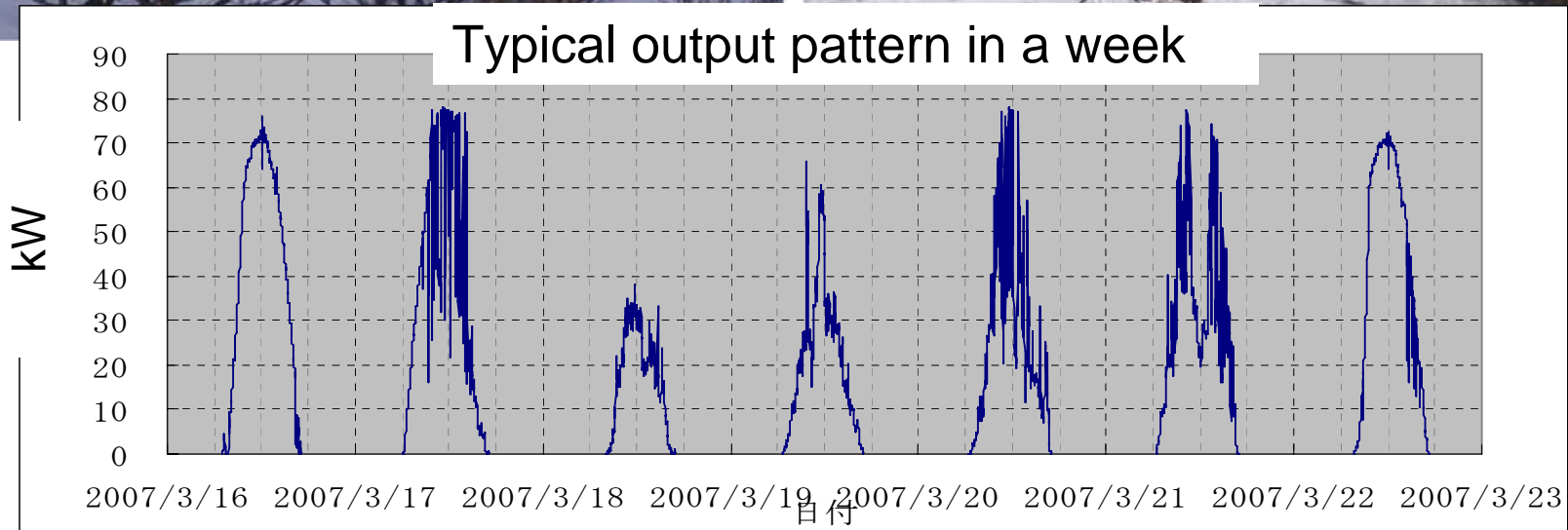
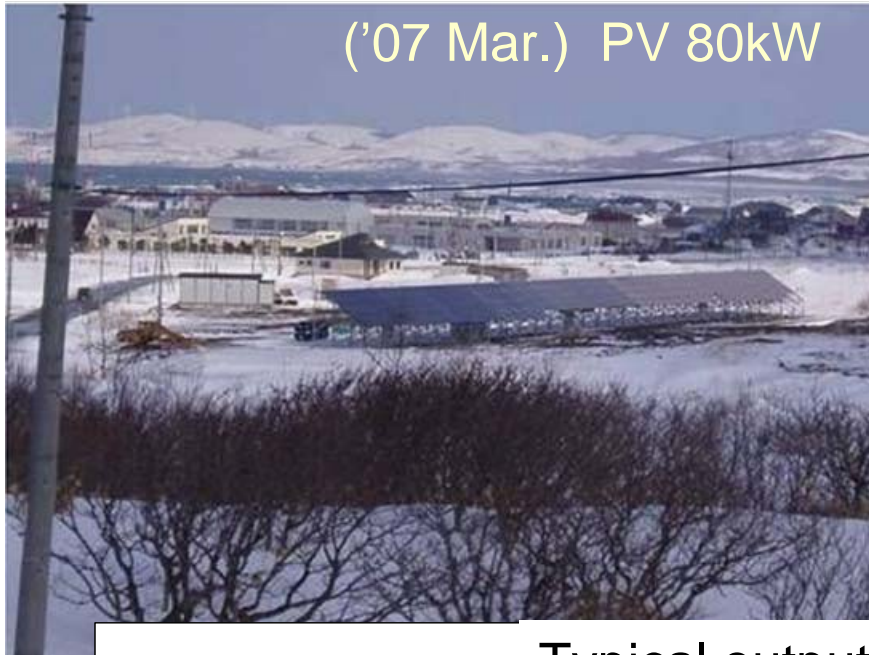


## Planned transmission by battery





# Wakkanai site PV system under construction



# Wakkanai site PV system under construction

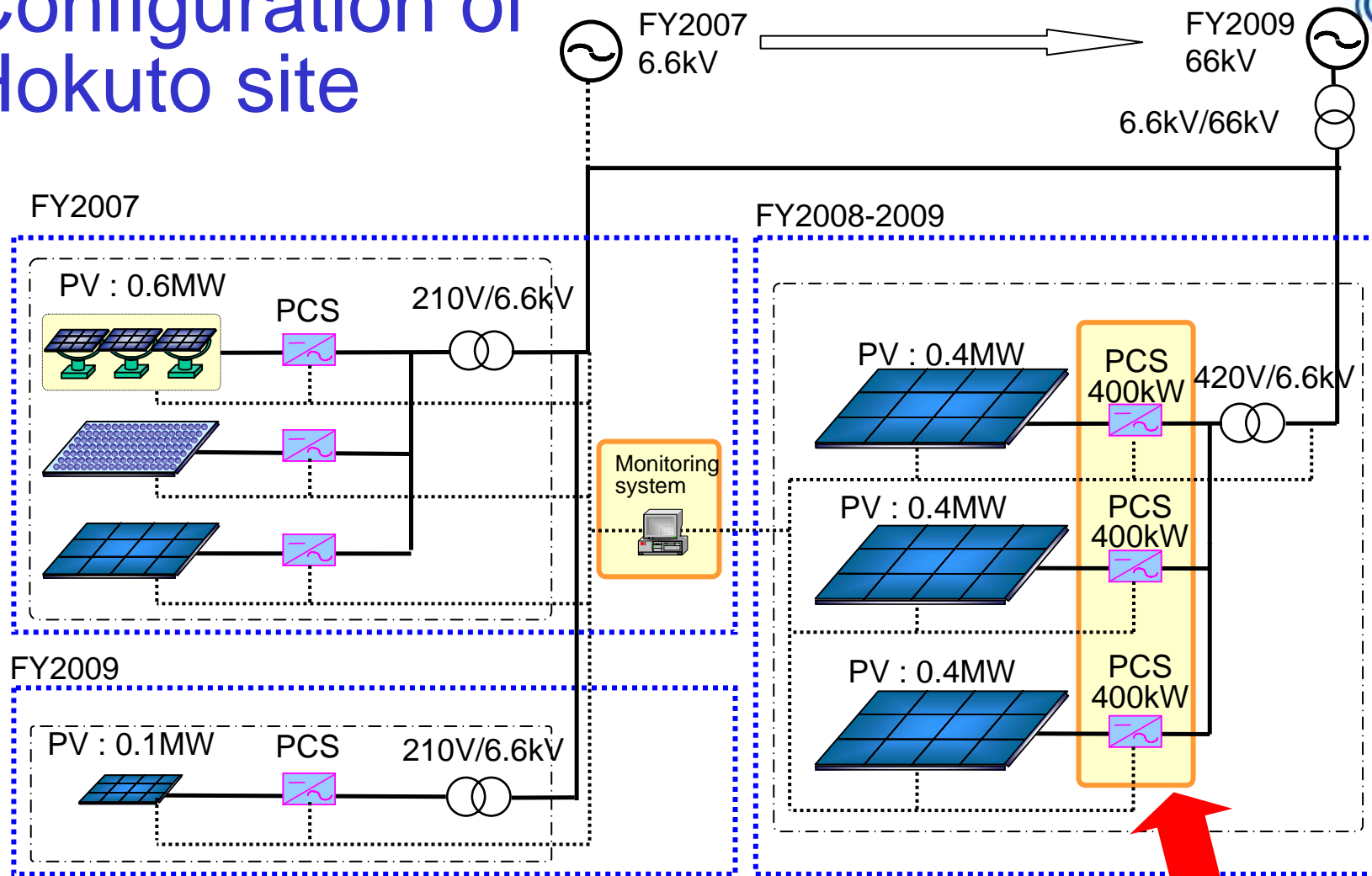


2007 July  
(PV: 80kW)



2009 October  
(PV: 5MW)

# Configuration of Hokuto site



Output Power: 400kW

Function :  
 to suppress voltage fluctuation  
 by controlling reactive power  
 to have voltage sag ride-through capability  
 to have suppressed harmonic function

Development of large-scale PCS

# Hokuto site under land forming



2007 October

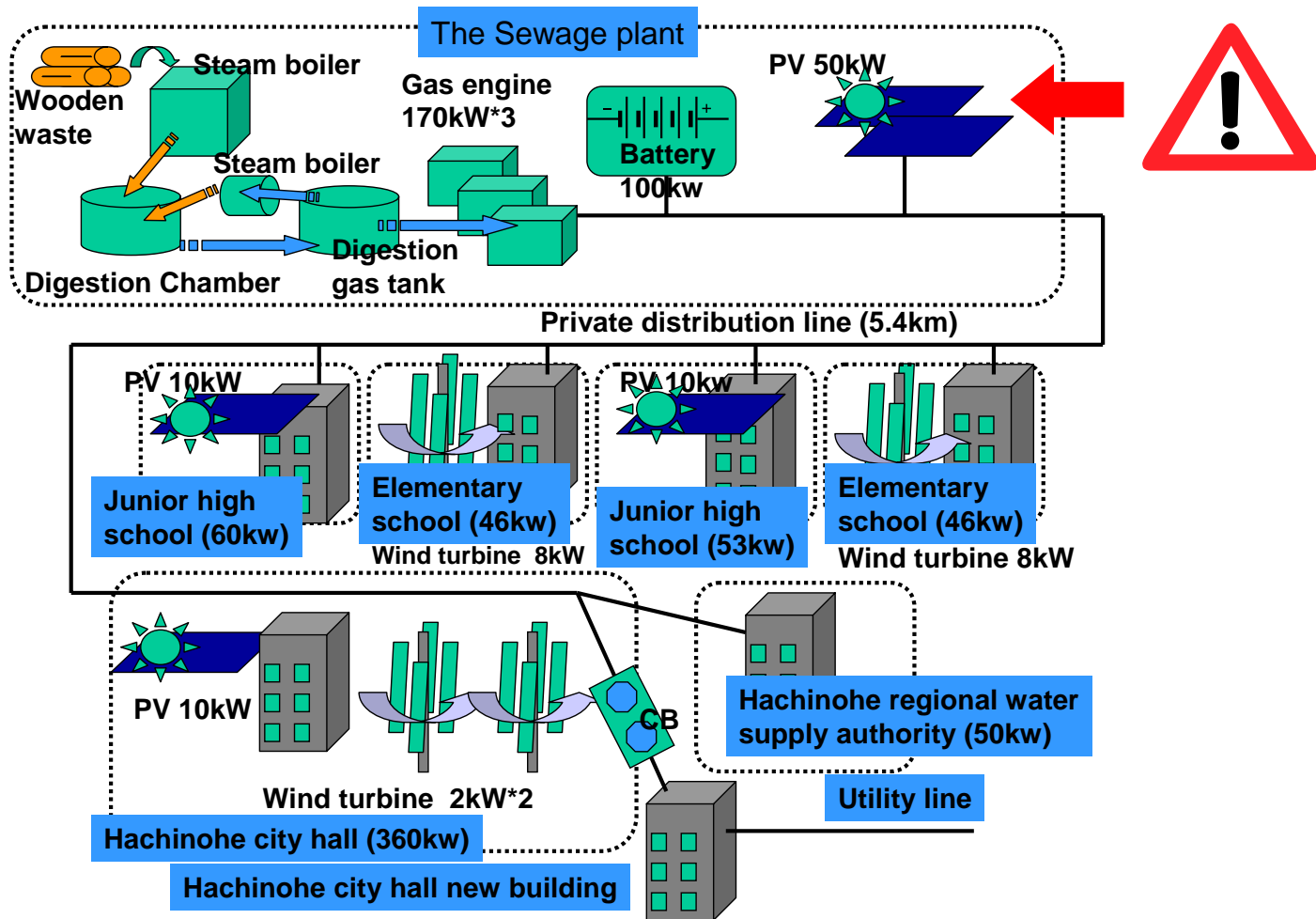


2009 November  
(PV ~2MW)

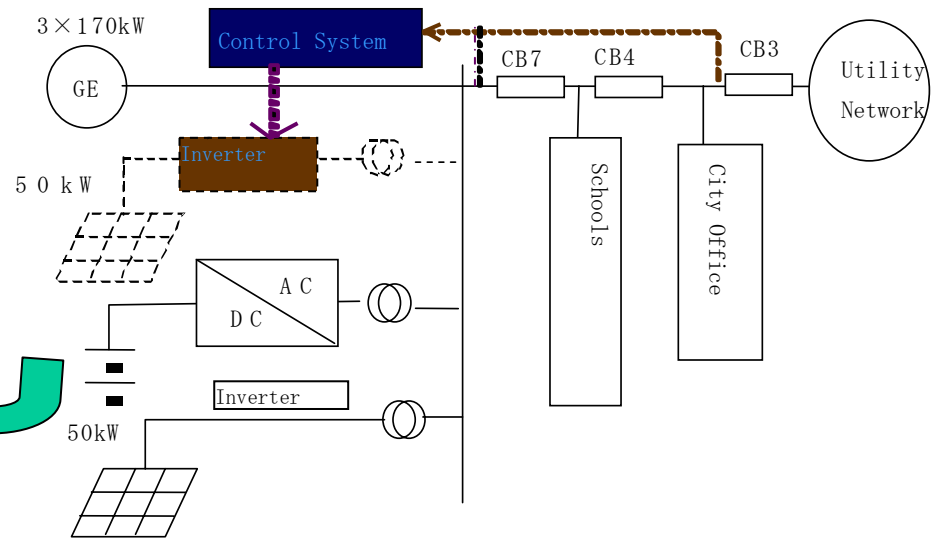
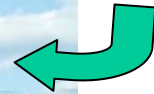
# PV application in micro-grid project

## Hachinohe project

Structure of supply system with local private Grid.



# Compensating imbalance of three phase by PV power conditioner in Hachinohe



# Summary

- PV has potential to change electric power system.
- To achieve such a paradigm shift, solving grid-connection issues is necessary.
- NEDO thinks such technology development shown in our presentation is very important.

Thank You for your attention !!



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