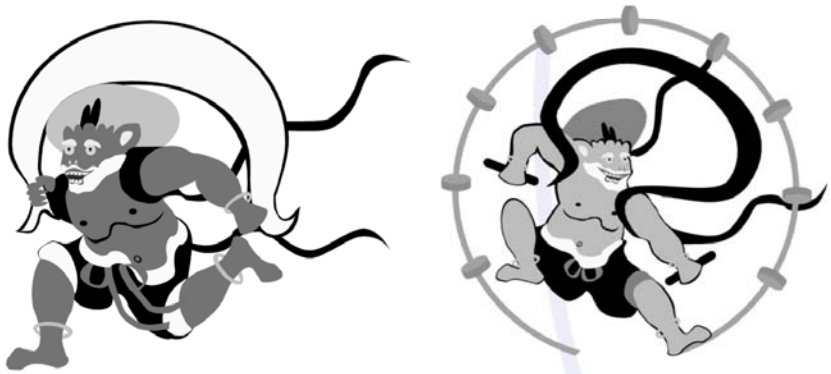

NEDO Research Related to Large-scale PV-related Grid-connection Projects

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Project Coordinator for Grid-Connected Power Systems

New Energy and Industrial Technology Development Organization

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.

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

1) Frequency stabilization
2) Voltage control
3) Protection
4) Other power quality issues
5) Technology development

NEDO's Grid-connection Related Projects

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 multiple new energy and dispersed generation

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 multiple diesel generators 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

Installation of clustered photovoltaic systems on distribution networks is anticipated.

The output from PV systems causes tangible problems, including overvoltage resulting from reverse power flows.

Objectives

-To develop technology to eliminate restrictions on PV system output.

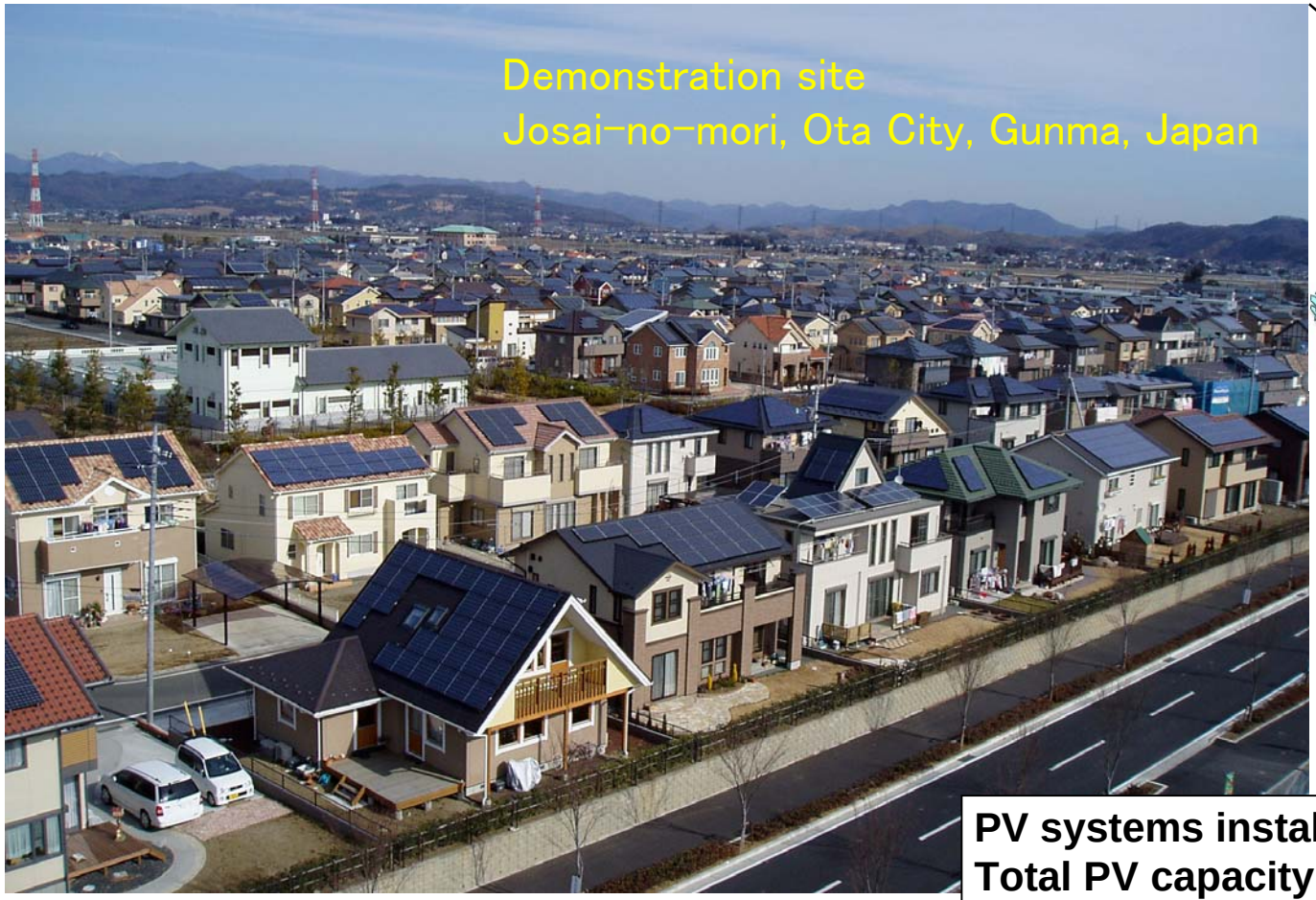
-To develop a method to detect unintentional islanding.

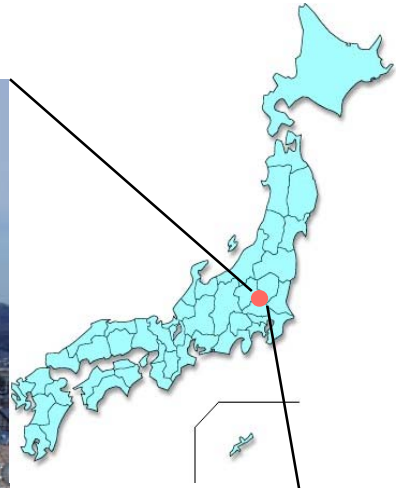
-To develop applied simulation technologies.

Results

-550 PV systems were installed.
-Effects of using batteries to control voltage on distribution line were studied.
-Possibility for interference among the equipment used to prevent islanding was detected.
-New equipment that can avoid such interference is now being developed.

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

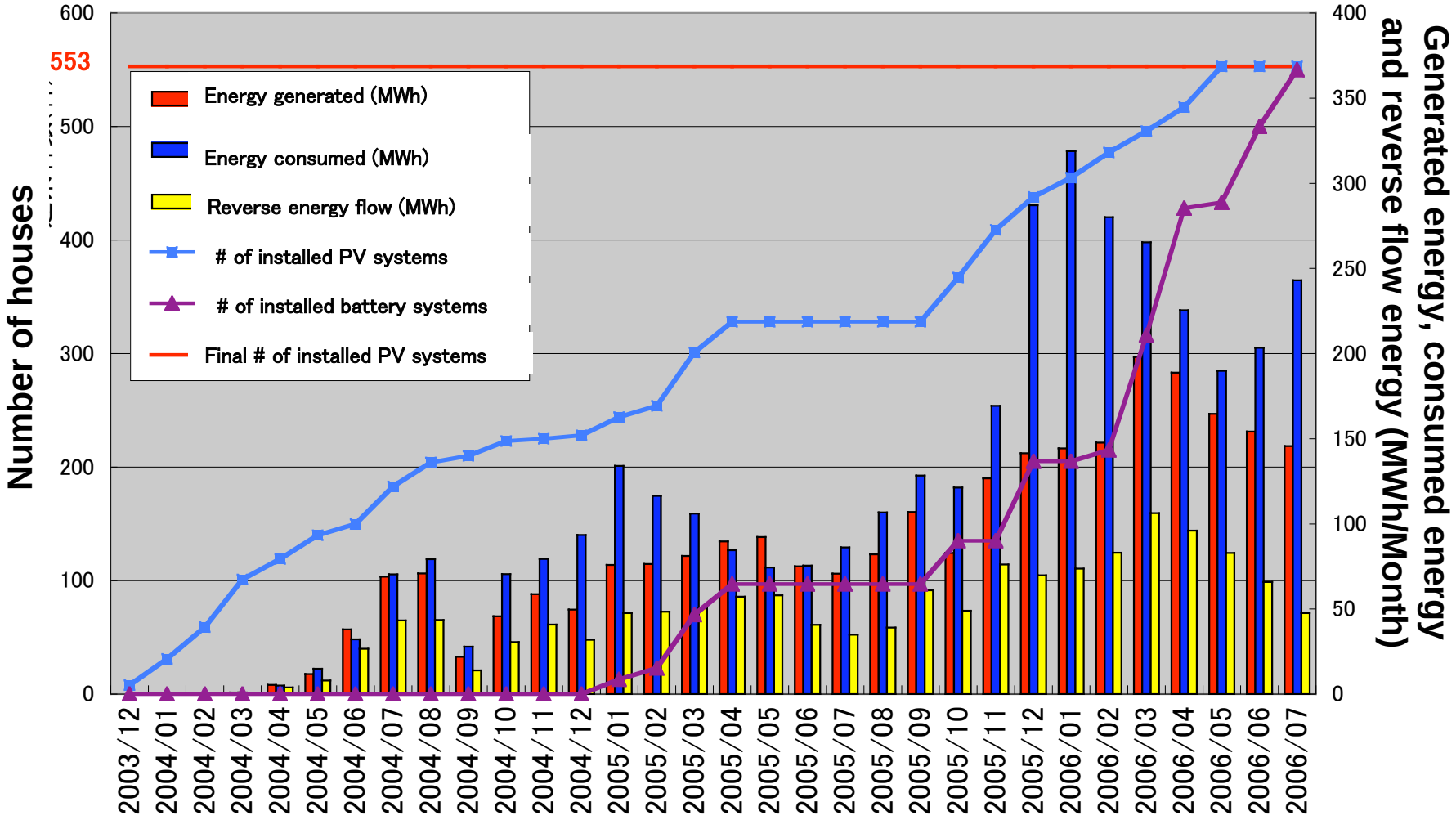




PV systems installed: 553
Total PV capacity: 2,129 kW
Avg. system capacity: 3.85 kW

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

Installation Timeline

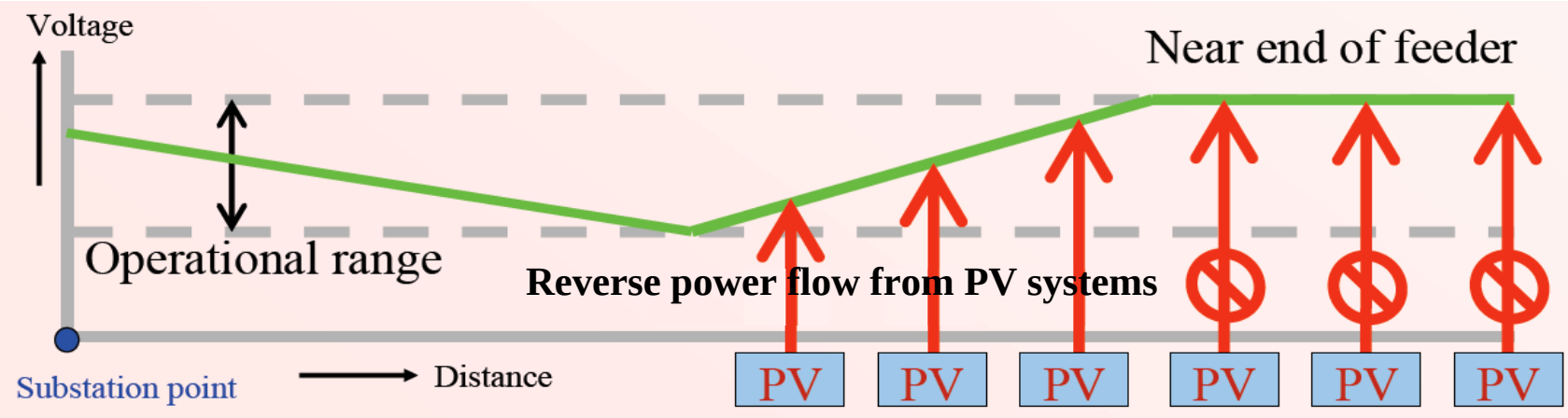


Demonstrative Project on Grid-interconnection of Clustered Photovoltaic Power Generation (FY2002-2007)

Development of technology to eliminate restrictions on PV system output

The voltage on distribution lines sometimes exceeded the maximum nominal voltage of 107V or 222V because of excessive output from PV systems.

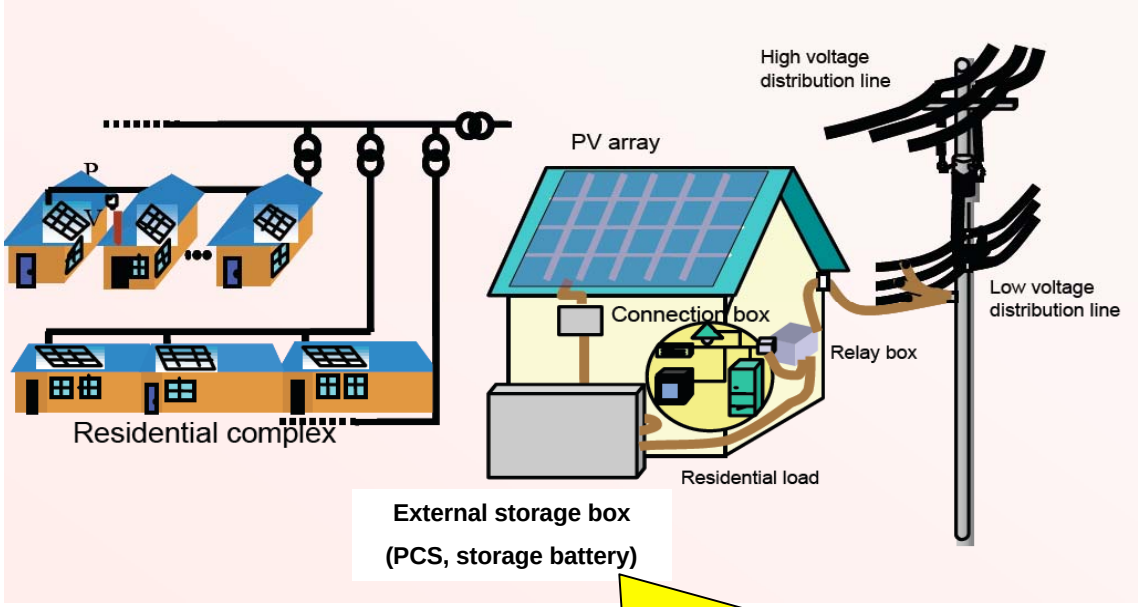
Output of PV must be restricted to keep line voltage within operational range (101±6V, 202±20V).



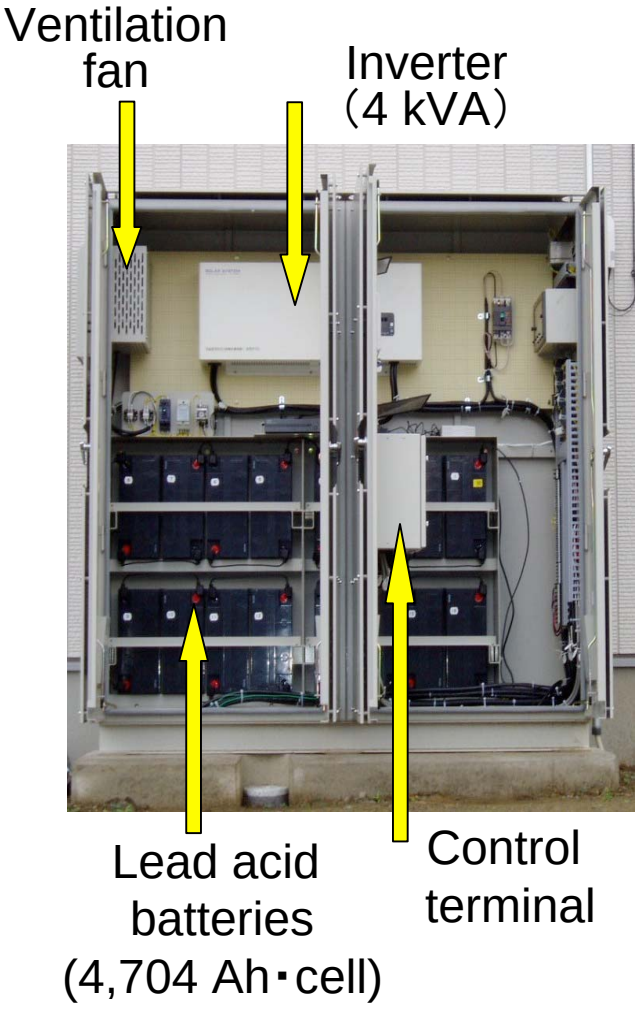
Several battery operating modes to reduce reverse power flow were developed in this project.

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

Image of battery storage system



A storage box connected to the PV system of each residence houses an inverter, battery and measuring instruments.

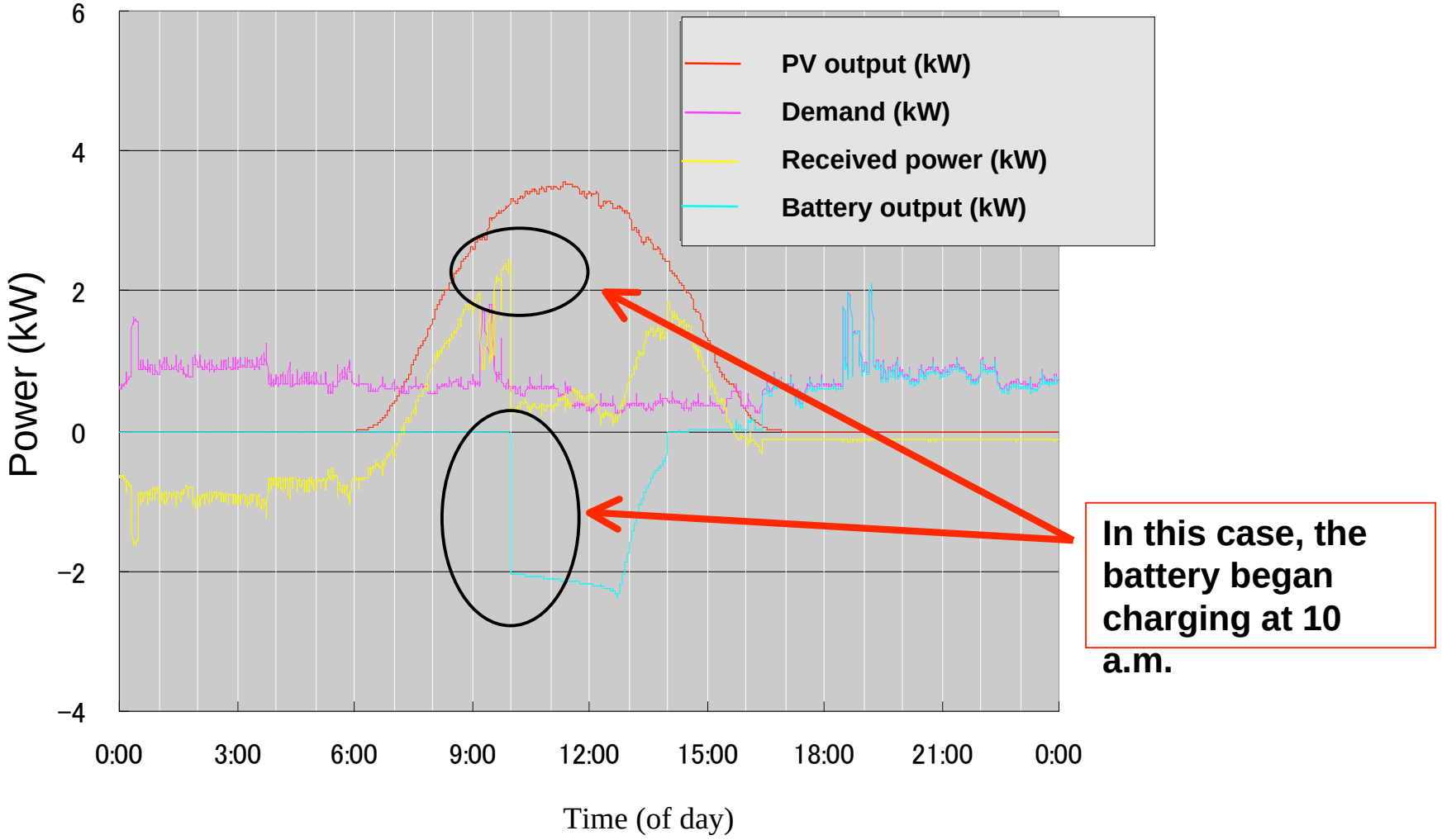


External storage box

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

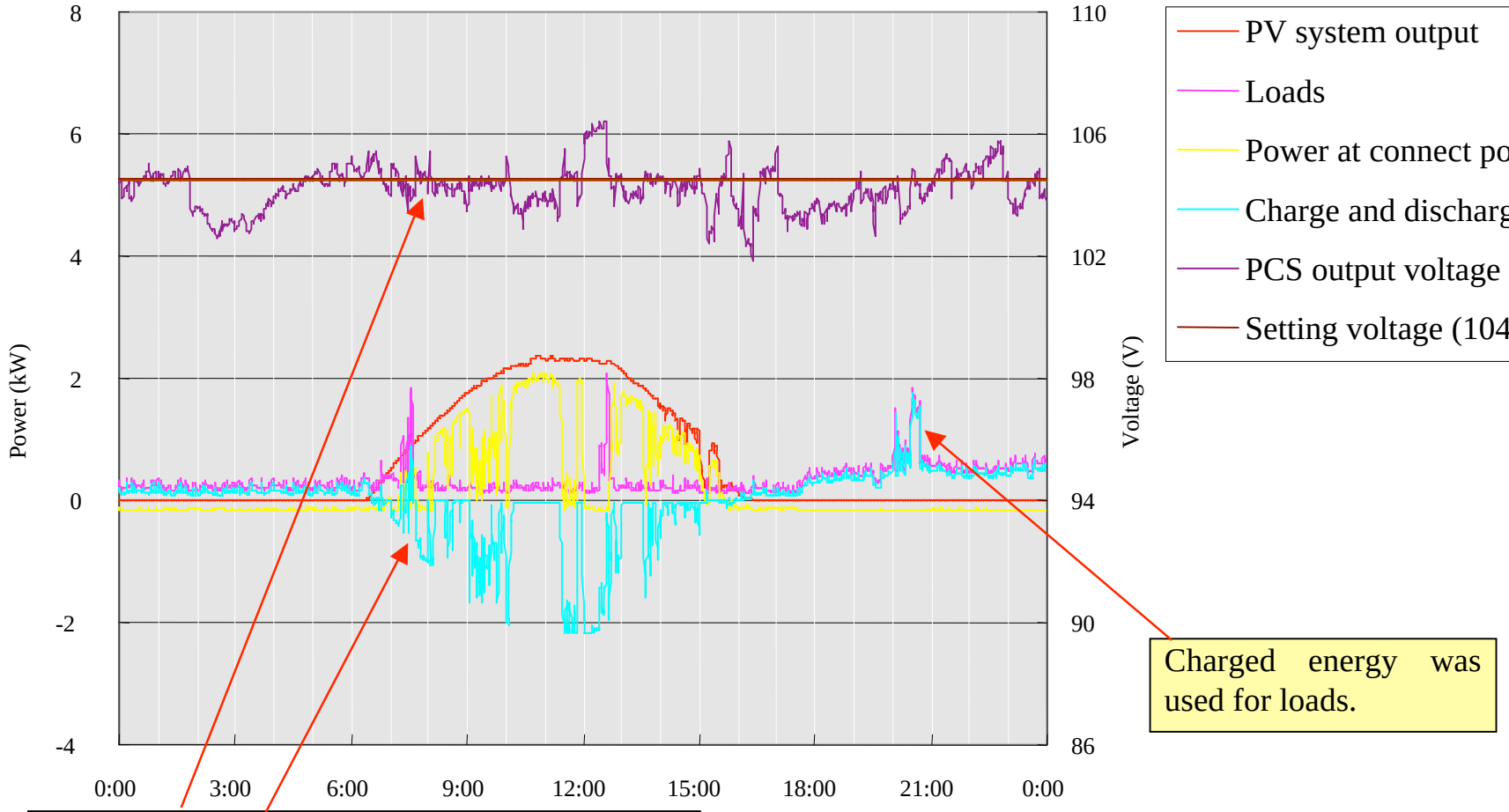
Example of battery usage

Charging and discharging of battery are pre-programmed.



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

Example of battery usage (voltage control operation)



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

Development of function to detect unintentional islanding

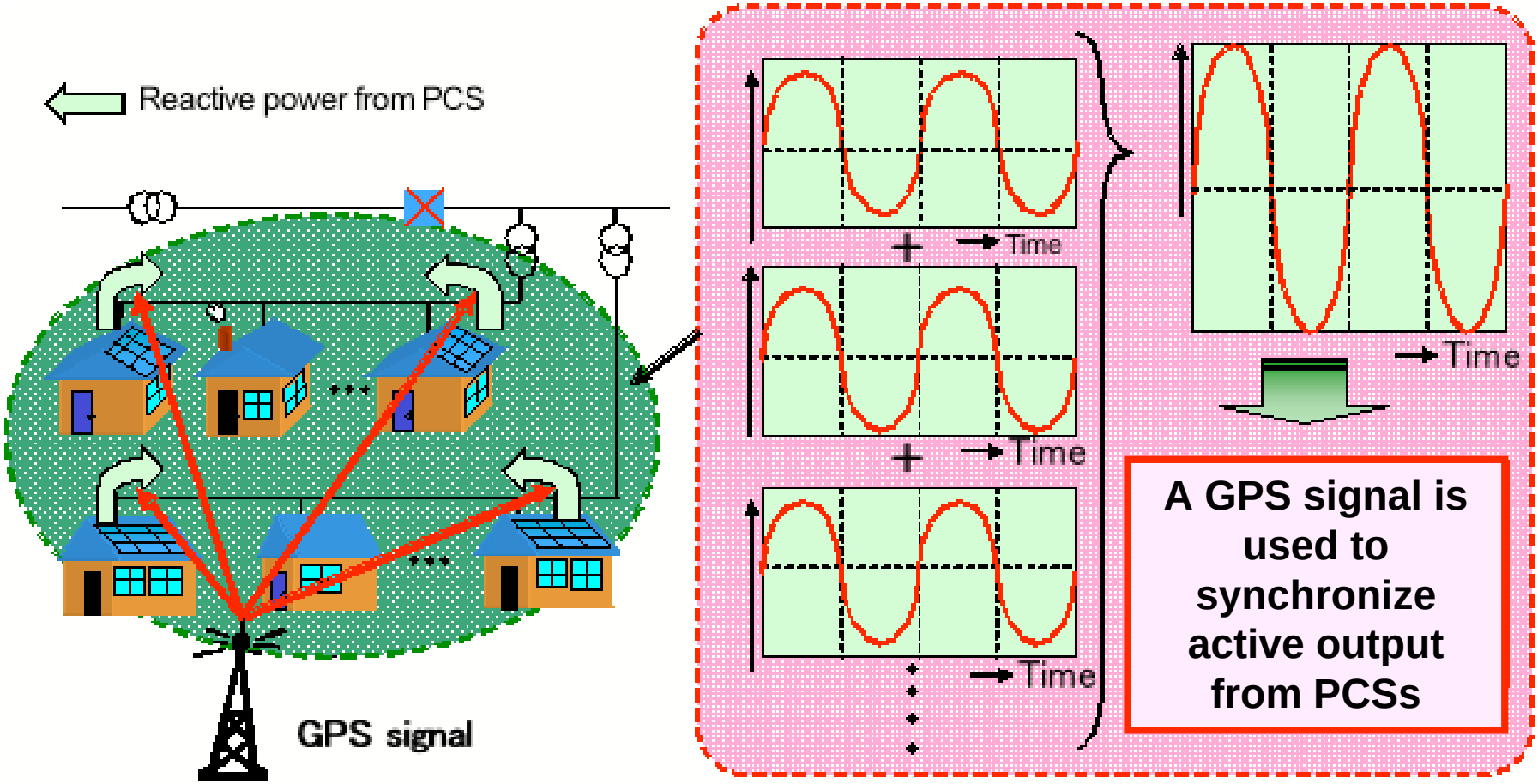
- **A function to detect islanding disconnects the PV system from the power grid in the event of service interruptions. Interference among the islanding detection equipment arises when PV systems are installed in a cluster.**
- **Methods to prevent this from happening have been developed and verified through demonstration testing.**

- ✓**Developing new islanding detection method**
- ✓**Testing this method at test facility in Maebashi City**
- ✓**Installing field-test equipment at demonstrative site in Ota City**
- ✓**Installing improved devices at demonstrative site in Ota City**

Test facility in Maebashi

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

Concept for conflict-free islanding detection



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

Status of the project

(1) During the final stage of the project, we obtained several results.

An extensive amount of data on actual residential demand, PV output and battery storage operation was collected.

- ✓ Economic feasibility for introducing batteries was summarized.
- ✓ New islanding detection method for clustered PV systems was developed.
- ✓ A simulation method related to this project is being developed.

(2) Post-project

- ✓ NEDO is planning to start technology development for an islanding detection certification system for clustered generation systems.
- ✓ We are able to disclose operating data to interested parties who are willing to sign a non-disclosure.

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

Background

If PV gains market acceptance, more large (MW-scale) PV power stations will be built and connected to power grids.

It is possible that such large-scale PV power stations may impact voltage and frequency on utility systems.

Objectives

(1) To demonstrate battery storage system technology to reduce voltage and frequency fluctuations using. Also, countermeasures for harmonics will be developed and demonstrated.

(2) To develop simulation methods related to the technologies mentioned above.

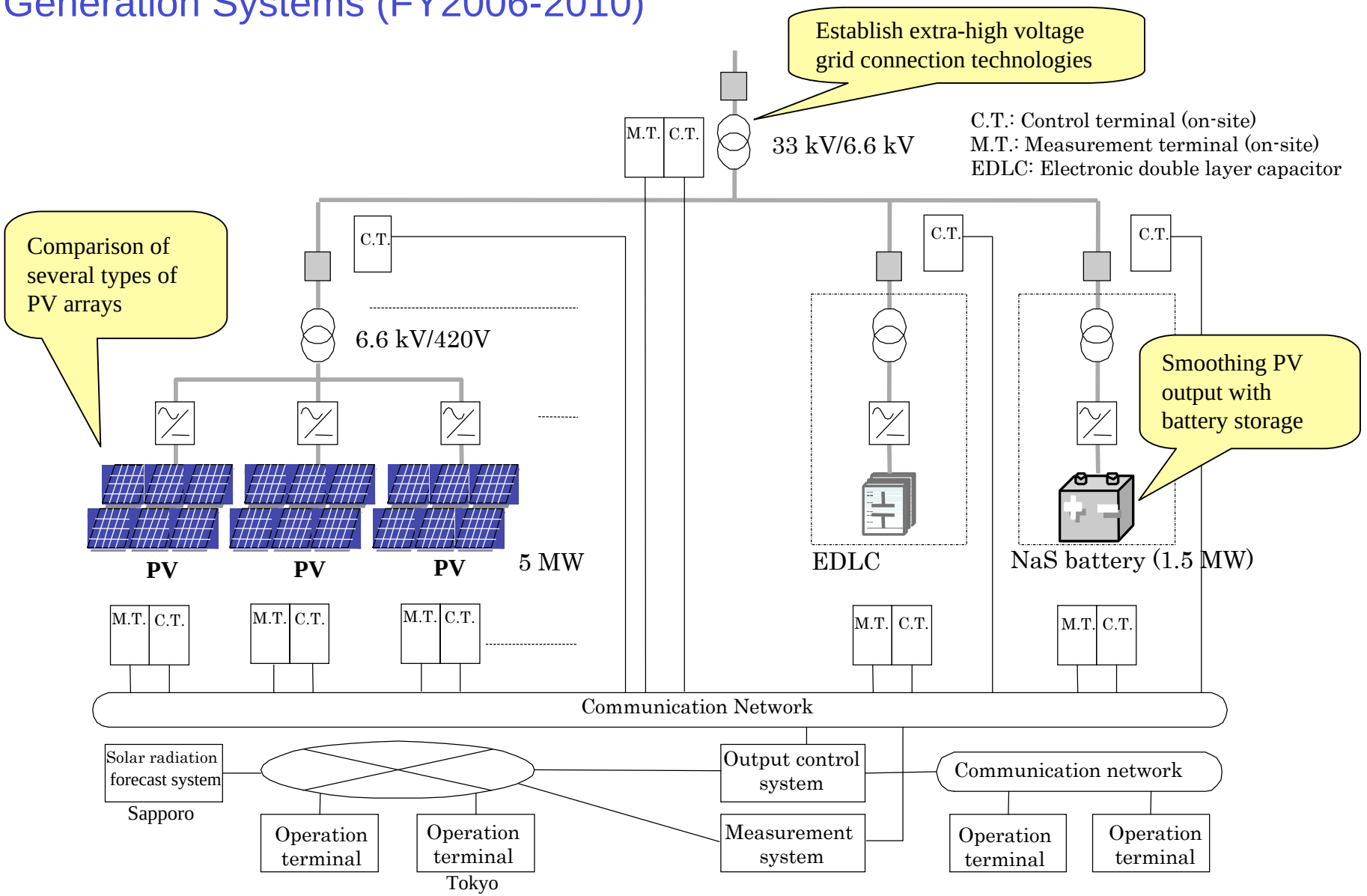
Verification of Grid Stabilization with Large-scale PV Power Generation Systems (FY2006-2010)

Rendered image of Wakkanai site

Rendered image of Hokuto site

The first mega-solar systems installed in Japan

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



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

Mega-solar system comparison

	Wakkanai City	Hokuto City
PV capacity	Max. 5 MW	Max. 2 MW
Module type	Crystalline	Various advanced modules
Energy storage	NaS: 1.5 MW – 11.8 MWh EDLC: 1.5 MW – 25 kWh	–
PCS	250 kW (commercialized product)	400 kW (under development)
Grid connection	33 kV transmission line	66 kV transmission line
Forecasting	Solar radiation forecast	–

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

Wakkanai site

	2006	2007	2008	2009	2010
PV capacity (MW)		Mar. ’07 80 kW	Mar. ’08 2.0 MW	Dec. ’08 4.0 MW	Oct. ’09 5.0 MW
NaS battery (MW)			Jan. ’08 0.5 MW	Oct. ’08 1.5 MW	
EDLC (MW)					1.5 MW
Grid connection		Mar. ’07 6.6 kV	Nov. ’07 33 kV		

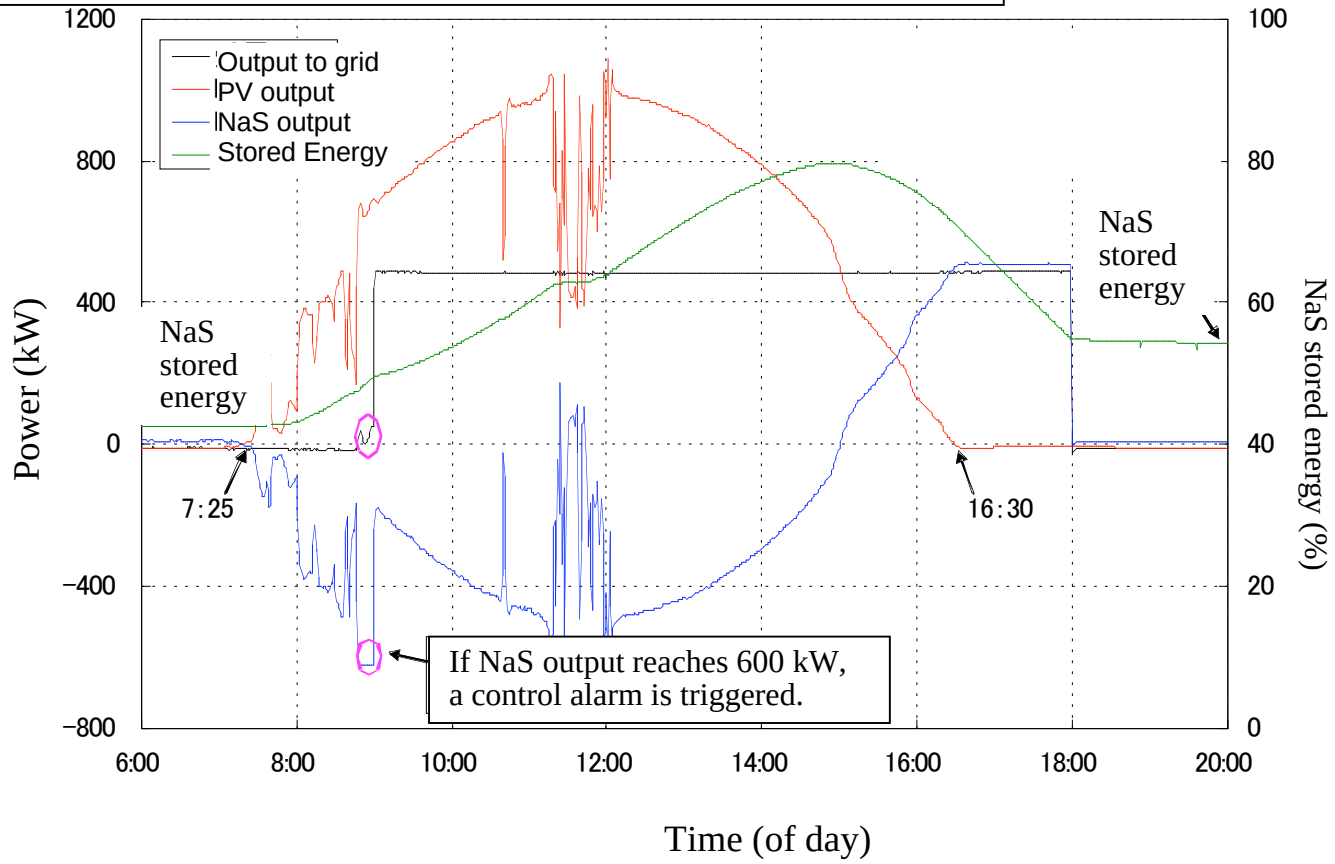
Hokuto site

	2006	2007	2008	2009	2010
PV capacity (MW)			Feb. ’08 0.6 MW		Sep. ’09 2.0 MW
Grid connection			Feb. ’08 6.6 kV		Sep. ’09 66 kV

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

Stabilization of mega-solar output: typical planned operation

Date: 2008/2/10
Operation schedule
9:00-18:00 (9 hours)
500 kW constant transmission



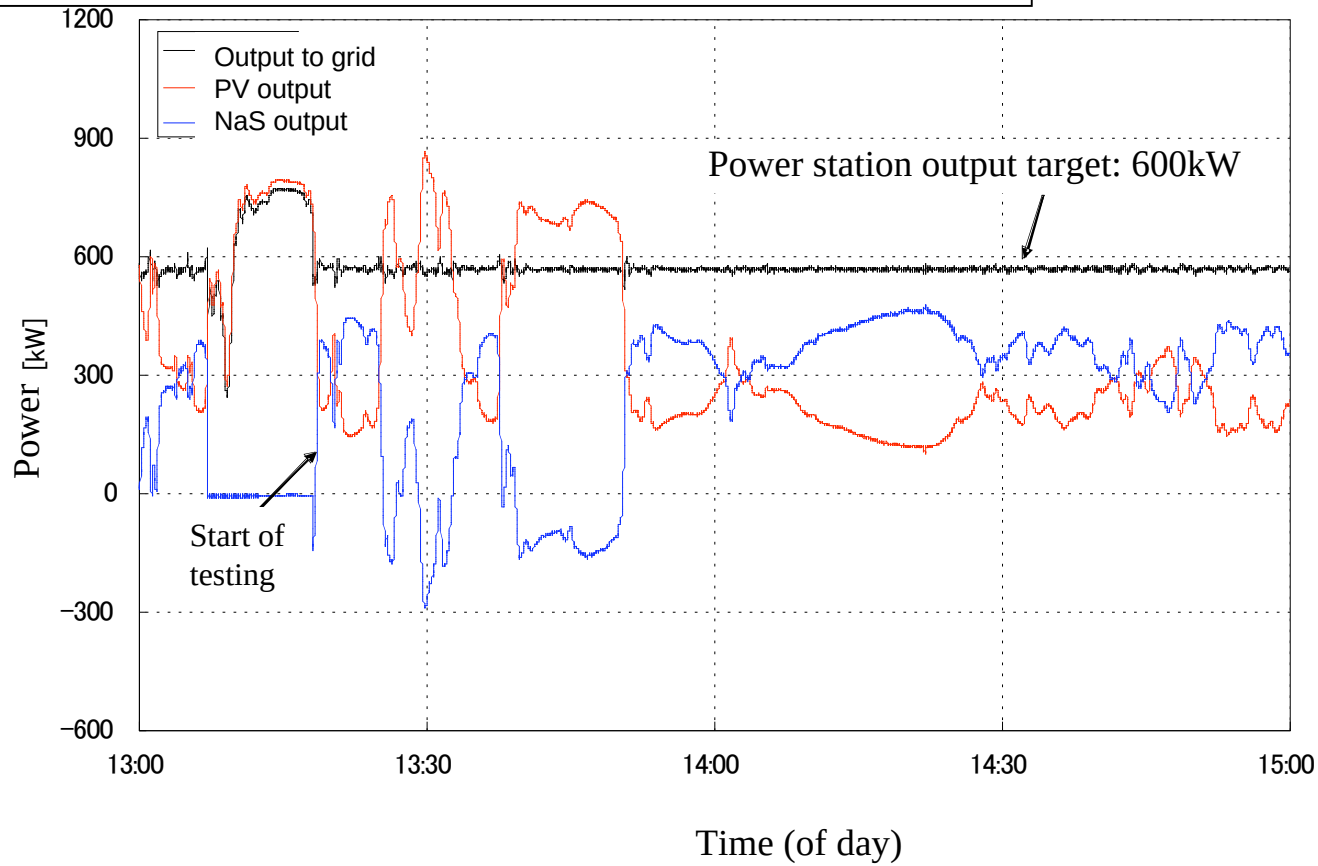
Comment:

We succeeded in meeting our planned output control, which was 500 kW constant transmission from 9:00 to 18:00.

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

Stabilization of mega-solar output: typical planned operation

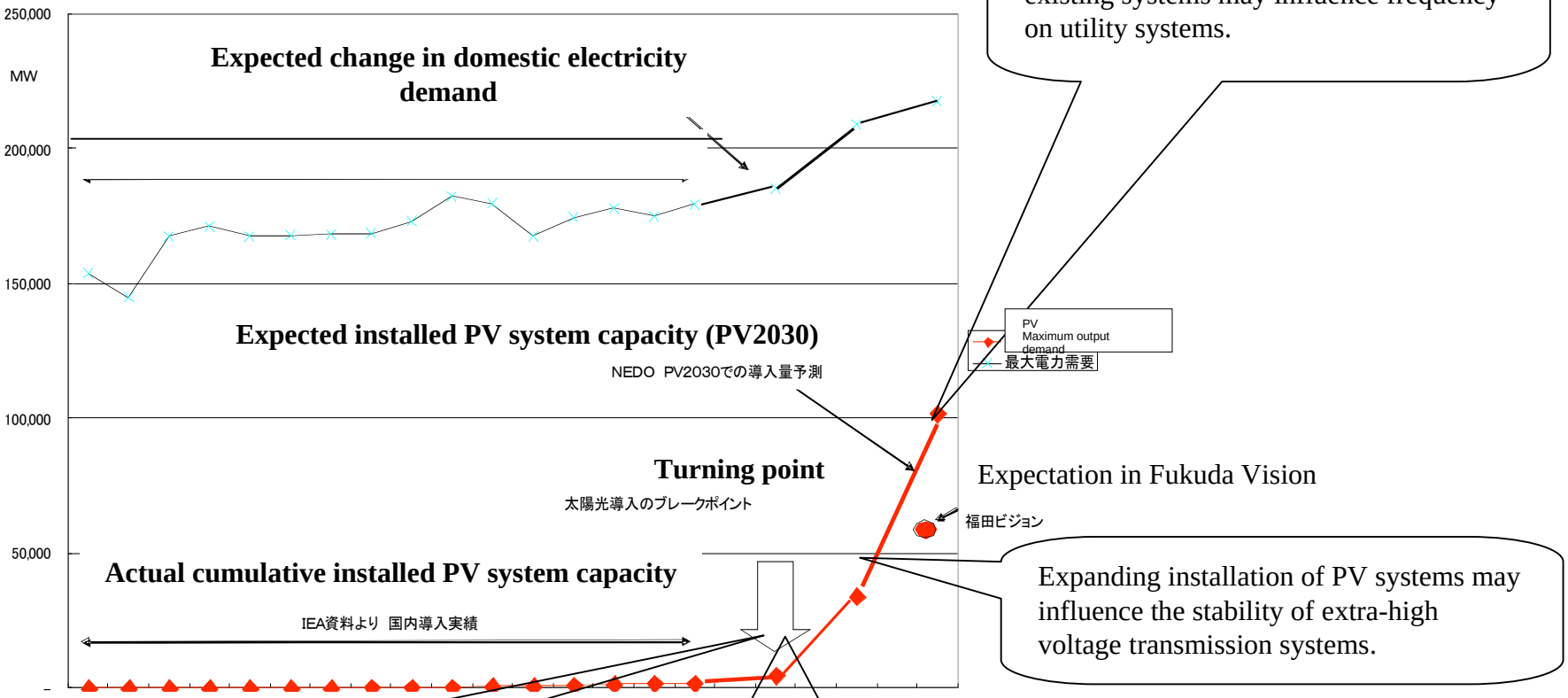
Date: 1/16/2008



Comment:

The difference between the output target, 600 kW, and real output, 580 kW, was caused by a control system error. We will minimize this error through field testing.

Overview of “PV Roadmap 2030”



Imbalance of output from PV systems and existing systems may influence frequency on utility systems.

Expanding installation of PV systems may influence the stability of extra-high voltage transmission systems.

Development of function to detect unintentional islanding

Development of technology to avoid restricting PV system output

Targets of NEDO grid-connection projects

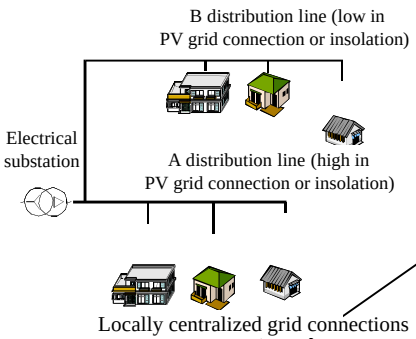
Study for Next Generation Technology

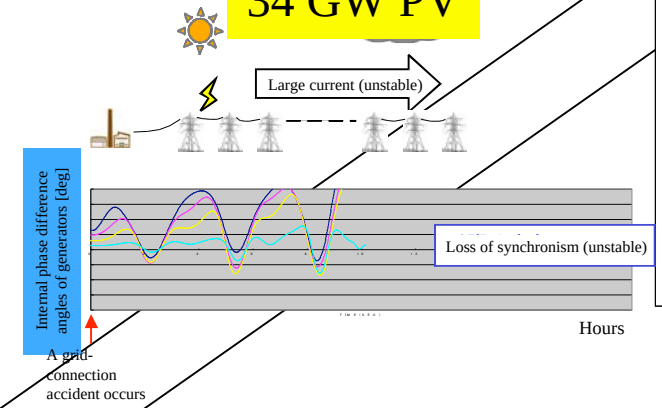
NEDO has begun creating a forecast of needs for grid connection technology related to renewable energy

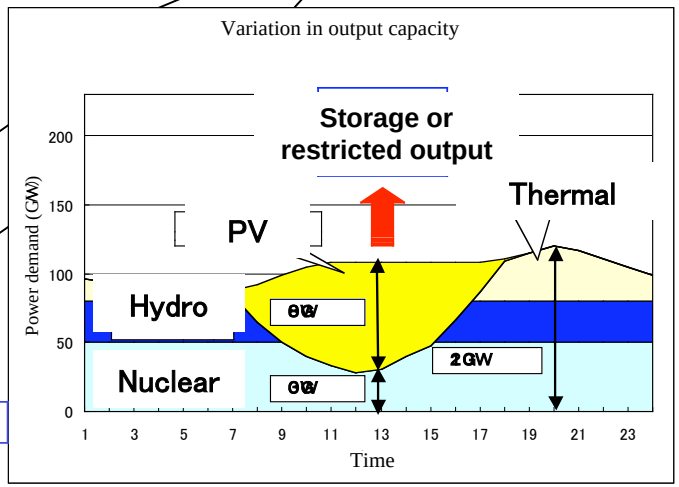
Year 2030
100 GW PV

Year 2020
34 GW PV

Year 2010
4 GW PV

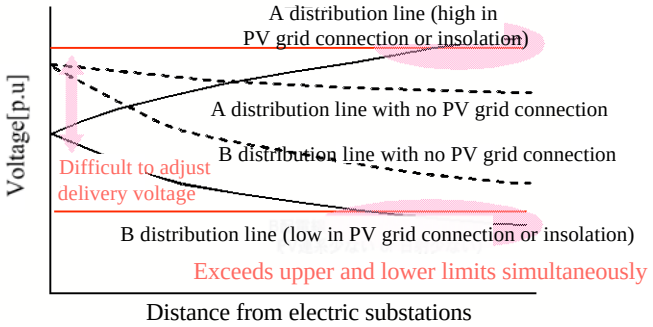






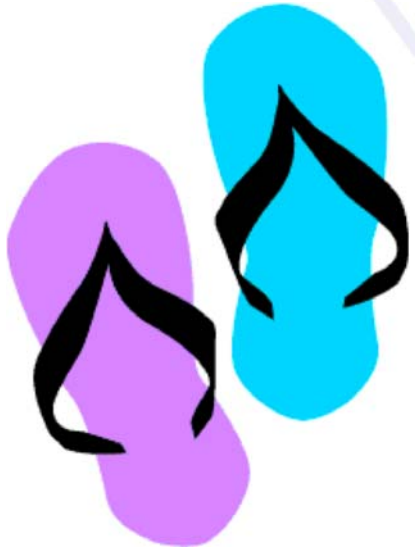
Uncertainty of balancing

Increased instability



Increase in voltage limit violations

Thank you for your attention!!



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