NEDO Research Related to Battery Storage Applications for Integration of Renewable Energy

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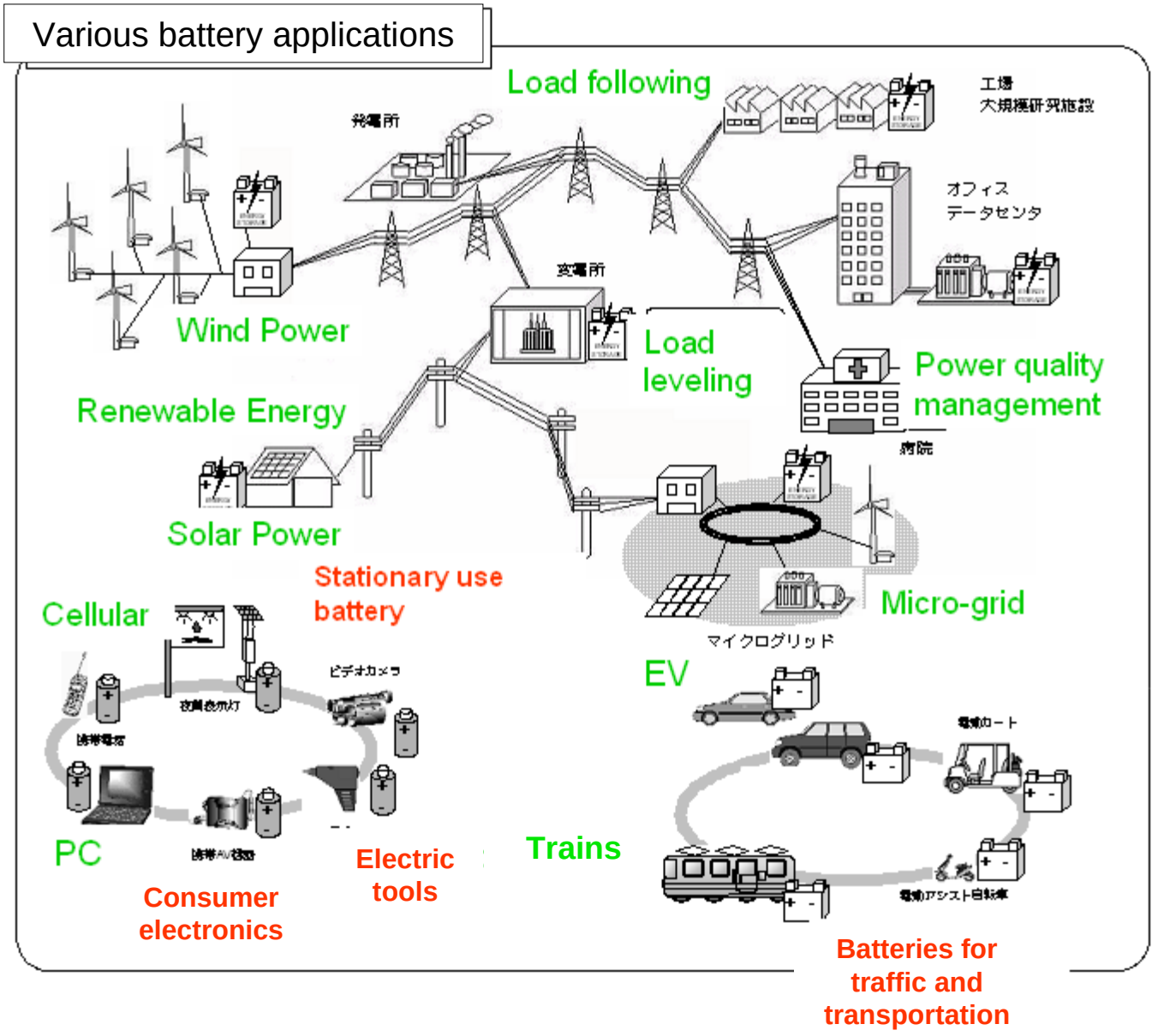
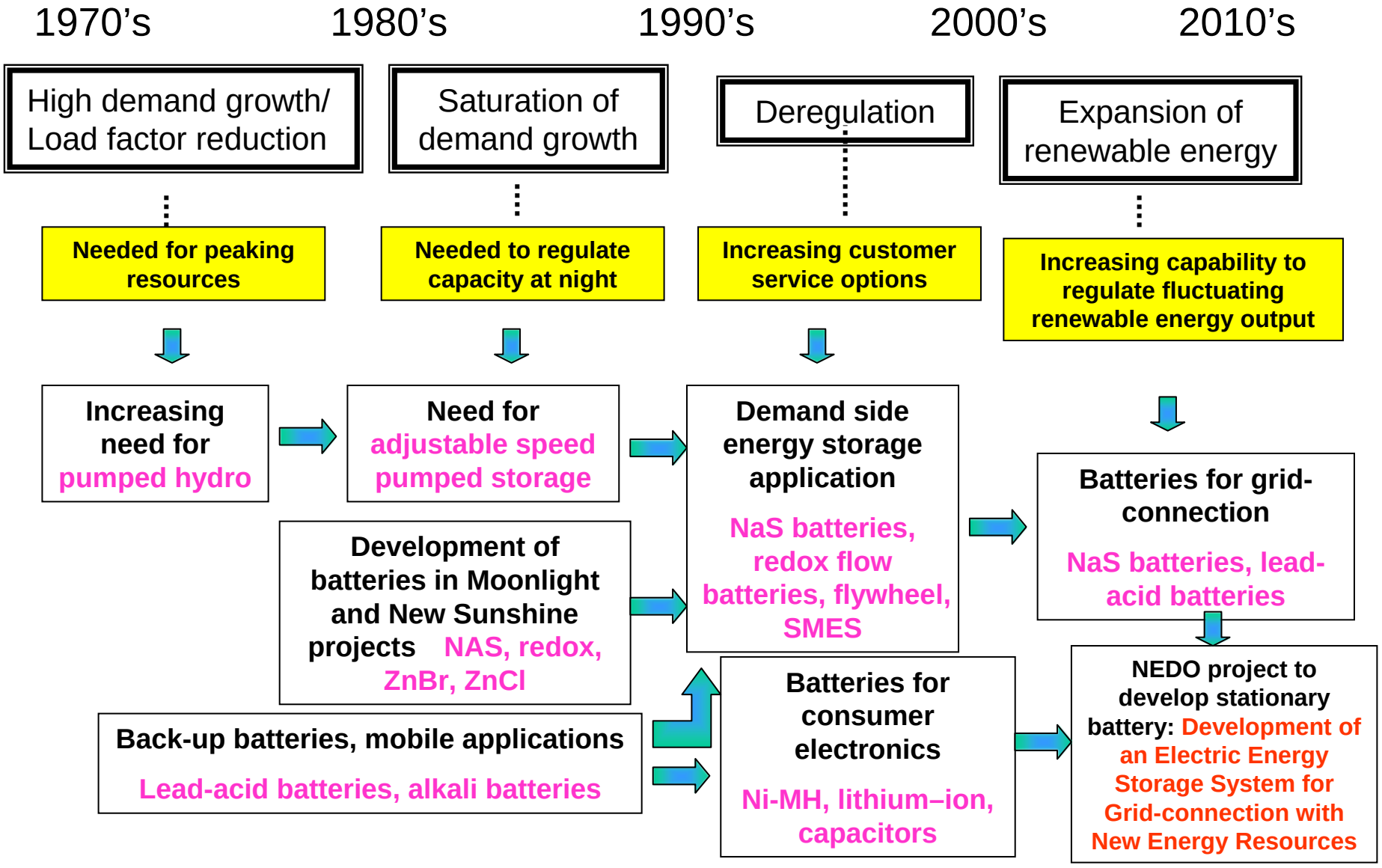
New Energy and Industrial Technology Development Organization (NEDO)

Energy Storage
- General trends -

Battery Storage Applications



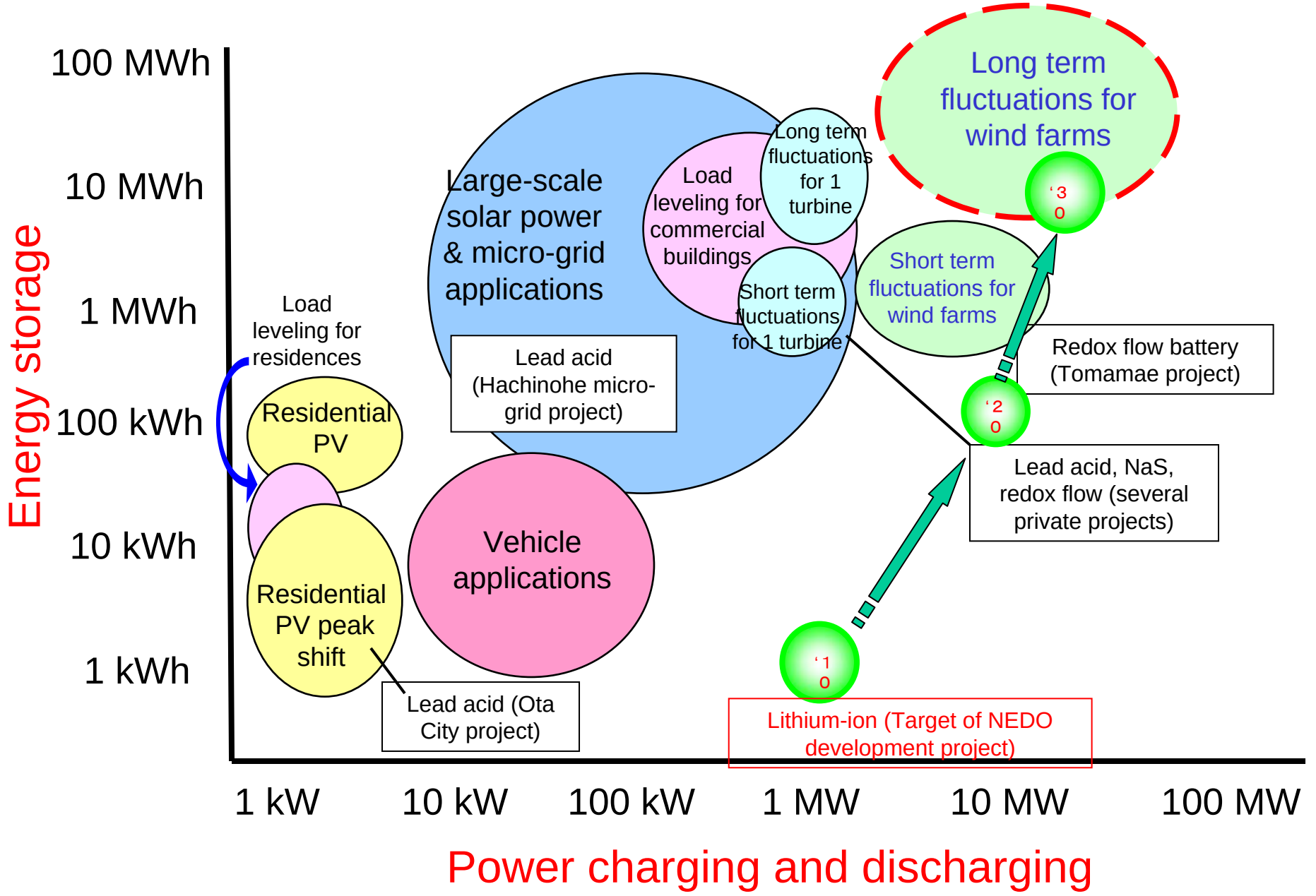
History of Evolution in Energy Storage Needs



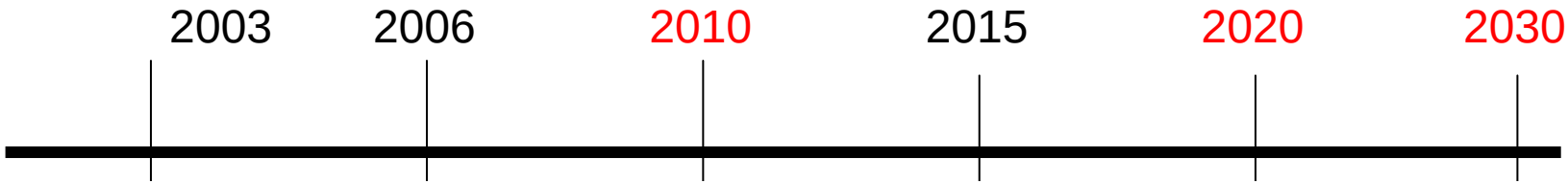
Typical Energy Storage Application

Application	Load leveling	Power system stabilization	Renewable energy	Load following	Power quality
Purpose	Leveling daily demand curve of power system	Stabilizing power system and maintaining as constant a frequency as possible	Compensating for fluctuating renewable energy output	Compensating for fluctuating demand	Reducing influence of voltage sags or other voltage problems
Specification	Larger than MW-scale. Required storage capacity: 8-10 hours.	Larger than MW-scale. Several minutes to 1 hour storage capacity is adequate.	For wind farms and mega-solar, MW-scale is needed. For small PV, kW-scale is adequate. It is expected that 8-10 hours of storage capacity will be required.	Amount of storage required depends on amount of demand (kW-MW). Several minutes to 1 hours storage capacity is adequate.	Size of storage depends on amount of demand (kW-MW). Several minutes of storage capacity is adequate.
Technologies	Pumped hydro Battery storage CAES	Battery storage SMES Flywheel	Battery storage (sometimes supported by capacitors)	Battery storage SMES Flywheel Capacitors	SMES Capacitors
Examples of real applications	Several pumped storage hydro systems exist in Japan. (e.g. Okumino 1500 MW, Shin-Takase 1280 MW …and others)	ROTES (26.5 MVA flywheel system) in Okinawa	Futamata Wind Farm (34 MW NaS battery system)	Flywheel generators for JT-60 (Nuclear fusion plasma research facility)	SMES system for SHARP's Kameyama factory

Relationship between Storage Capacity and Power



Battery Storage Market for Renewable Energy in Japan



If renewable energy installations constitute more than 5% of a utility's system capacity, we assume that battery storage equal to the amount of renewable energy output minus 5% will be needed to compensate for output fluctuations.

Power system

220 GW | 184 GW | 201 GW

Assuming most wind turbines will be installed in smaller utility districts

Wind power

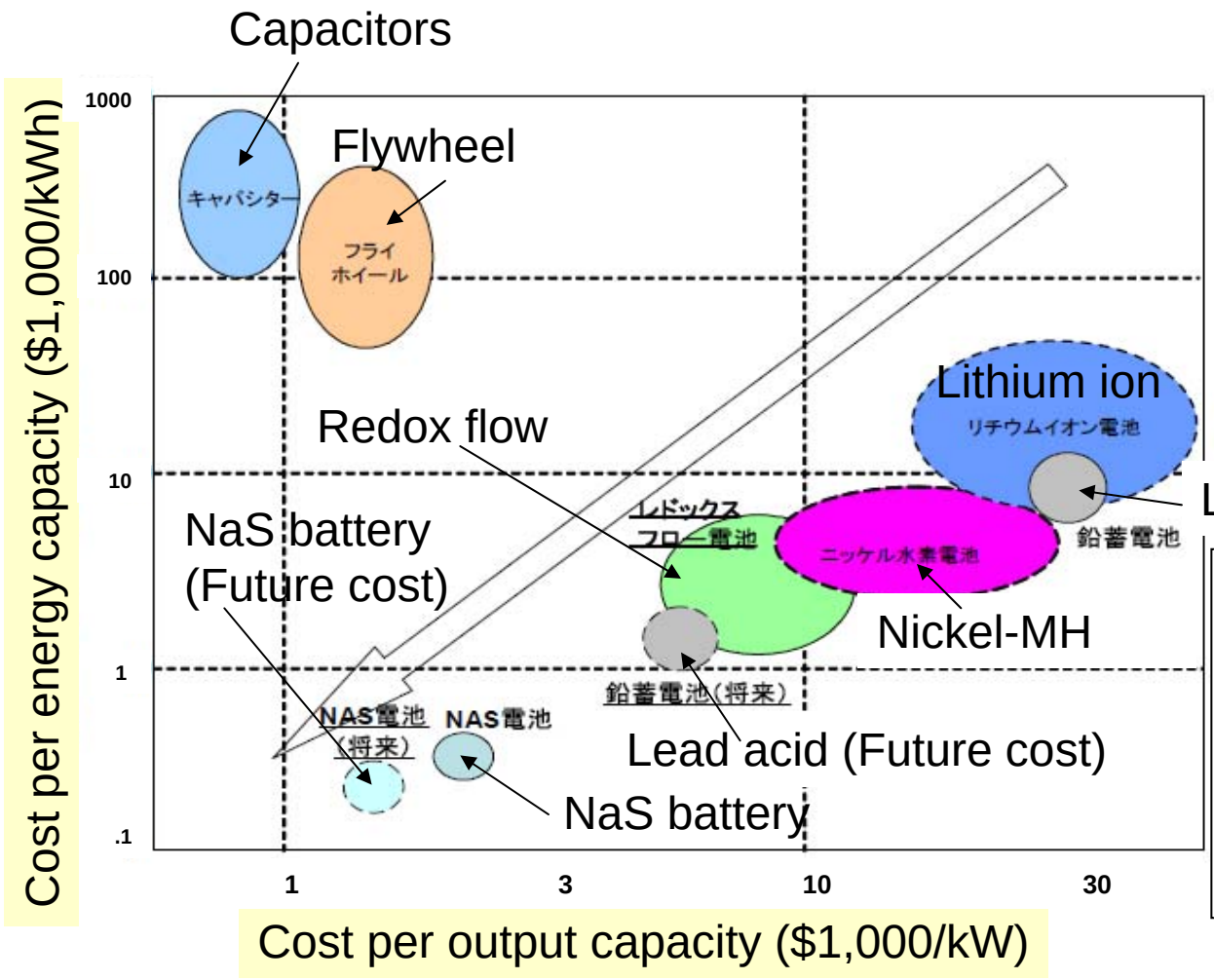
	2010	2020	2030
Installed capacity	3000 MW	4500 MW	6000 MW
Storage needed	150 MW	1500 MW	2700 MW
(Watt capacity: 7 hrs)	**1540 MWh**	**10500 MW h**	**18900 MWh**

PV

	2010	2020	2030
Installed capacity	4820 MW	34200 MW	101900 MW
Storage needed		24000 MW	91000 MW
(Watt capacity: 4 hrs)		96000 MWh	364000 MWh

In accordance with PV Roadmap 2030 (NEDO)

Relative Cost of Each Type of Battery Technology



Capacity of each technology

NaS battery 7.2 hours
Redox flow 1-8 hours
Lead acid 5 hours
Capacitors 6-8 seconds
Flywheel 15 seconds

Battery Storage
- How storage has been applied in NEDO projects -

Four Different Operating Modes Demonstrated in NEDO Projects

- Avoiding voltage increases on distribution lines
  - ⇨ **Demonstrative Project on Grid-interconnection of Clustered Photovoltaic Power Generation Systems**
- Reducing output fluctuations from renewable energy
  - ⇨ **Wind Power Stabilization Technology Development Project**
- Achieving scheduled output from renewable energy
  - ⇨ **Verification of Grid Stabilization with Large-scale PV Power Generation Systems**
- Balancing demand and supply on a micro-grid
  - ⇨ **Demonstrative Project of Regional Power Grids with Various New Energies**

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

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

Avoiding voltage increases on distribution lines

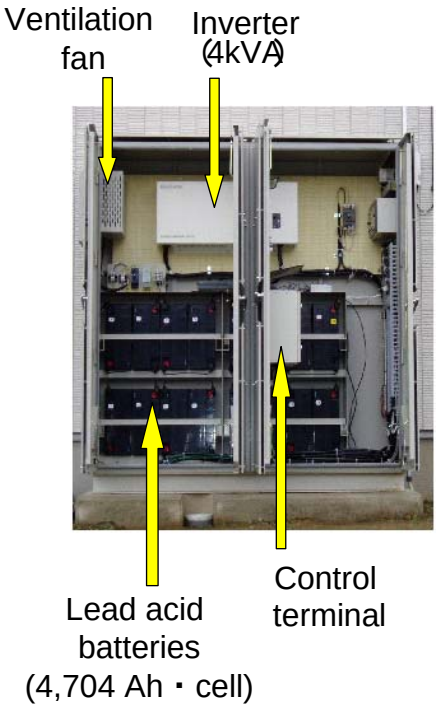
PV systems:
◆**Number of PV systems installed: 553**

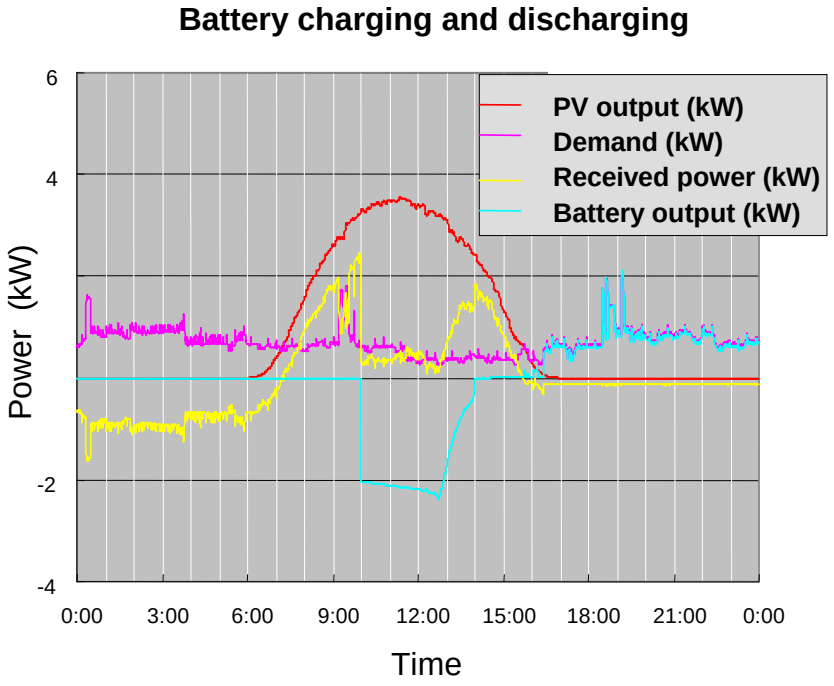
◆**Total PV capacity: 2,129 kW**

◆**Average PV capacity: 3.85 kW**

Battery storage:
◆**Number of installations: 550**

◆**Storage capacity: 4704 Ah≒9 kWh**





Wind Power Stabilization Technology Development Project (FY2003-2007)

Wind Power Stabilization Technology Development Project (FY2003-2007)

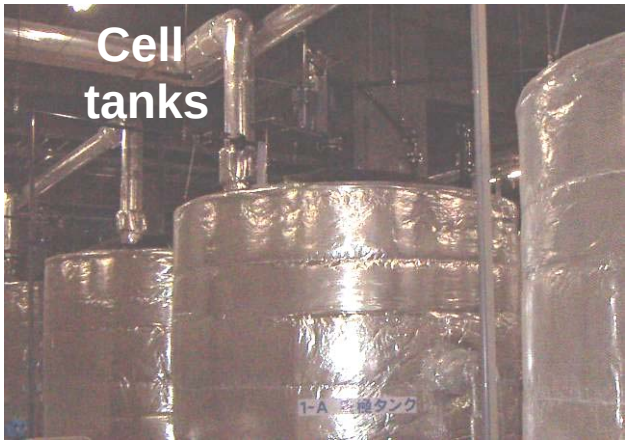
Reducing output fluctuations from renewable energy

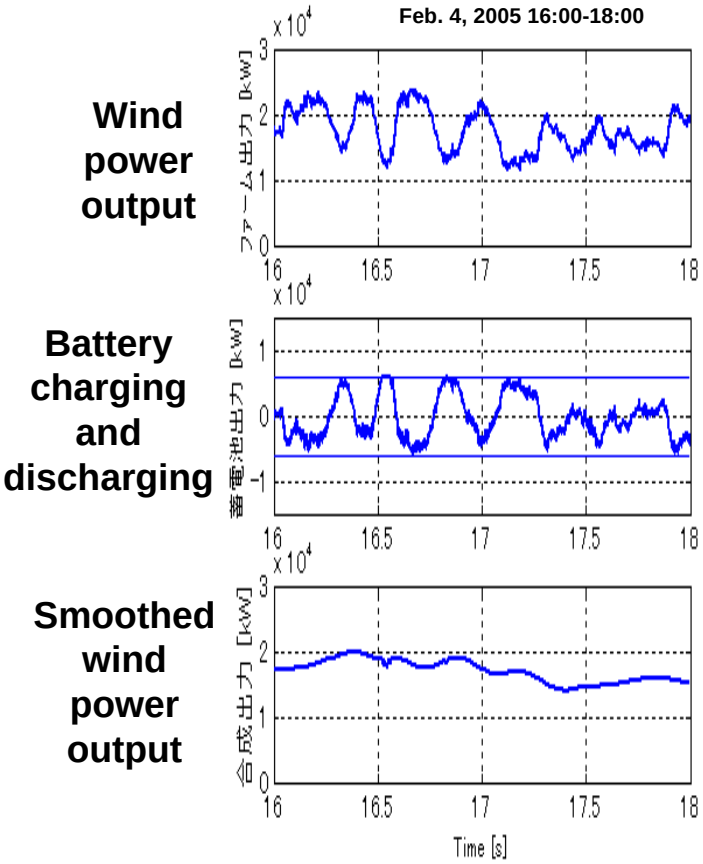
◆Redox flow battery inverter capacity: 6000 kW (Same as short term output rate of battery)

◆Nominal capacity of battery: 4000 kW

◆Storage capacity: 6000 kWh

◆Total weight: 950 tons





Smoothing time constant
T = 10 Minute

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)

Achieving scheduled output from renewable energy

Mega-solar capacity data

◆**Wakkanai site**

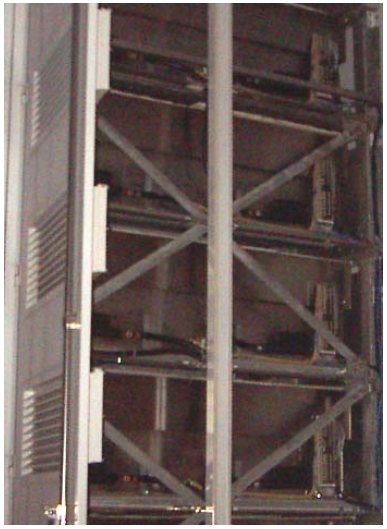
2 MW, (5 MW will ultimately be installed). Most PV cells are crystalline.

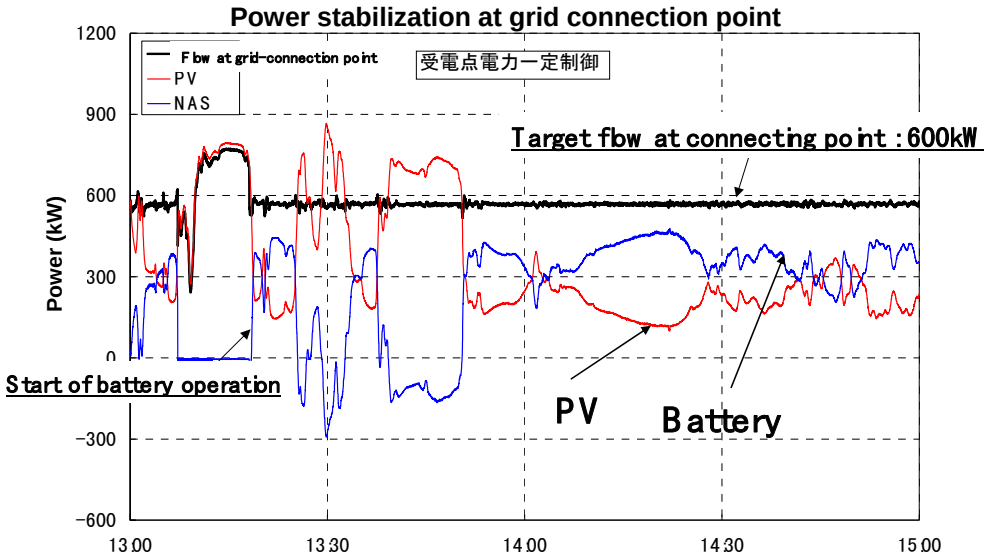
◆**Hokuto site**

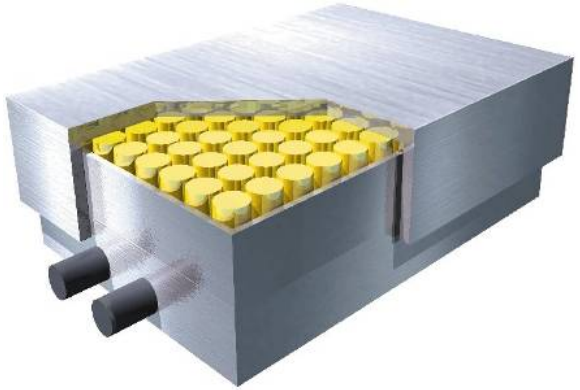
600 kW (2 MW will ultimately be installed).
26 types of PV arrays have been installed.

Battery storage installed at Wakkanai site

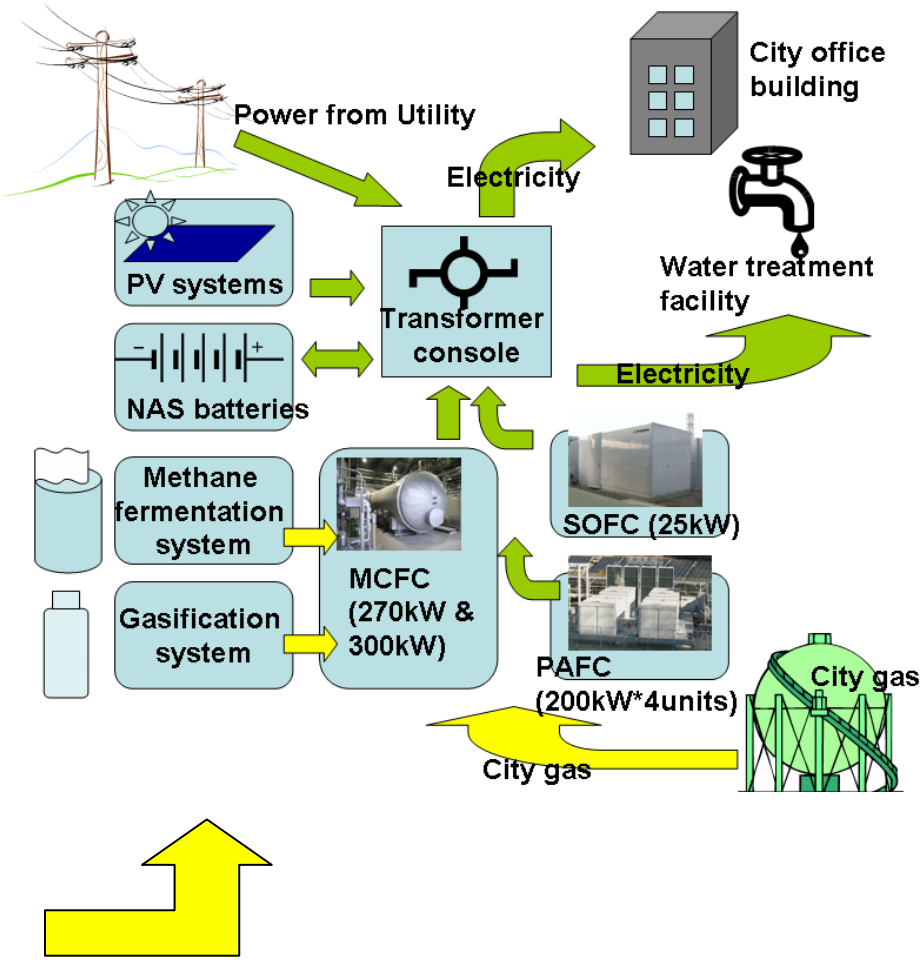
◆**NaS (sodium sulfur) battery: 500kW-7.2 hrs (1500 kW-7.2 hrs will ultimately be installed.)**







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

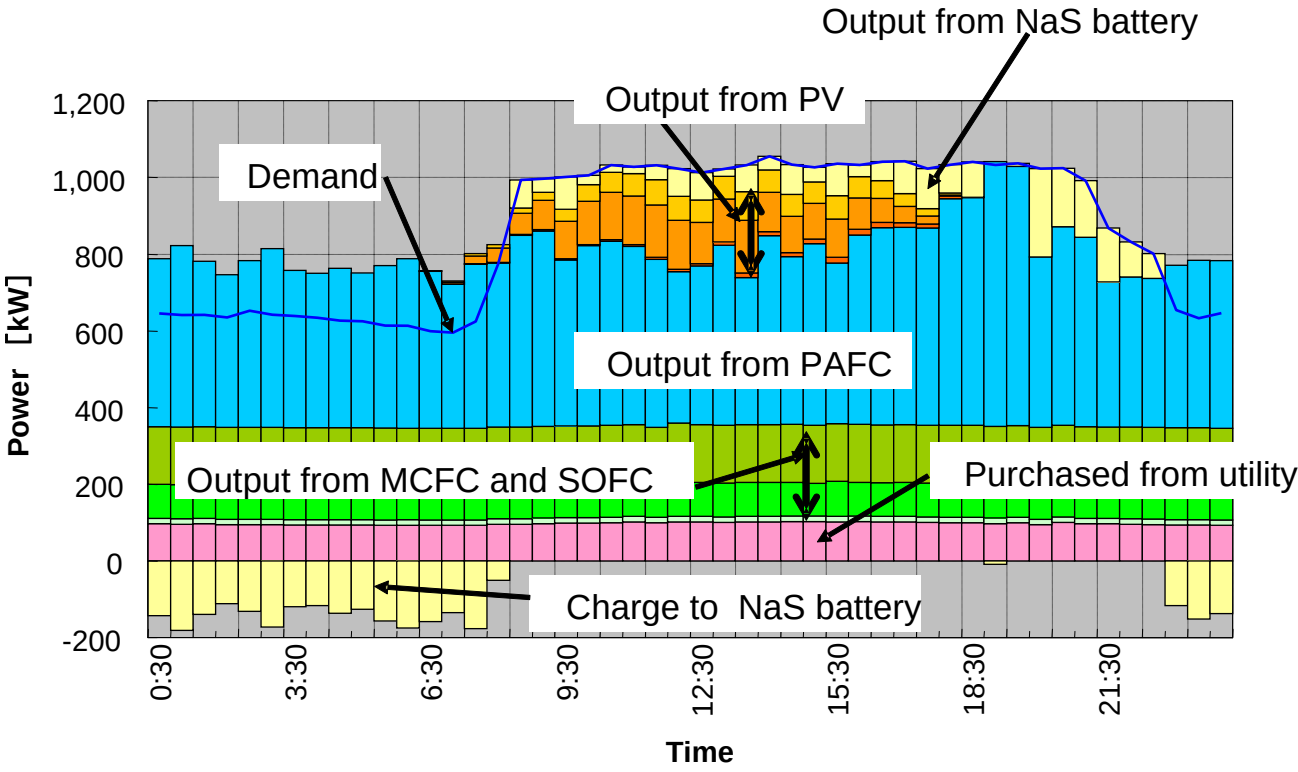


Demonstrative Project of Regional Power Grids with Various New Energies (FY2003-2007)

Balancing demand and supply on a micro-grid

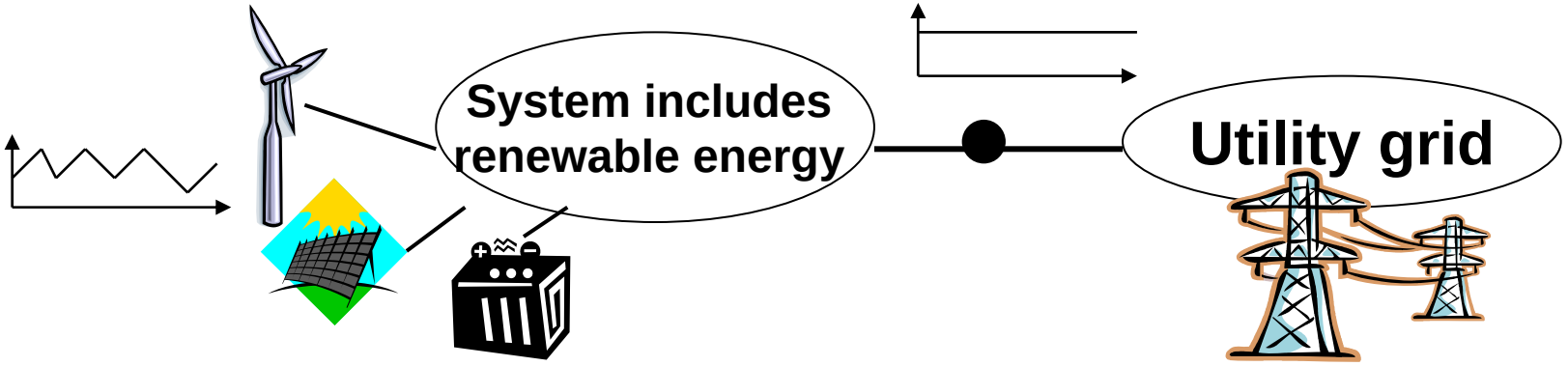
NaS battery: 500 kW

Other generators
MCFC: 300 kW
MCFC: 270 kW
SOFC: 25 kW
PAFC: 200 kW x 4 units
PV: 330 kW



Knowledge Obtained through NEDO Projects

■ **Battery storage can reduce output fluctuations from renewable energy.**

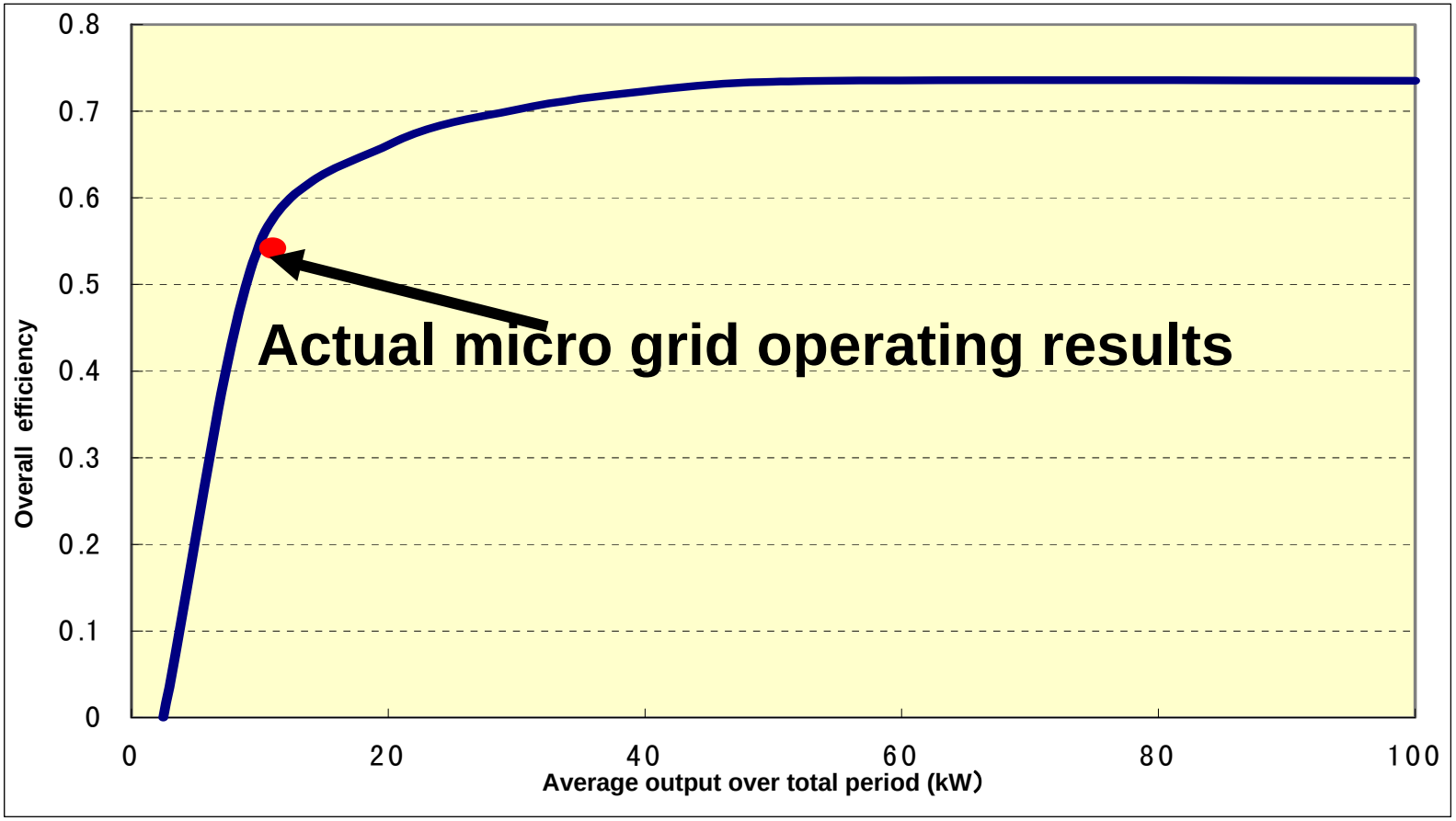


■ **However, battery costs should be reduced to half of recent prices for sodium battery systems (¥25000 (~$250)/kWh) .**

■ **Maintaining the efficiency of inverter system is very important (not easy) for renewable power applications.**

Knowledge Obtained through NEDO Projects

Lower operating factor of battery systems applied to renewable energy installations results in total efficiency of battery storage being less than 70%, due to constant inverter loss.



Battery Storage
- NEDO battery technology development project -

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

NEDO

Project objectives:

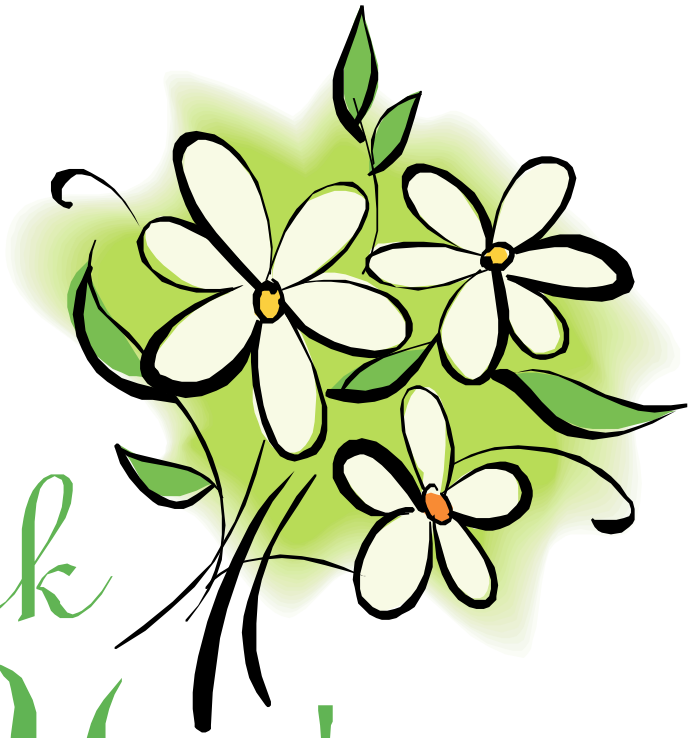
(1) Establish technologies for large-scale (MW) storage system

(2) Establish module level technologies to reduce costs and expand capacity (¥48000 ($480)/kWh if commercialized, 10 year lifecycle, 1 MW-scale)

(3) Develop low cost, next generation storage technologies (¥15000($150)/kWh, 20 year lifecycle, 30 MW-scale), aiming for commercialization in the year 2030

(4) Conduct fundamental research study to evaluate safety, economics and lifecycle

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



Thank You!