Resilient and Expandable Distribution Networks for Smarter Grids

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Outline of Presentation

- ***Clean Energy Technology for Stable Supply and CO_2 Reduction after Natural Disaster***
- ***Paradigm Shift to Best Energy Mix for Stable Power Supply in Japan***
- ***Implementation and Verification of Smart/Micro Grids in Japan***
- ***Resilient and Expandable Smart Distribution Grid for Efficient Use of Sustainable Energy***
- ***Prospect of Smart Grid Development in Japan***

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Clean Energy Technology for Stable Supply and CO_2 Reduction after Natural Disaster

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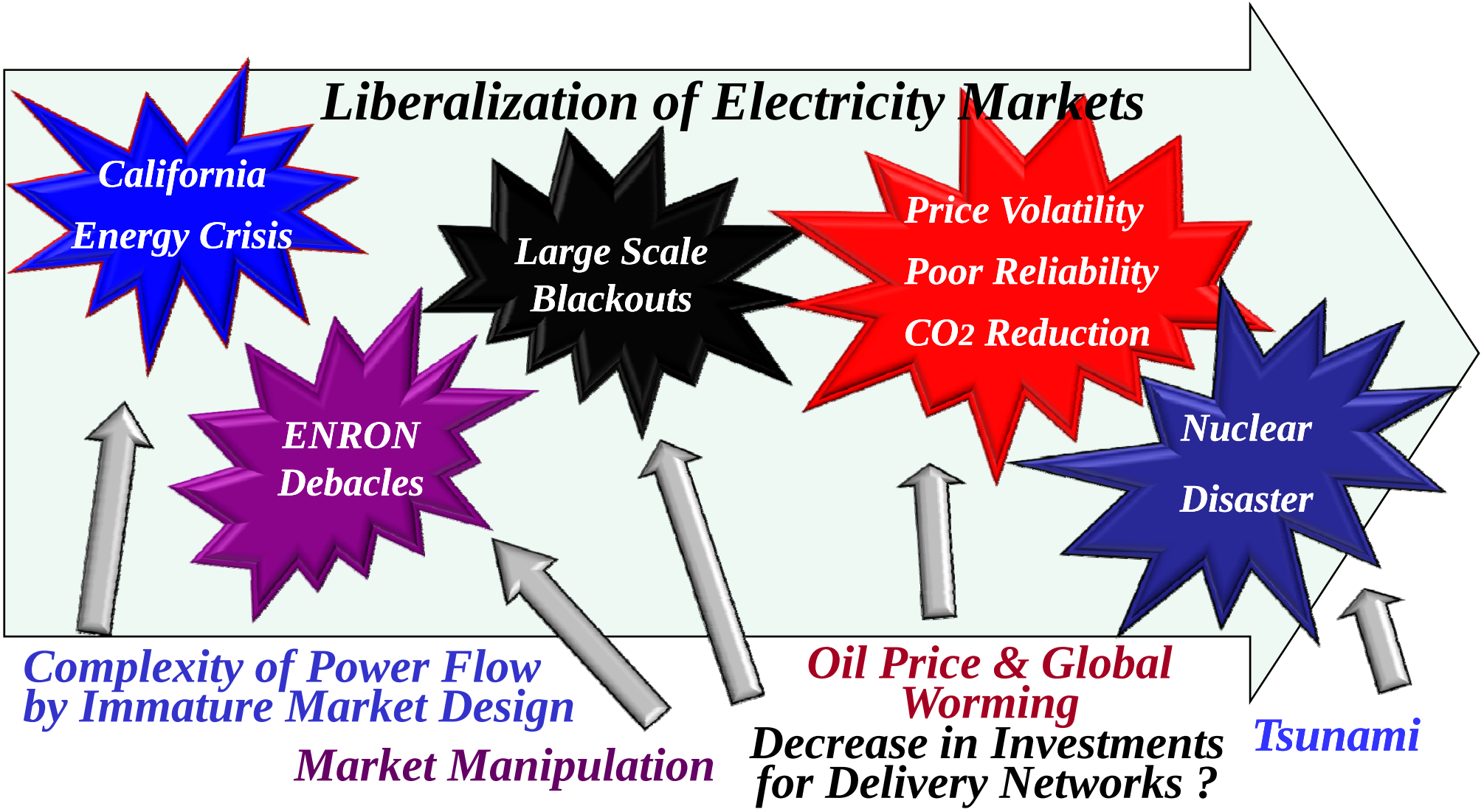
Happenings of Negative Aspects in Front Runners of Power Markets



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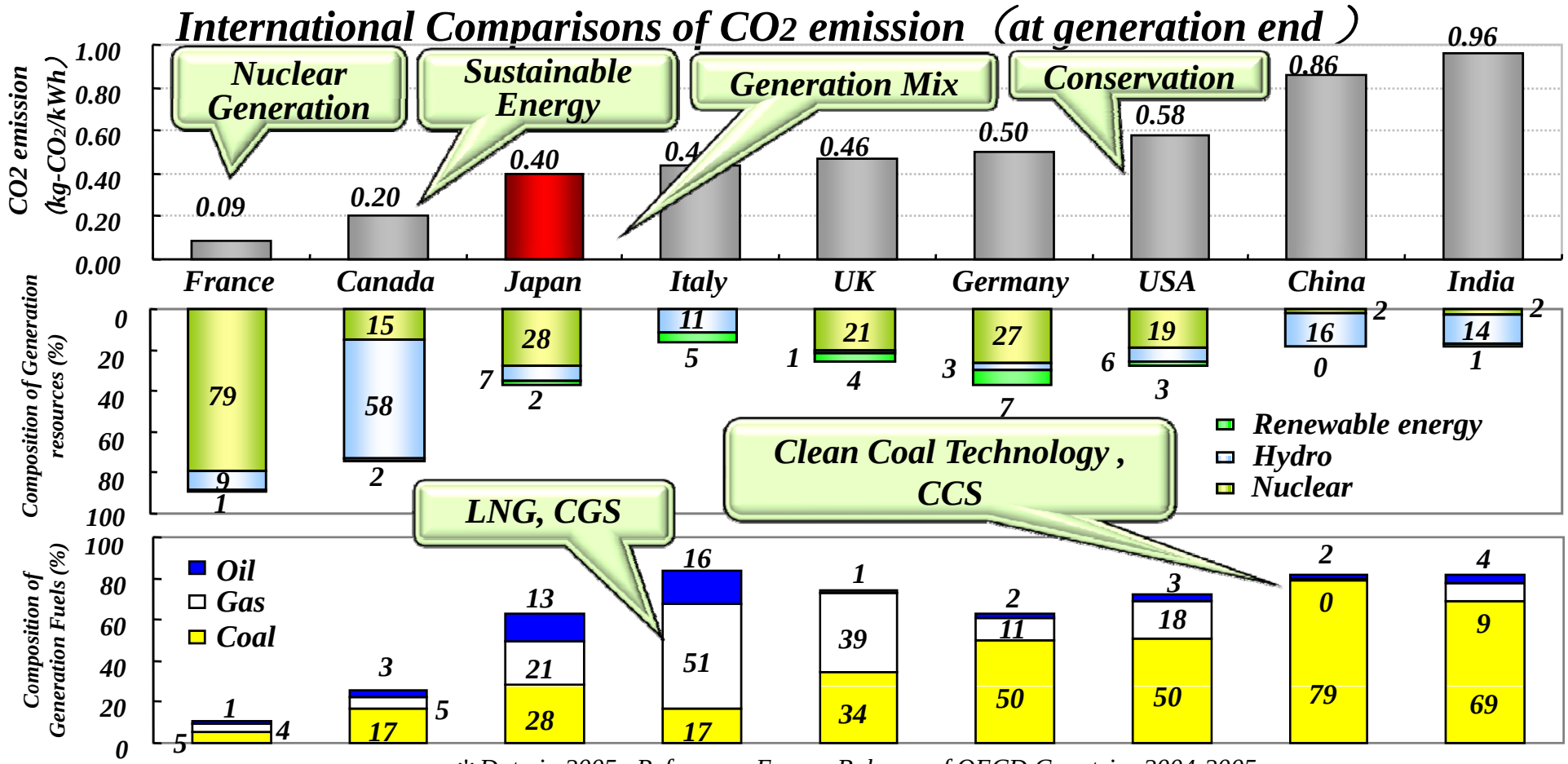
Comparison of CO_2 Emission in Countries
(Kg-CO2 / Kwh at Generation End)

- CO2 emission in Japan is relatively low compared with other countries
- France(Nuclear centered) and Canada(Hydro centered) are the top runners in the world.
- As Germany abolished nuclear plants by national consensus, the ratio of coal plants is high.



＊Data in 2005 Reference: Energy Balance of OECD Countries 2004-2005
＊CHP Plants include

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Disaster by Tohoku/Pacific Coast Tsunami

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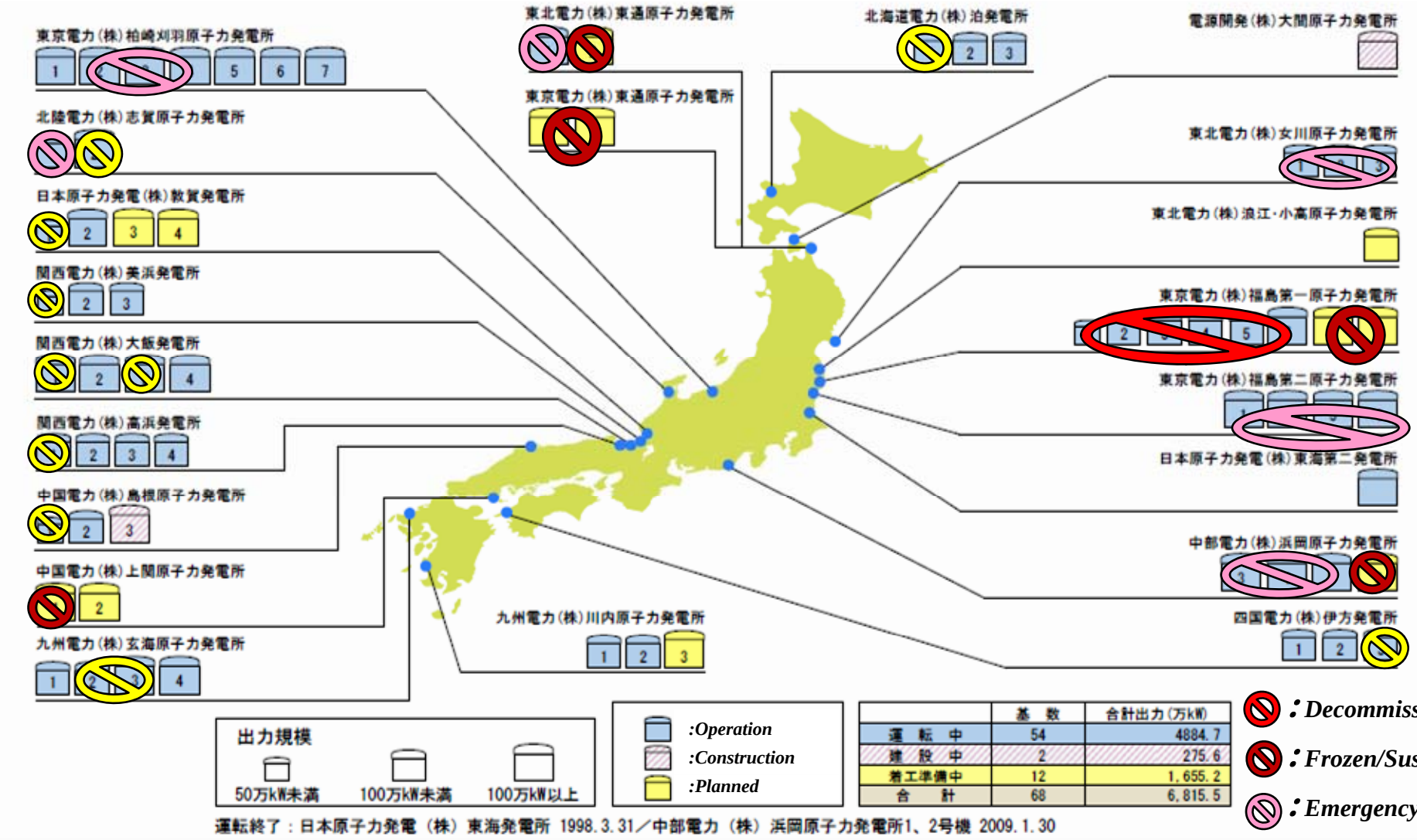
Current Situation of Nuclear Plants in Japan



	基数	合計出力(万kW)
運転中	54	4884.7
建設中	2	275.6
着工準備中	12	1,655.2
合計	68	6,815.5

:Decommissioning

:Frozen/Suspended

:Emergency Stop

:In Maintenance

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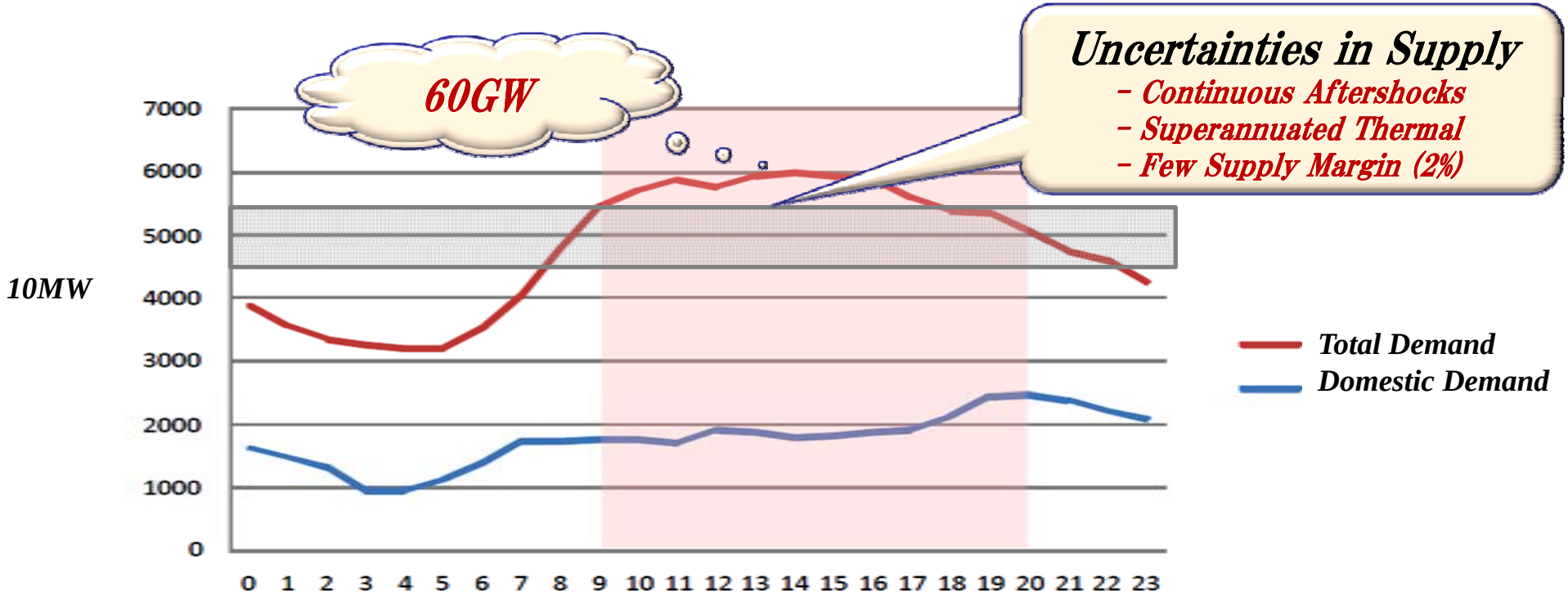
Power Shortage at Peak Period in Summer 2011



Power Supply Capability

- Tokyo Electric Power Co. sends 1.4GW to the disaster-stricken Tohoku Electric Power Co.
- Supply Capacity in Tokyo Area : 53.80GW(July), in Tohoku Area : 13.7 GW(August)

Demand/Supply Balance after accommodating power through tie lines

- Estimated Peak Demands in Tokyo and Tohoku Areas : 60.0 GW、 14.8 GW
- Estimated Power Supply after Accommodations : 53.8 GW、 13.7 GW
- Necessary Electricity Saving Ratio : ▲10.3%、 ▲7.4%

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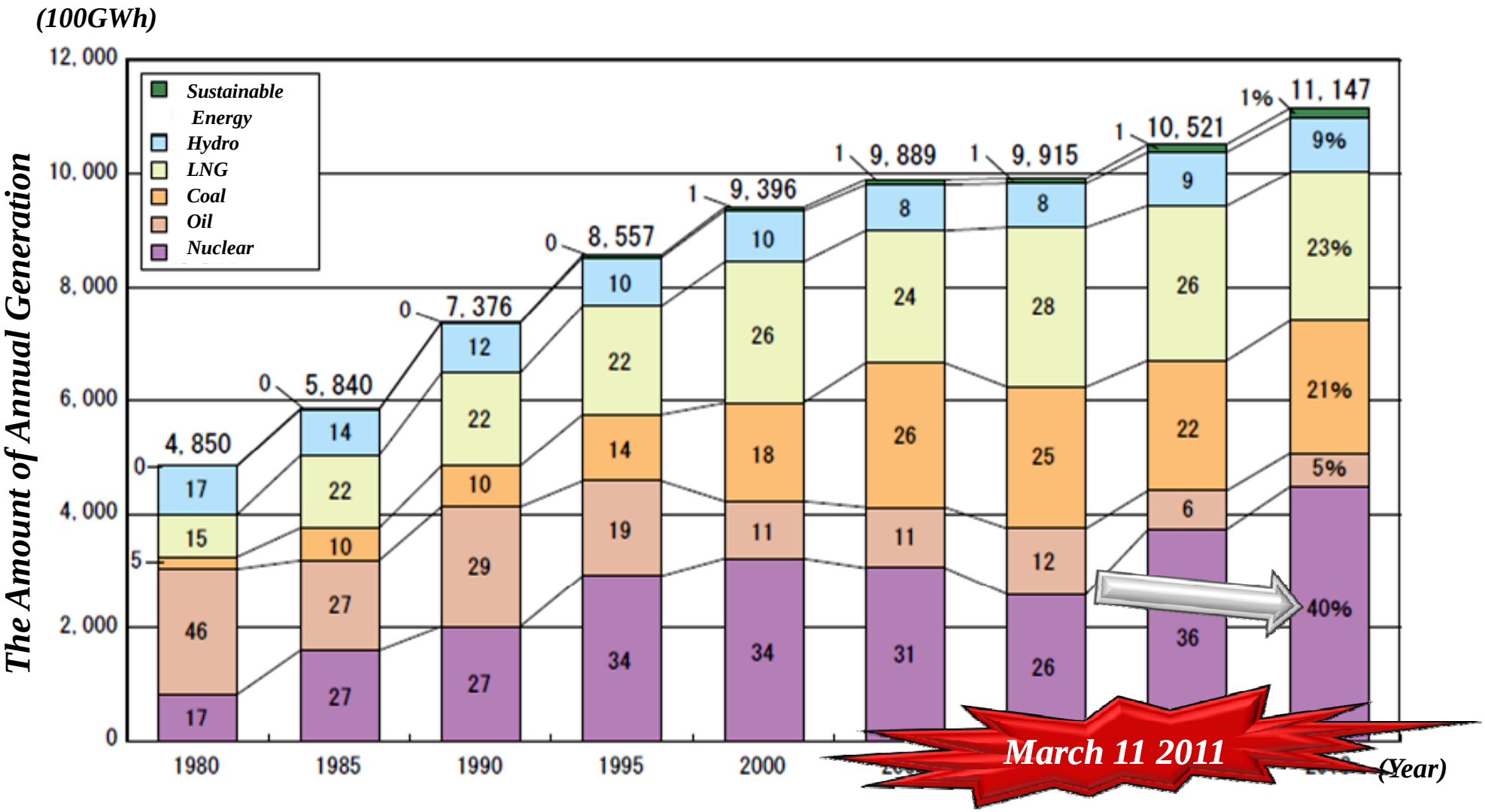
Transition and Prospect of Generation Mix in Japan



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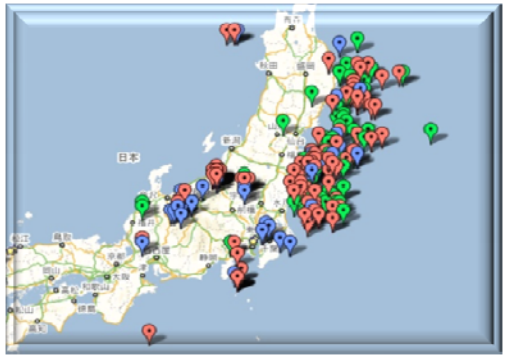
Amount and Ratio of Economic Damage for Invested Stock by Natural Disaster

- **Total Amount of Direct Economic Damages : 14～18 Trillion Yen**
- **Damages (Trillion Yen) of Social Stocks : 5.8～7.1 , Houses: 2.3～3.1 , Enterprises' Families: 5.3～7.3, Stocks: 0.6**

Capitals and Stocks	Amount of Damages (Trillion Yen)		Damage Ration	
	Total of 7 Prefectures	3 Prefectures	Total of 7 Prefectures	3 Prefectures
Social Capital	5.8 - 7.1	4.5 - 6.1	7.2%	21.0%
Road	1.1 - 1.4	1 - 1.4		
Harbor Facility	1.2 - 1.3	0.6 - 0.9		
Water /Waste Treatments水	0.5 - 0.6	0.4 - 0.6		
City Parks	0.1 - 0.1	0.1 - 0.1		
Culture /Education Facility	0.6 - 0.8	0.6 - 0.8		
Afforestation/River/Coast	0.5 - 0.7	0.4 - 0.6		
Agriculture/Fishery	1.7 - 2.1	1.3 - 1.7		
Houses	2.3 - 3.1	2.3 - 3.1	6.4%	26.1%
Enterprise Facilities	5.3 - 7.3	5.3 - 7.2	6.9%	25.1%
Buildings	3.4 - 4.6	3.3 - 4.6		
Machines /Facilities	2 - 2.7	1.9 - 2.6		
Stocks	0.6	0.6	6.5%	23.9%
Manufactures' Stocks	0.4	0.4		
Commodity Stocks	0.2	0.2		
Total	14.1 - 18.1	12.6 - 17	6.9%	23.5%



Prefecture	Damage Ratio: All Stocks Average
Hokkaido	0.6%
Aomori	1.9%
Iwate	23.8%
Miyagi	33.7%
Fukushima	12.8%
Ibaraki	1.6%
Chiba	0.7%

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Paradigm Shift to Best Energy Mix for Stable Power Supply in Japan

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Contribution of Electric Power Sector for Carbon Free Society

- Main streams of CO_2 reduction by electric power sector are ;
  - Supply side : Enhancement of Efficiency and Nuclear and Sustainable Energy
  - Demand Side : Efficient Facilities and Energy Saving by Electrification
- Practical and effective countermeasures on supply and demand sides in cooperation with government, industries and academic organizations

Supply side

Enhancement of Efficiency
Reduction of CO_2

- ~~Expansion of Nuclear~~
- Diffusion of Sustainable Energy

Demand Side

Efficient Facilities
Energy Saving by Electrification

- Energy Saving, Energy Storage
- Heat pump, Electric Vehicles

Future Network

Stable Power Supply

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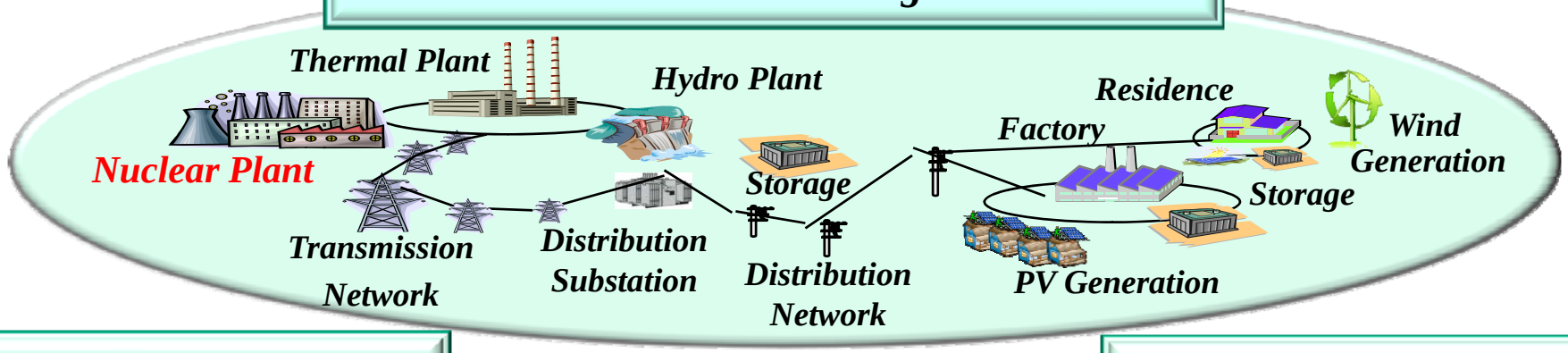
Toward Best Energy Mix from Nuclear-Centered Generation Mix

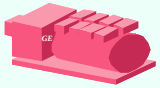
Generation Mix based on Large Scale Plants



Energy Saving → **Local Generation**

Best Energy Mix based on Distributed Generation and Network

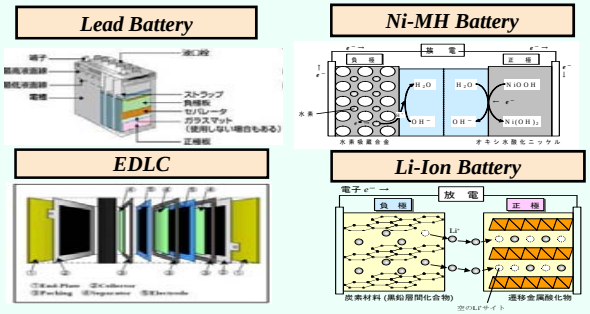
Generation with Fossil Energy



- LNG Thermal Plant (1GW)
- Gas Combined Cycle (0.3GW)
- Gas Engine (10KW – 1MW)
- IGCC (Clean Coal Generation)
- Fuel Cell

Generation with Sustainable Energy

Battery Energy Storage



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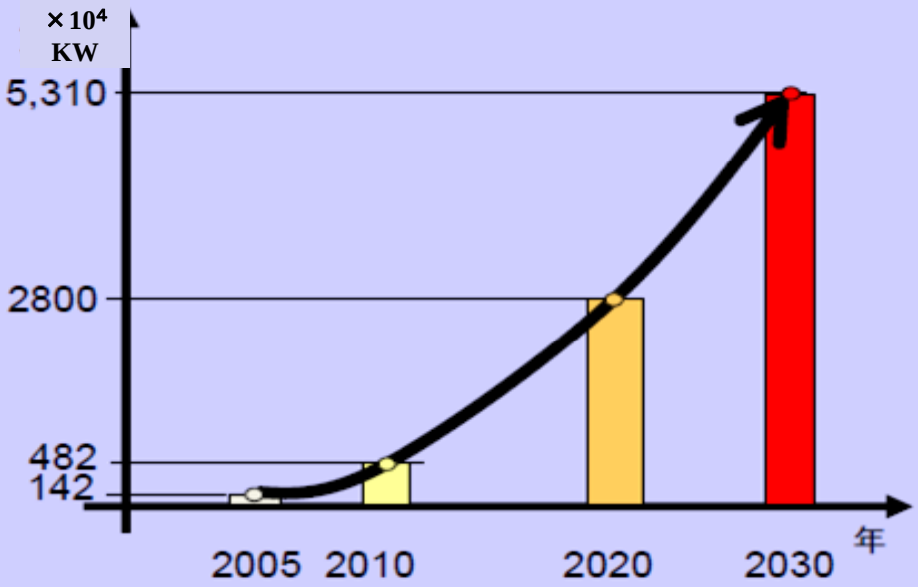
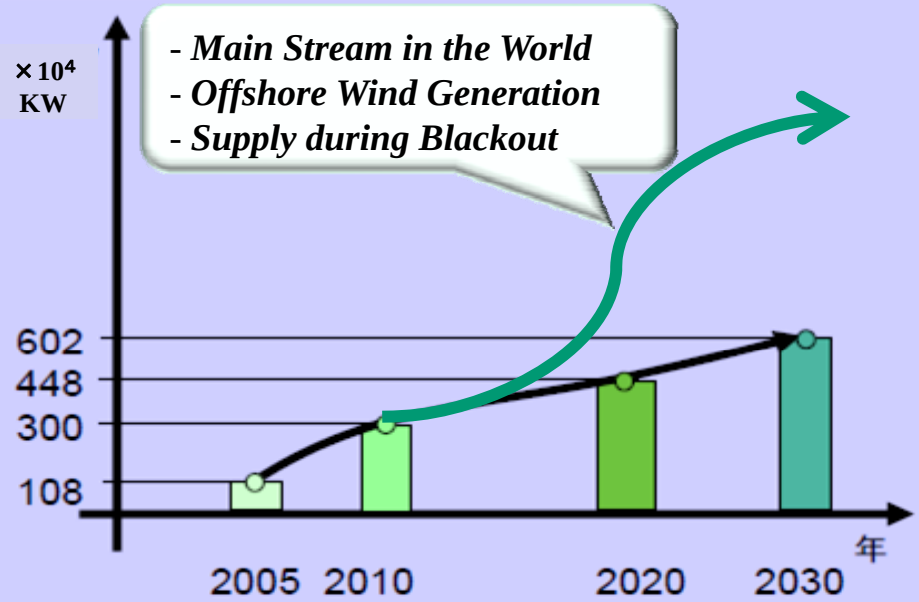
Middle Term Targets of Sustainable Energy Installation in Japan

PV Generation



	Target (×10⁴KW)	Ratio against 2005
2005	142	1
2010	482	3.4
2020	2800	20
2030	5310	40

Wind Generation



	Target (×10⁴KW)	Ratio against 2005
2005	108	1
2010	300	3
2020	448	4.5
2030	602	6

Ref.: Mitsubishi Elec. Com.

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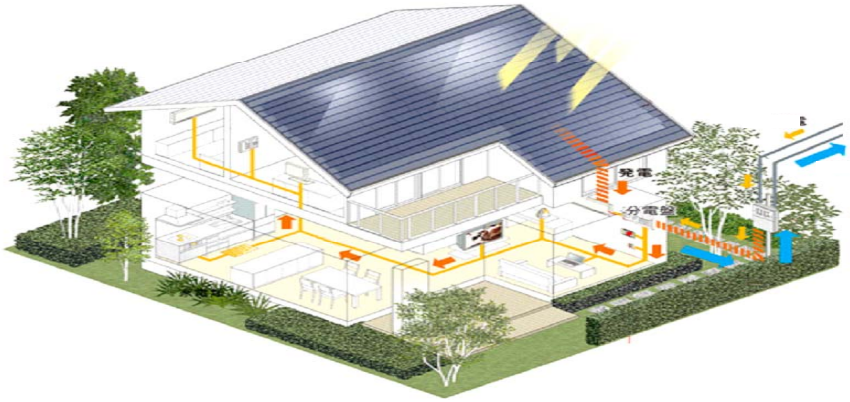
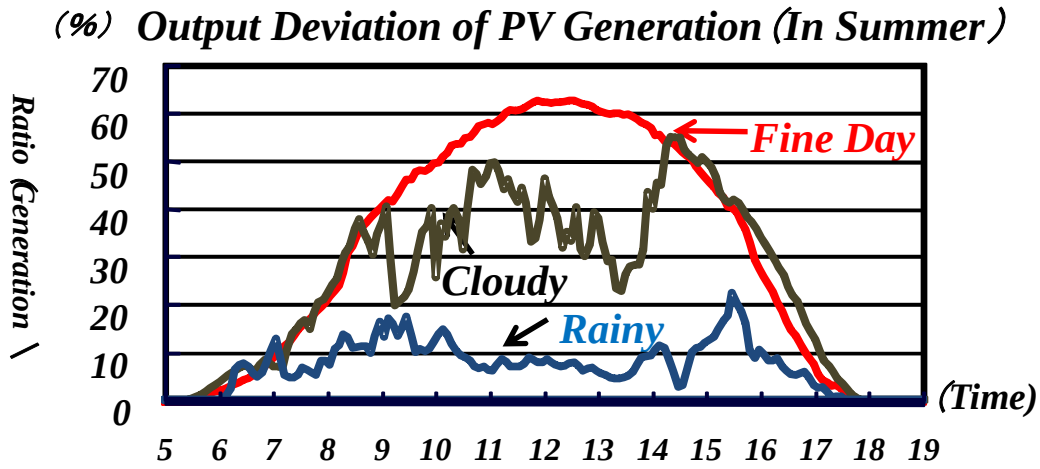
Issues in Power System Operation by Large Scale Instillation of Sustainable Energy

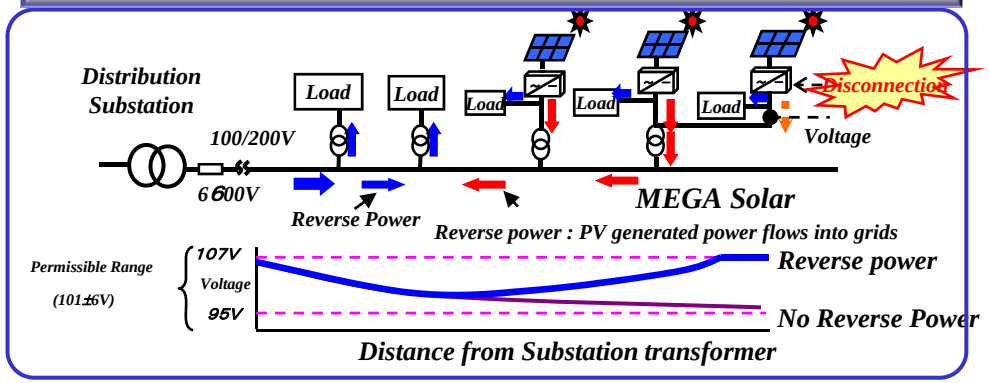
- By large scale installation of sustainable energy such as PV generation, new problems in power grids ; Excess energy, Voltage increase and Shortage of frequency control capacity occur.
- Necessity of power stabilization control to keep their own functionality of power networks



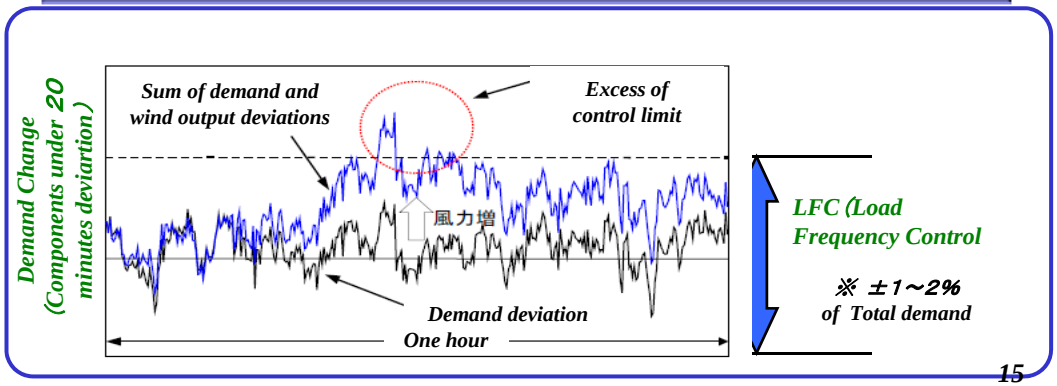


Technical Issue in PV Generation Installation

1. Voltage Increase and Reverse Power in Distribution Networks



2. Shortage of Frequency Control Capacity



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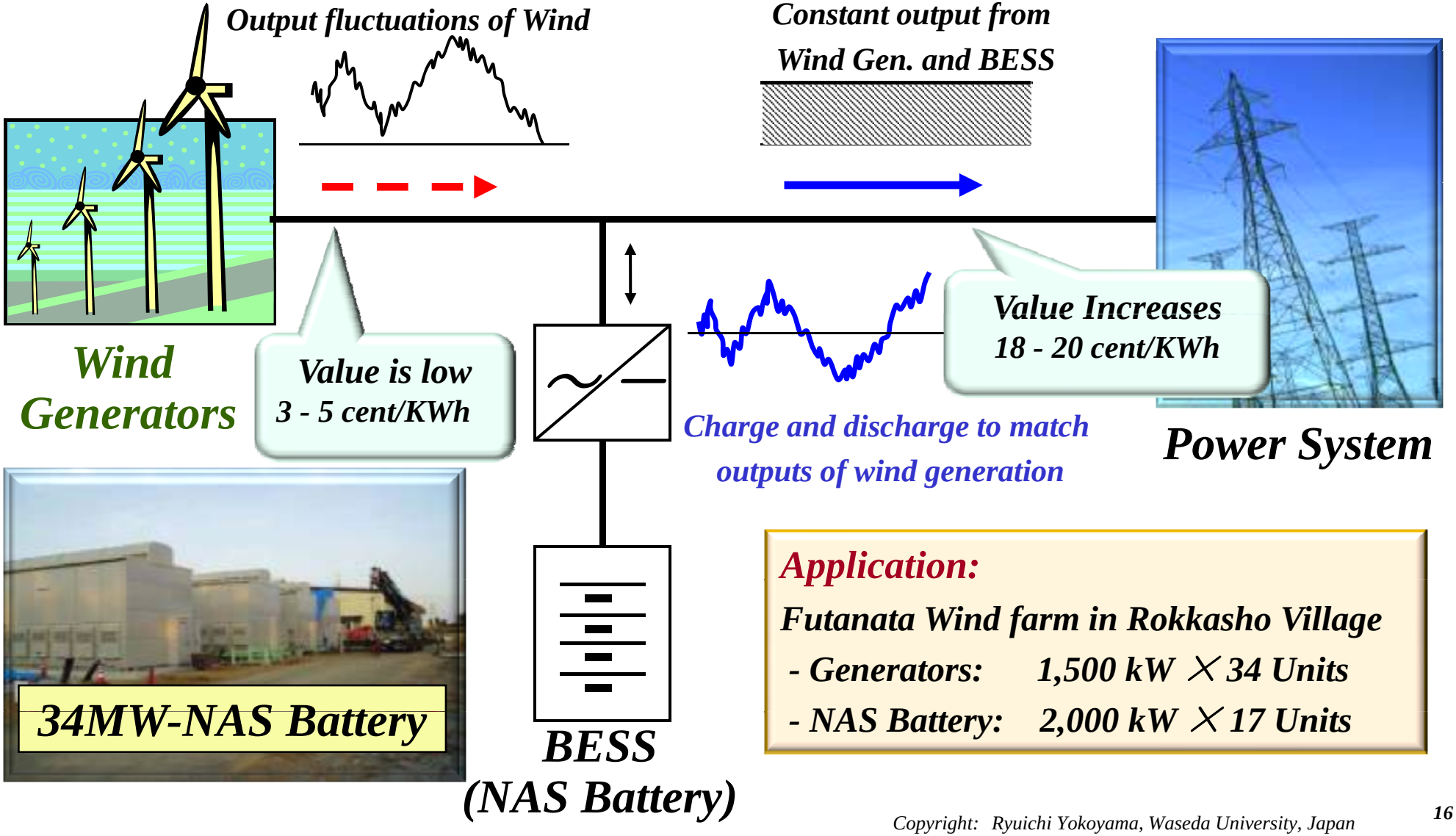
Stabilization of Wind Generation Outputs by BESS (Battery Energy Storage System)



Application:

Futanata Wind farm in Rokkasho Village

- *Generators: 1,500 kW × 34 Units*
- *NAS Battery: 2,000 kW × 17 Units*

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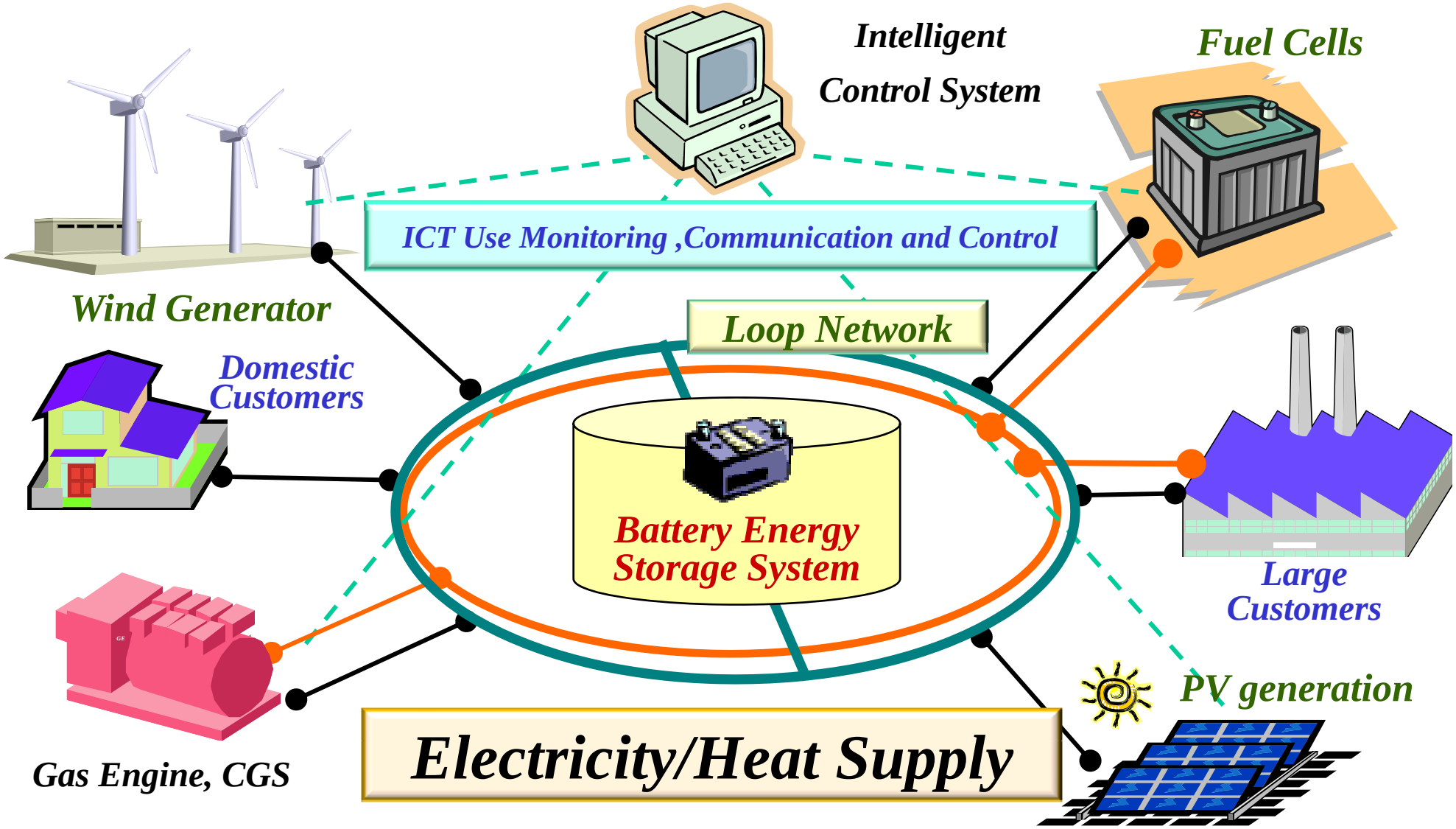
Structure and Components of Autonomous Energy Delivery Networks



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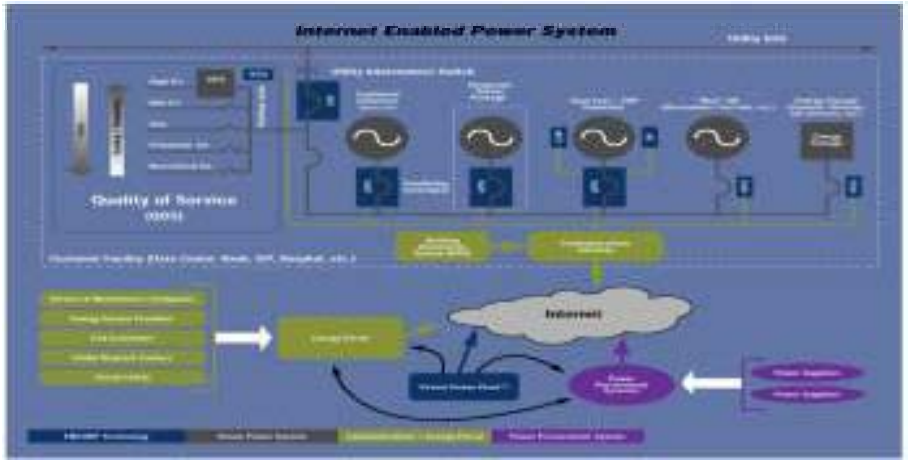
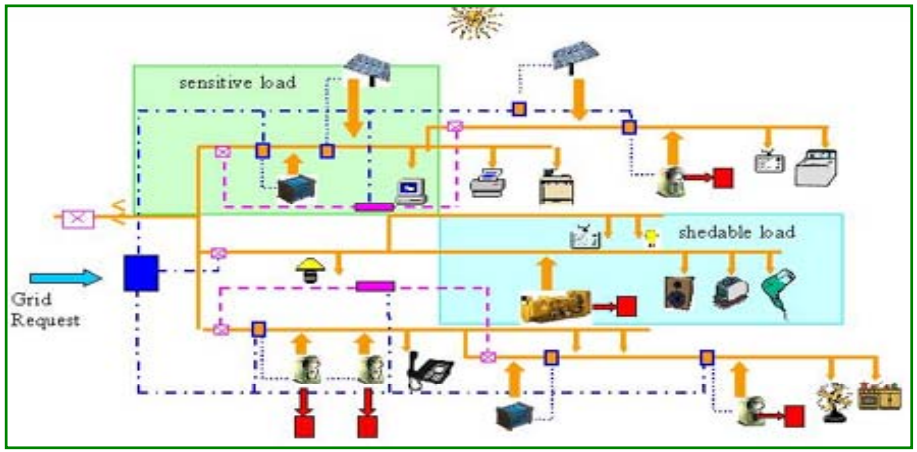
Features of Proposed Energy Delivery Networks

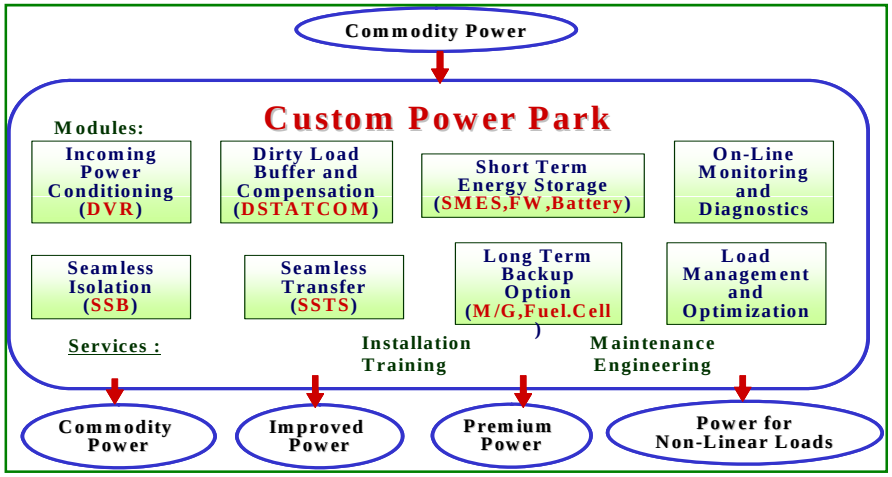
Virtual Power Plant (ENCORP)



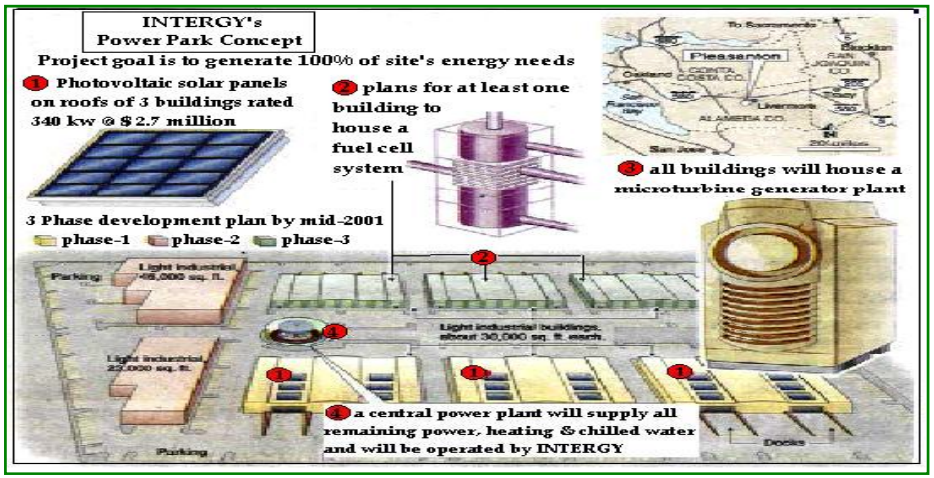
Micro-Grid (EOLBNL)



Custom Power Park (Westinghouse)



Pleasanton Power Park (Real Energy)



Reference: Chris Marney, Lawrence Berkeley National Laboratory

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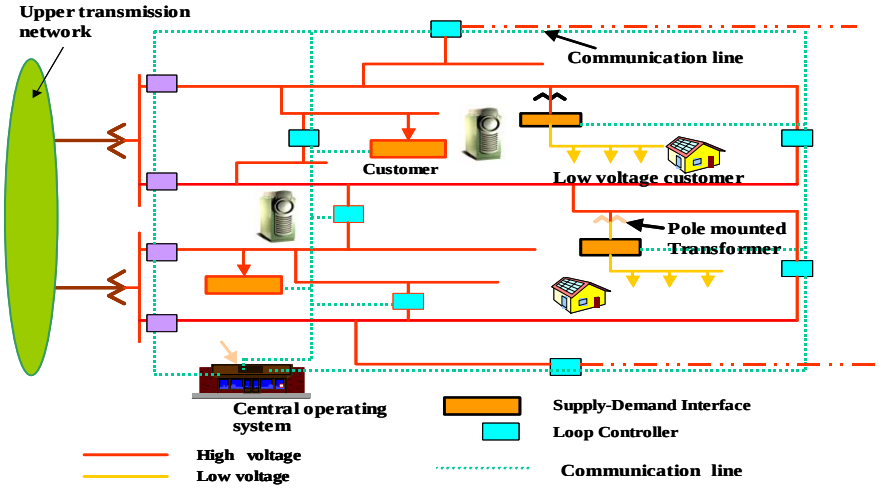
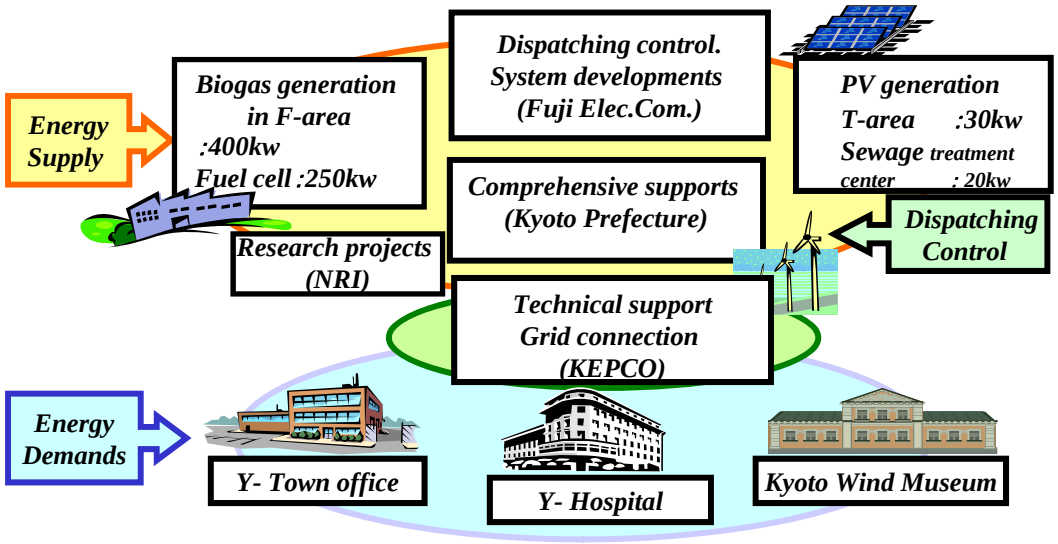
Features of Proposed Delivery Networks

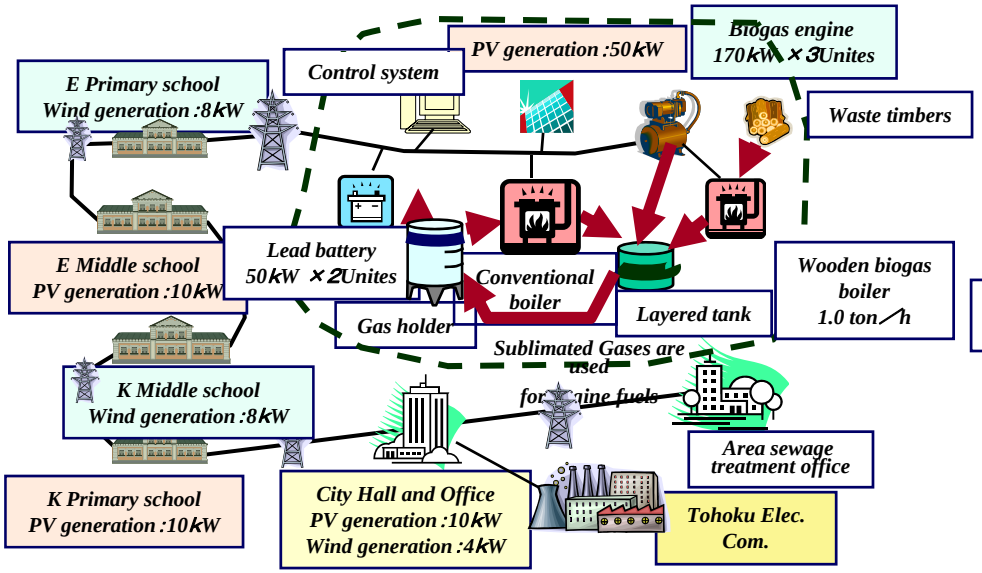
Demand Area Power System (CRIETI)



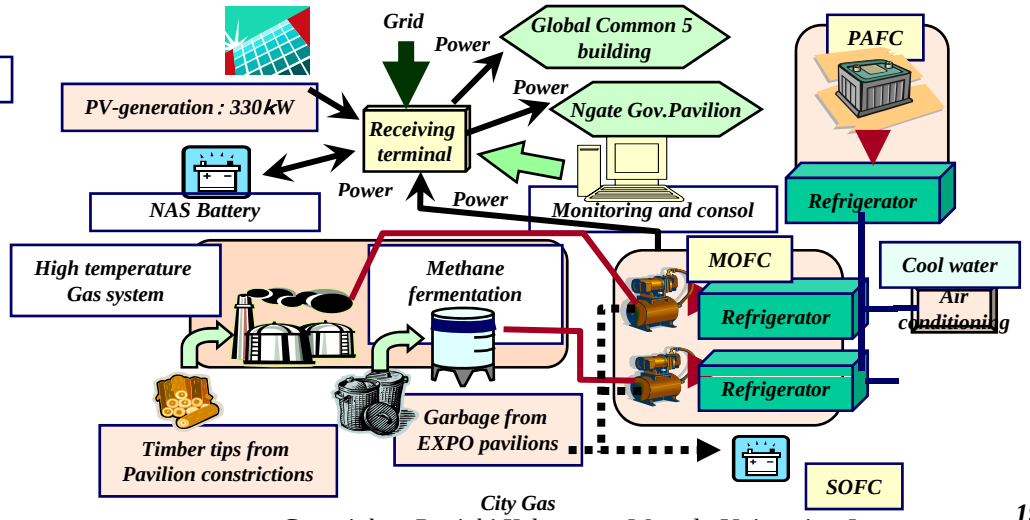
Kyoto Eco-energy Project (Kyoto, Fuji Elec. Co.)



Hachinohe Municipal Microgrid Project



Aichi EXPO-2005 New Energy System (METI, Japan)



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Implementation and Verification of Smart/Micro Grids in Japan

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Verification Projects of Smart Community and Related Experience

- Technology development of renewable energies (PV, WT, etc.)
- Grid-connection technology development and demonstration related to renewable energy

Up to FY2005	FY2005	FY2006	FY2007	FY2008	FY2009 and onward

Projects for Technology Development of Renewable Energies (PV, WT, etc.)

- New Sunshine Project - Large-scale wind power technology development - Advanced photovoltaic technology development - Future technology development - Ultra-high efficiency photovoltaic technology development

Grid-connected System

Operation and grid-connection of high penetration renewable energy or energy storage and EMS application technology to reduce fluctuation of renewable energy output

Single renewable energy grid-connection technology development (such as the Rokko Island project)

Demonstrative Project on Grid-interconnection of Clustered Photovoltaic Power Generation Systems (FY2002-FY2007)

Wind Power Stabilization Technology Development Project(FY2003-FY2007)

Demonstrative Project of Regional Power Grids with Various New Energies (FY2003-FY2007)

Demonstrative Project on New Power Network Systems (FY2004-FY2007)

Research and Development of Islanding Testing Technology for Clustered Photovoltaic Power Generation Systems (FY2008-FY2009)

Verification of Grid Stabilization with Large-scale PV Power Generation Systems (FY2006-FY2010)

Development of an Electric Energy Storage System for Grid-connection with New Energy Resources (FY2006-FY2010)

Promotion of Continuous Efforts to Develop Smart Community Technologies

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Demonstration Project on Grid-interconnection of Clustered PV Power Generation Systems (FY2002-FY2007)

Number of PV-equipped houses:	*553*
Total PV capacity:	*2,129 kW*
Average capacity per house:	*3.85 kW*

Ota City Demonstration Site

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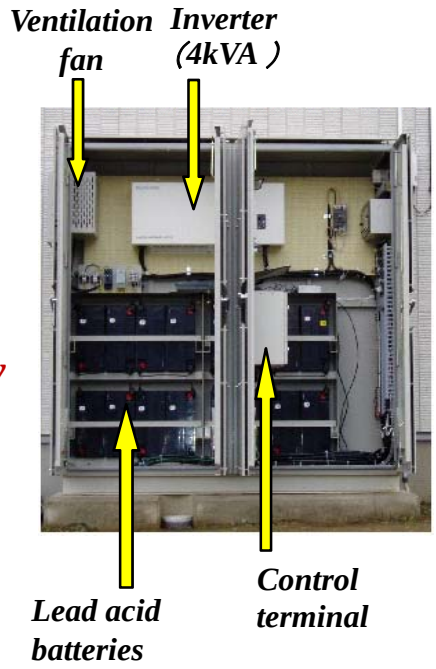
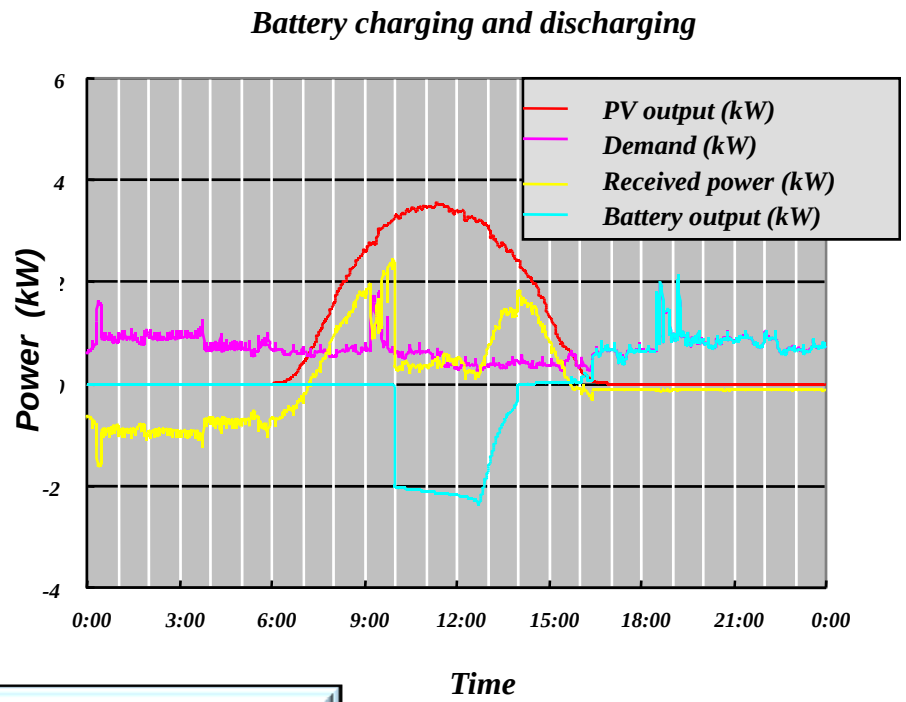
Demonstration Project on Grid-interconnection of Clustered PV Power Generation Systems
(FY2002-FY2007)

Prevention of voltage increases on distribution lines





Battery storage

- ◆Number of installations: 550
- ◆Storage capacity: 4,704 Ah (9kWh)

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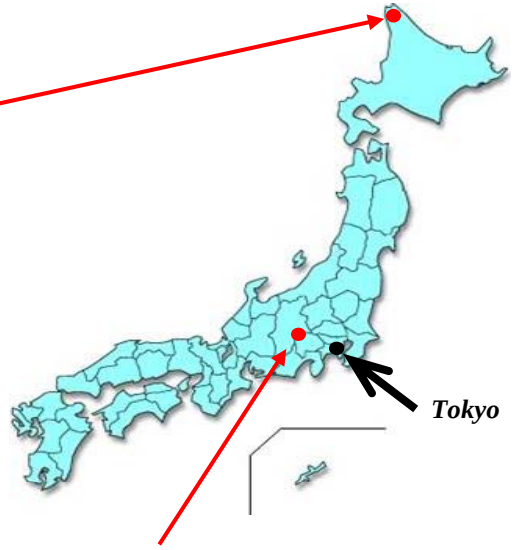
Verification of Grid Stabilization with Large-scale PV Power Generation Systems (FY2006-FY2010)



◆ ***Wakkanai site***

5 MW: Most PV cells are crystalline.

NaS battery: 1500 kW-7.2hrs

◆ ***Hokuto site***

1.8 MW: 26 types of PVs

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