New Issues in Deregulated Power Markets and Practical Use of Sustainable Energy

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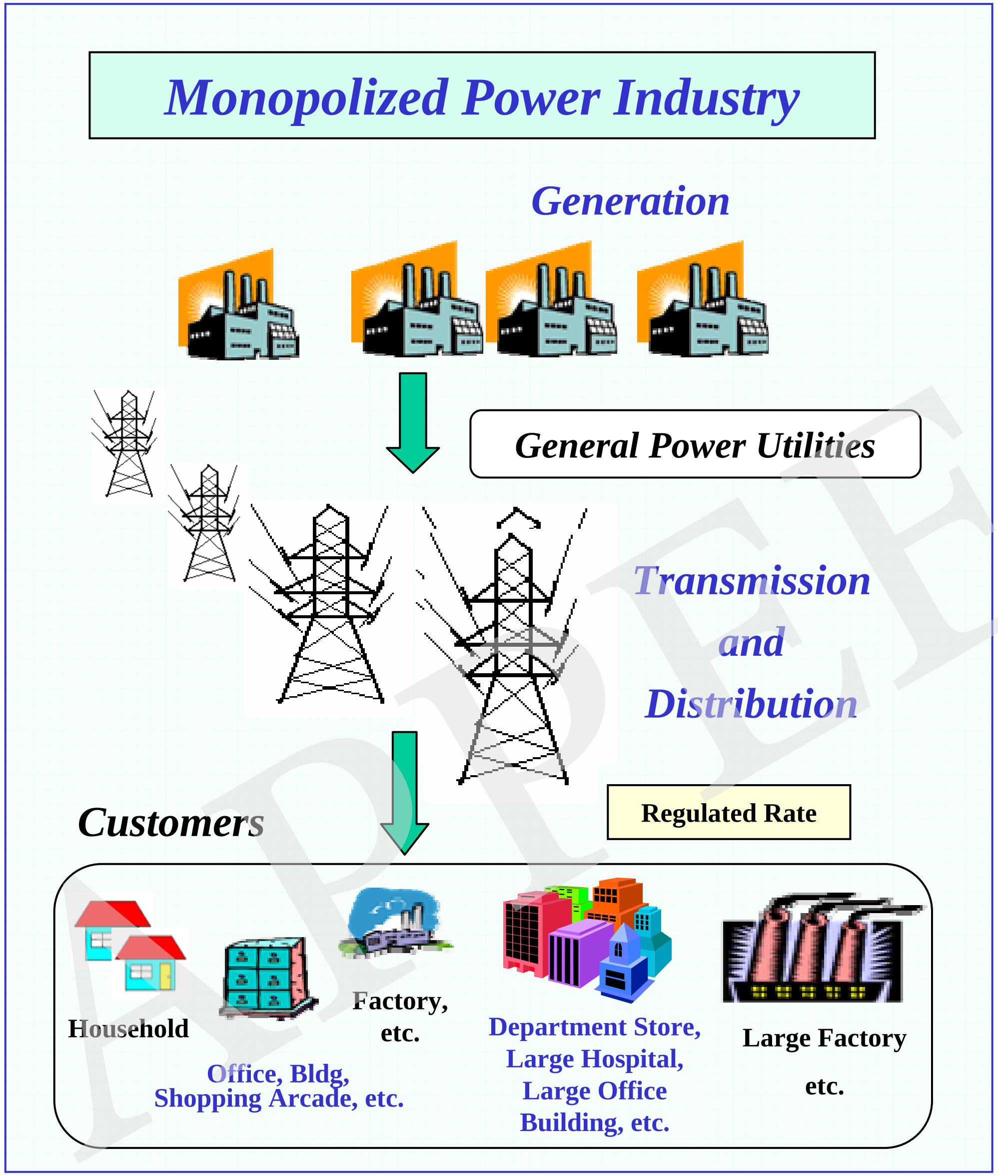
Outline of Presentations

- New Issues in Electric Power Industries and Markets
- New Dimensions for Reduction of CO_2 Emissions in Electric Power Sector
- Practical Use of Sustainable Energy and Future Electricity Delivery Systems for Reliable Power Supply
- The Role of Large Scale Energy Storage in Practical Use of Sustainable Energy
- Back to the Basics toward Reliable and Efficient Power Supply

New Issues in
Electric Power Industries and Markets

Regulations on Monopolized Power Industry



Traditionally, the public utilities ,such as electricity, gas, water, telecommunications, finance, airlines, and ground transportation have been regulated

- *Limited market participation,*
- *Regulated rate making,*
- *Regulated business rules*
- *Regulated supply obligations.*

- *Necessary for daily life and industrial activities*
- *High risk businesses by large capital investment*
- *Naturally established regional monopolies*
- *Industries with national security concerns*

Transition of Electricity Supply Structure due to Deregulations

Social Requirements for Deregulation of Markets

- Competition principal to create new business
- Versatile services and eligibility for customers
- Fairness and transparency of competitive markets
- Revitalization of economy
- Reliable and stable power supply
- Reduction of market power

Transition of Structure in Electric Industries

Introduction of Competition Principle → Open Access of Transmission → Complete Competition

Introduction of Competition Principle → Competition in Wholesale Market

Complete Competition → Competition in Retail Market

Vertically Integrated Structure of Power Supply

Generation

Transmission

Distribution

↓

Customers

Competitive Structure of Power Supply

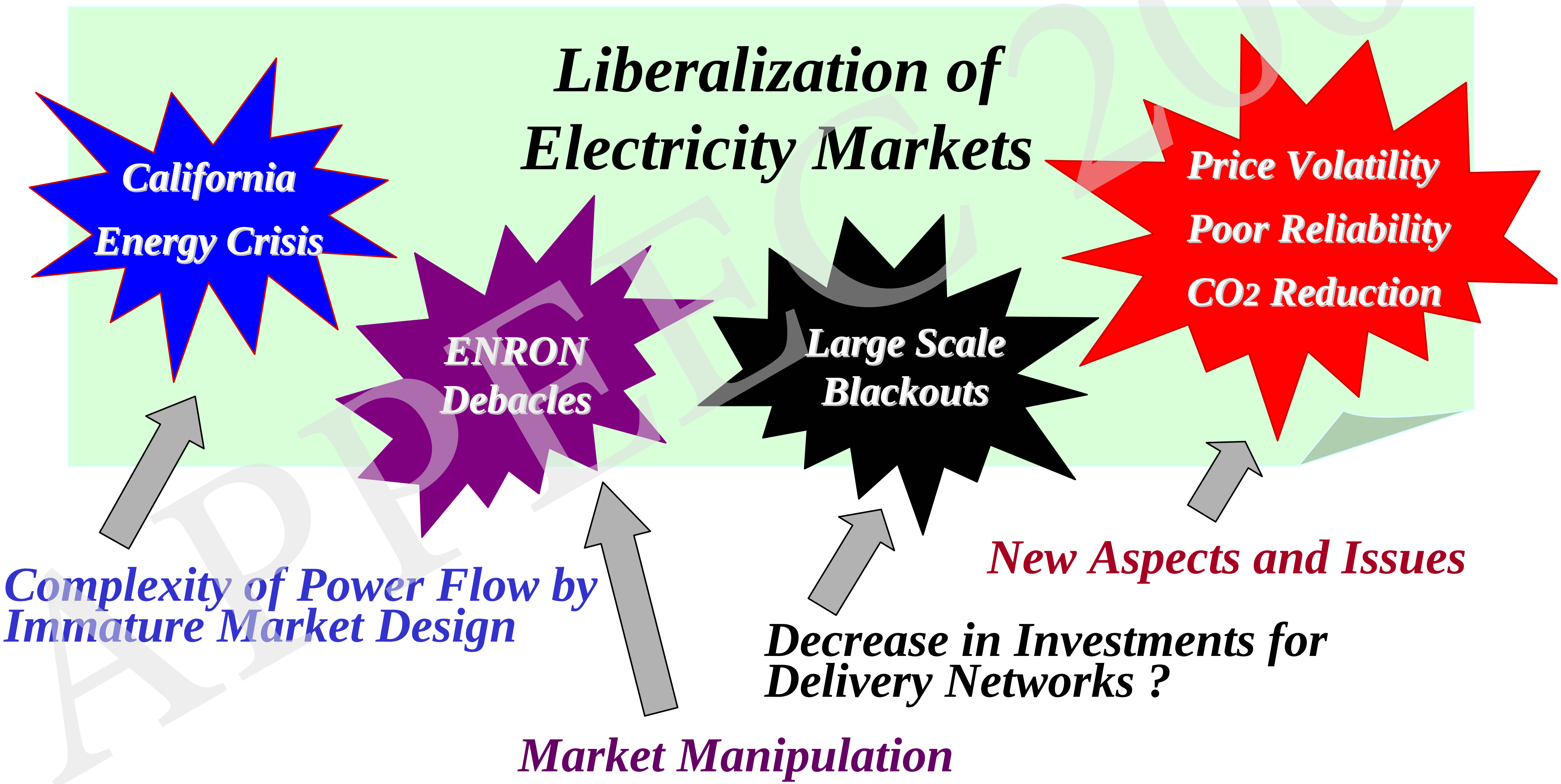
Supplier | Supplier | Supplier

Transmission（ISO）

Disco. | Disco. | Disco.

Customer | Customer | Customer

Happenings of Negative Aspects in Front Runners of Power Markets



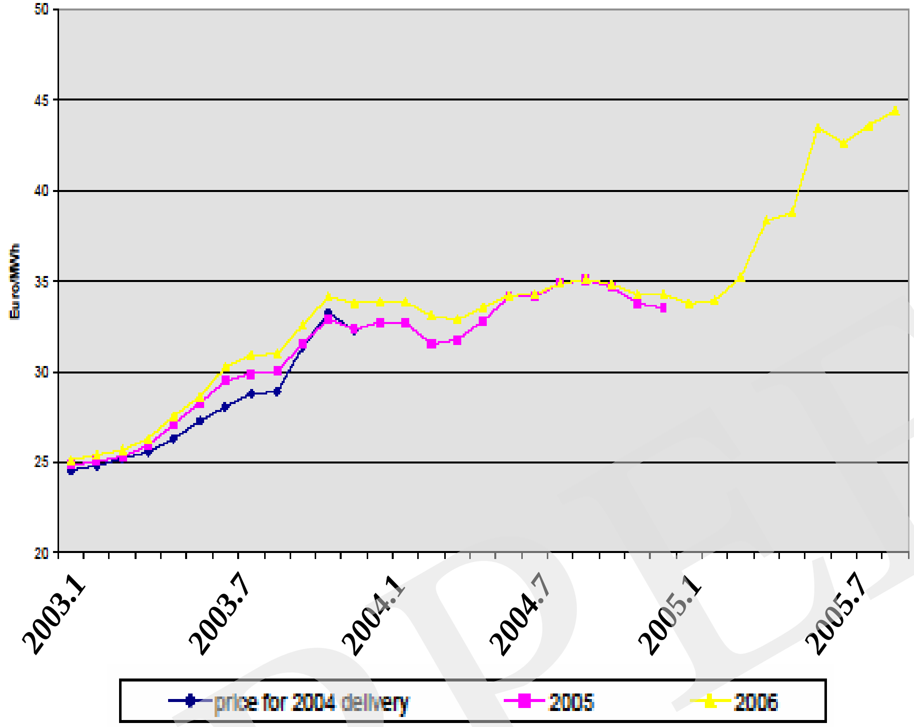
Occurrence of Large Scale Blackouts under Liberalization of Power Industry

Country	Date and Time	Influenced Area	Cause of Blackout	Scale of Damage	Duration Time
Italia	2003.6.26 2003.6.27	Major cities including Rome and Milan	Rapid increase of demands because of Summer heat	App. 6 mil. people	Rotation blackout
USA and Canada	2003.8.14	North-east US and Canada including 11 major cities	Cascading trips of transmissions and generation in northern Ohio	App. 62Gw App. 50 mil. people	43 hours
U.K.	2003.8.28	20% of London area、Underground and traffic lights stopped	Transmission failure caused by failure of transformer's alarm	724 Mw 0.15 mil. People	35 minutes
China	2003.9. 4	Shanghai	Stop of a thermal generation plant by full loading operation during Summer heat	App.1.2Gw App. 1000 Com.	2 hours
Denmark and Sweden	2003.9.23	Denmark and Southern Sweden including Copenhagen	Cascading outages and voltage collapse caused by a nuclear generation plant	App. 3Gw App. 4 mil. people	2 hours
Italia	2003.8.28	All areas in main Italia except for Sardinia Island	Deficiency of domestic supply capacity caused by cascading trips of International interconnection lines	App. 24Gw App. 57 mil. people	More than 13 hours

Congestion Management Schemes Adopted in USA and EU Countries

Scheme	Price Signal-Based (Depend on Price Elasticity)			Operation Rule-based (System Operator-Centered)	
Method	Locational Marginal Price	Market Splitting	Auction	Re-dispatch	Transmission Loading Relief
Country /Area	U.S.A. (PJM, NY/ISO)	NordPool	E.U. (Continents)	Sweden	U.S.A.

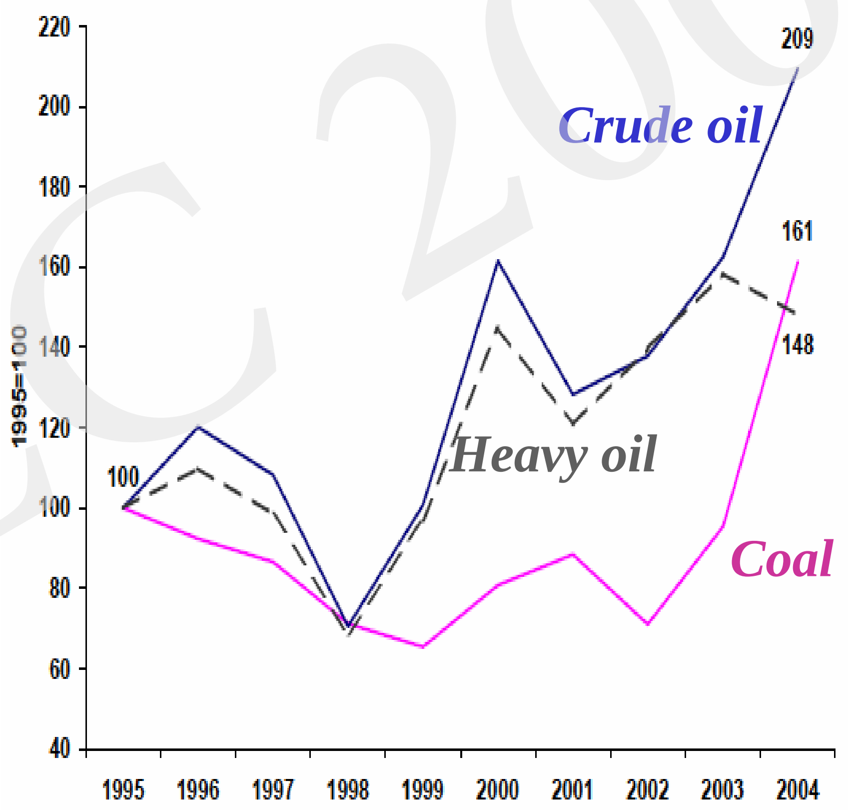
Large Volatility and Upward Tendency of Electricity and Fuel Prices



Trend in wholesale electricity prices

(one-year forward price for 2004-2006 delivery)

Source: EEX Leipzig

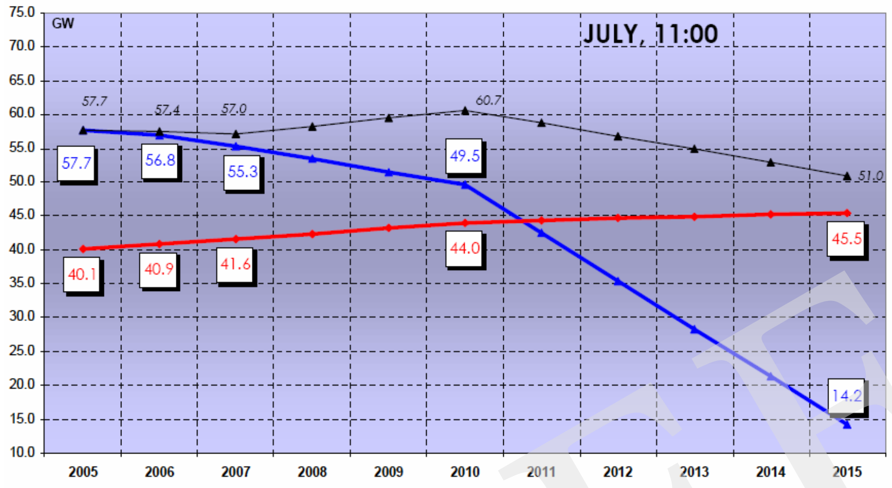


Trend in fuel prices

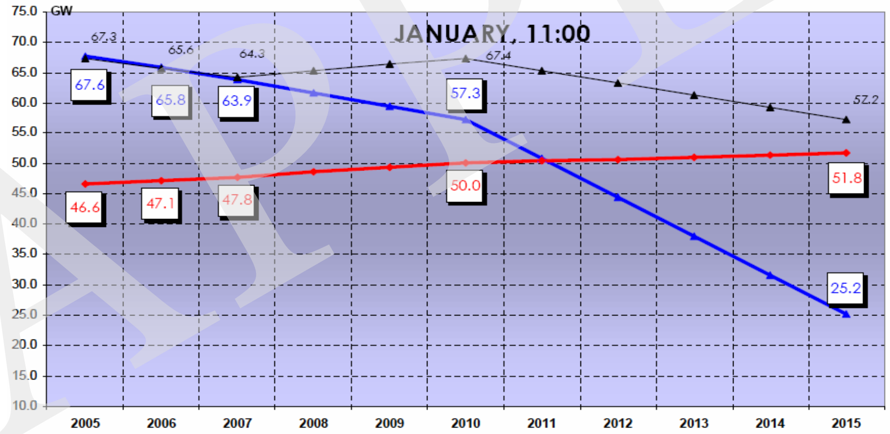
Source :KEMA

Future Prospects of Supply Capacity Margin on the EU Continent

(Summertime peak)



(Wintertime peak)



: **Supply capacity margin for peak load (Pessimistic & conservative scenario)**

: **Supply capacity margin required, 5% of total power generation capacity**

: **Supply capacity margin for peak load (Optimistic scenario)**

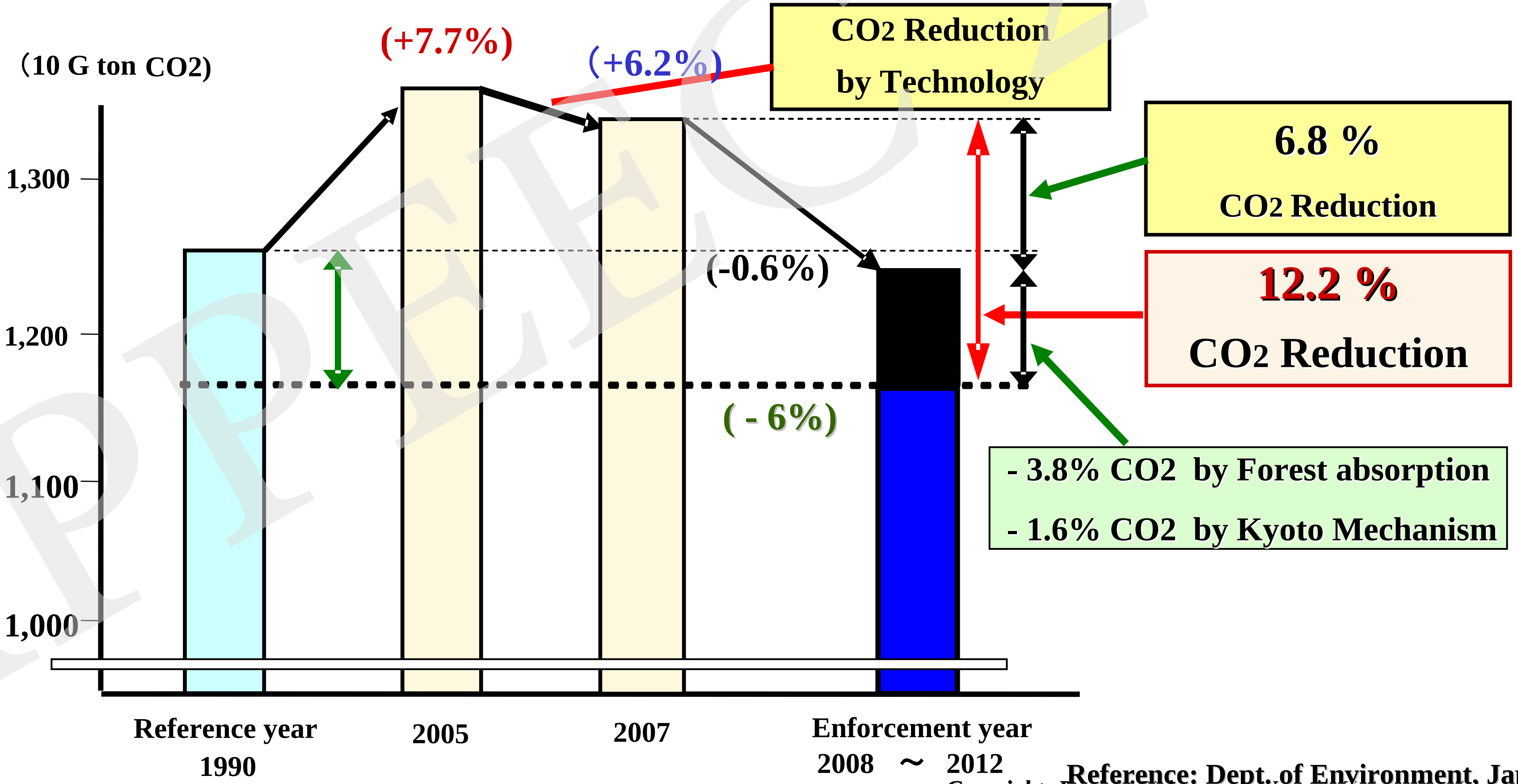
- **Supply capacity margin refers to an excess of supply capacity estimated during peak load, and**
- **it is estimated by subtracting the estimated peak load and system service reserve from the supply capacity.**

(Source) UCTE, "UCTE SYSTEM ADEQUACY FORECAST (2005-2015)"

UCTE: Trade association of transmission companies in which 23 European nations and 33 TSOs participate. The power consumption of the regions covered by UCTE is about 80% of the whole of Europe.

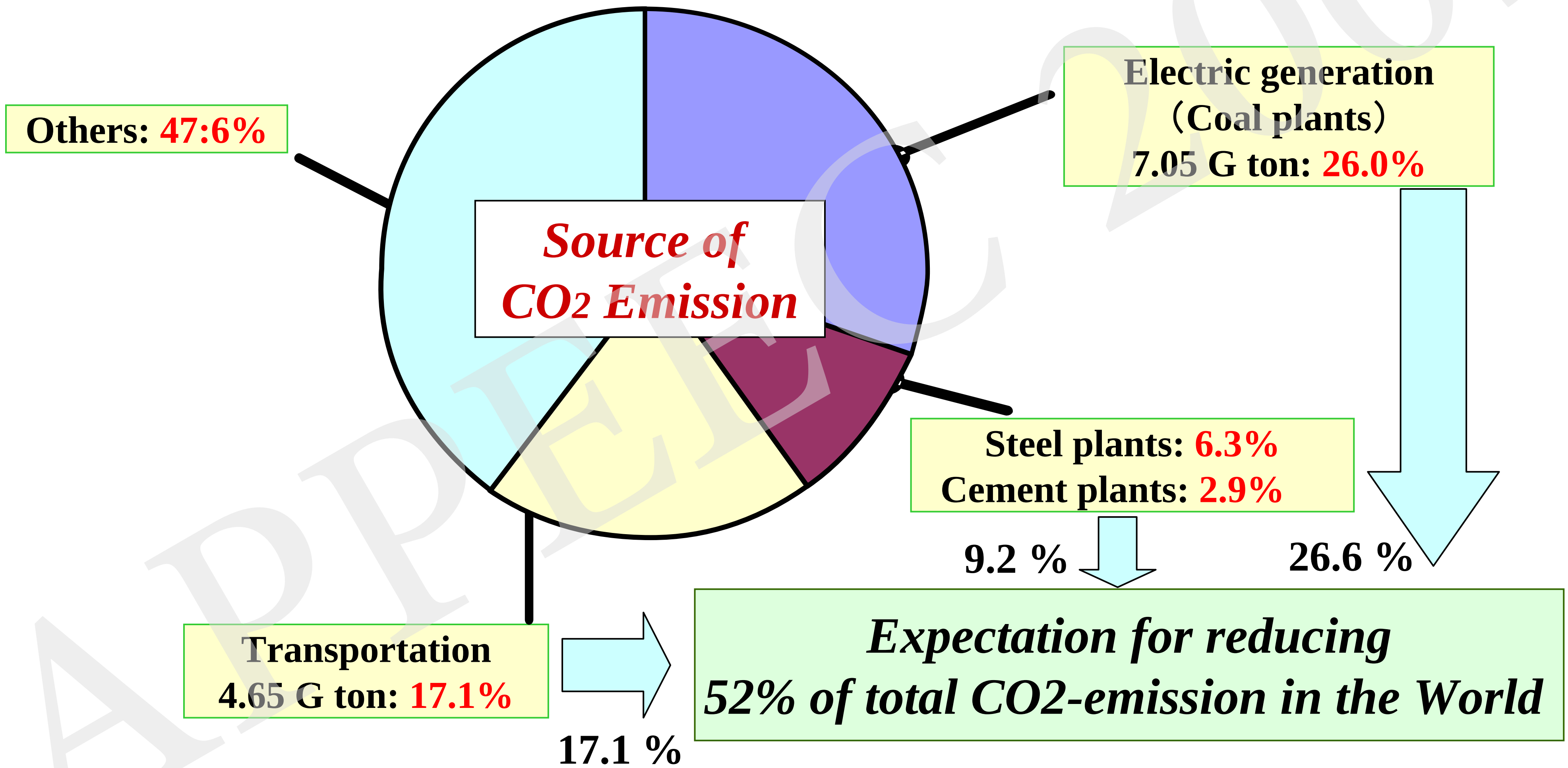
Kyoto Protocol regarding Reduction of Green House Effect Gas Emission in Japan

In 2007, total emission of GHE gases in Japan has exceeded that of of Reference year 1990 by 6.2 %, and to attain the Kyoto Protocol, it is necessary to reduce the emission by 6.8 %



Reference: Dept. of Environment, Japan

Sources of CO2 Emission in the World
(Drawn up based on 1971-2007 Data)



IEA CO2 emission from Fuel combustion 1972-2005,2007 etc.

Countermeasures for Reduction of CO_2 Emission by Japanese Electric Power Utilities

- Diversity of countermeasures for CO_2 emission reduction
- New development and high operation ratio of nuclear plants keeping the security and safety of operations

Supply side

Expansion of Non-fossil Energy

- New Construction and High Ratio of Operation of Nuclear Generation
- Development and Diffusion of Sustainable Energy

Hydro, Geothermal, Photo Voltaic, Wind , and Biomass

Enhancement of Facility Efficiency

- Improvement of Thermal Gen. Efficiency

Combined cycle generation , High efficiency coal plants

- Reduction of Transmission Loss

High voltage transmissions, Low loss transformers

International Corporations

- Utilization of Kyoto Mechanism

Financial support for clean and green development

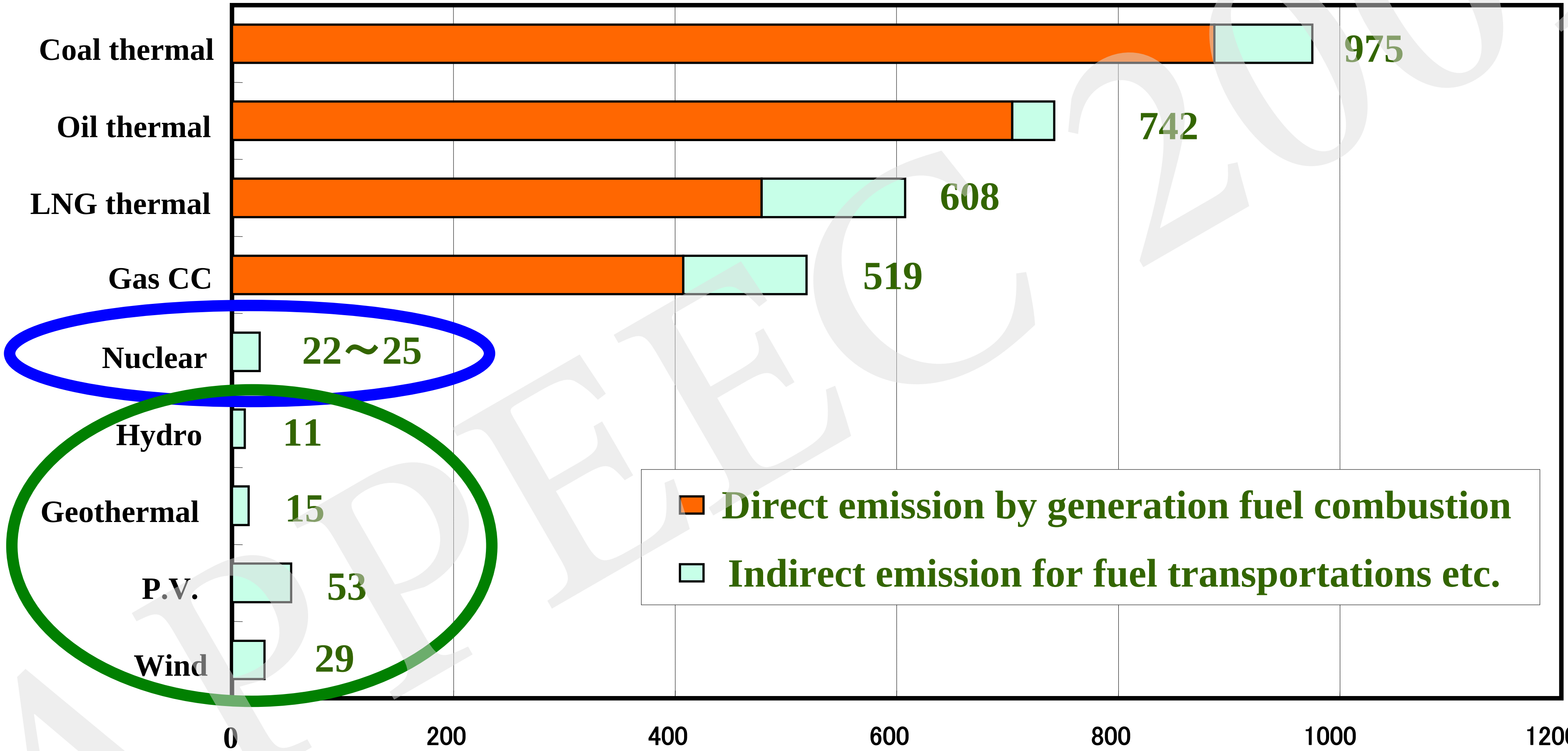
- Participation to APP

Education, Pier Review and Campaign

R & D etc.

- CCS, Clean Coal Technology

CO_2-Emission by Various Generation Resources
(Methane included)

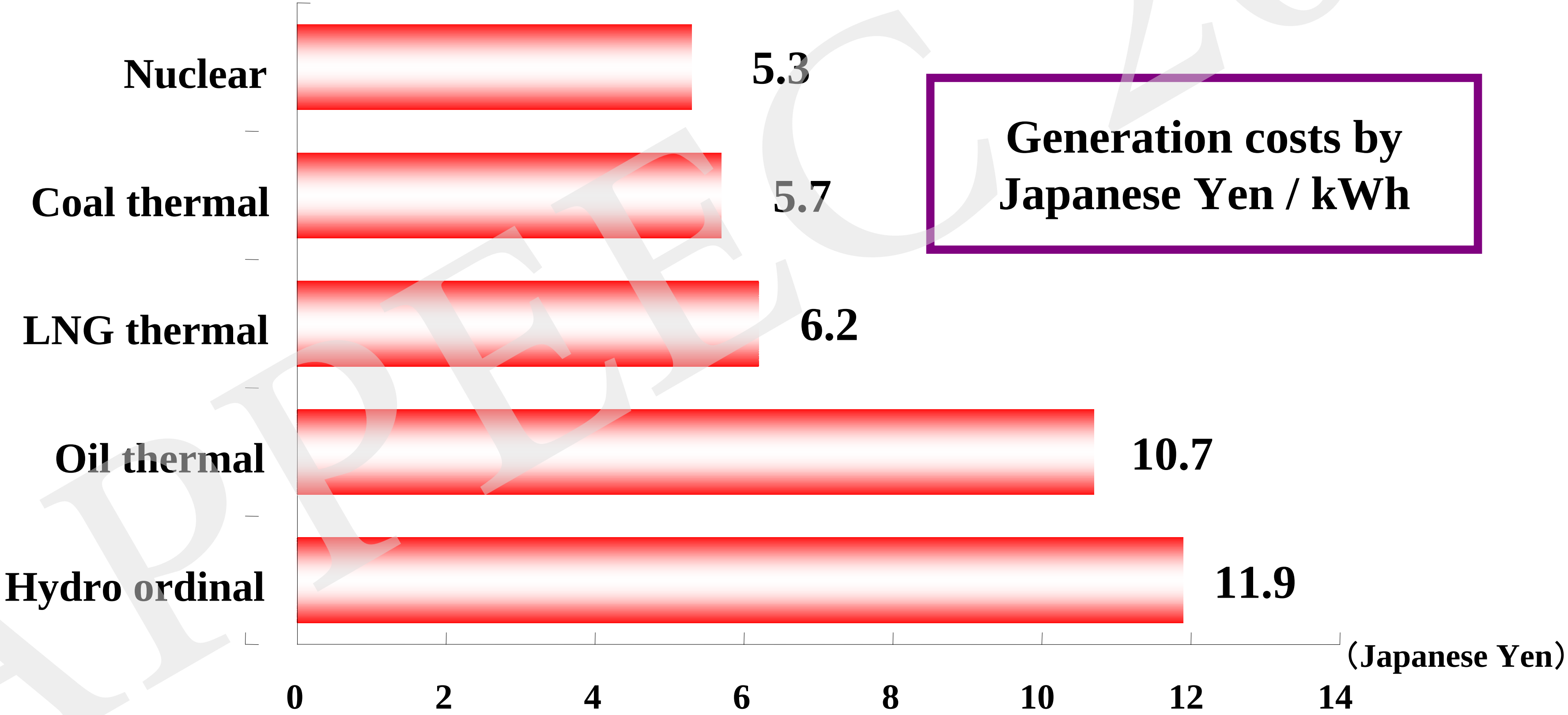


Life cycle CO2 emission （g – CO_2/Kwh at sending end)

Reference: CRIEPI Japan Report 2001、August and 2000、March

Comparisons of Generation Costs of Various Generation Resources

- **Nuclear , Coal, and LNG plants have low generation costs including fixed costs**
- **Oil thermal plants show high generation cost due to high ratio of fuel cost in the total cost, and generation costs are very sensitive to fuel costs**

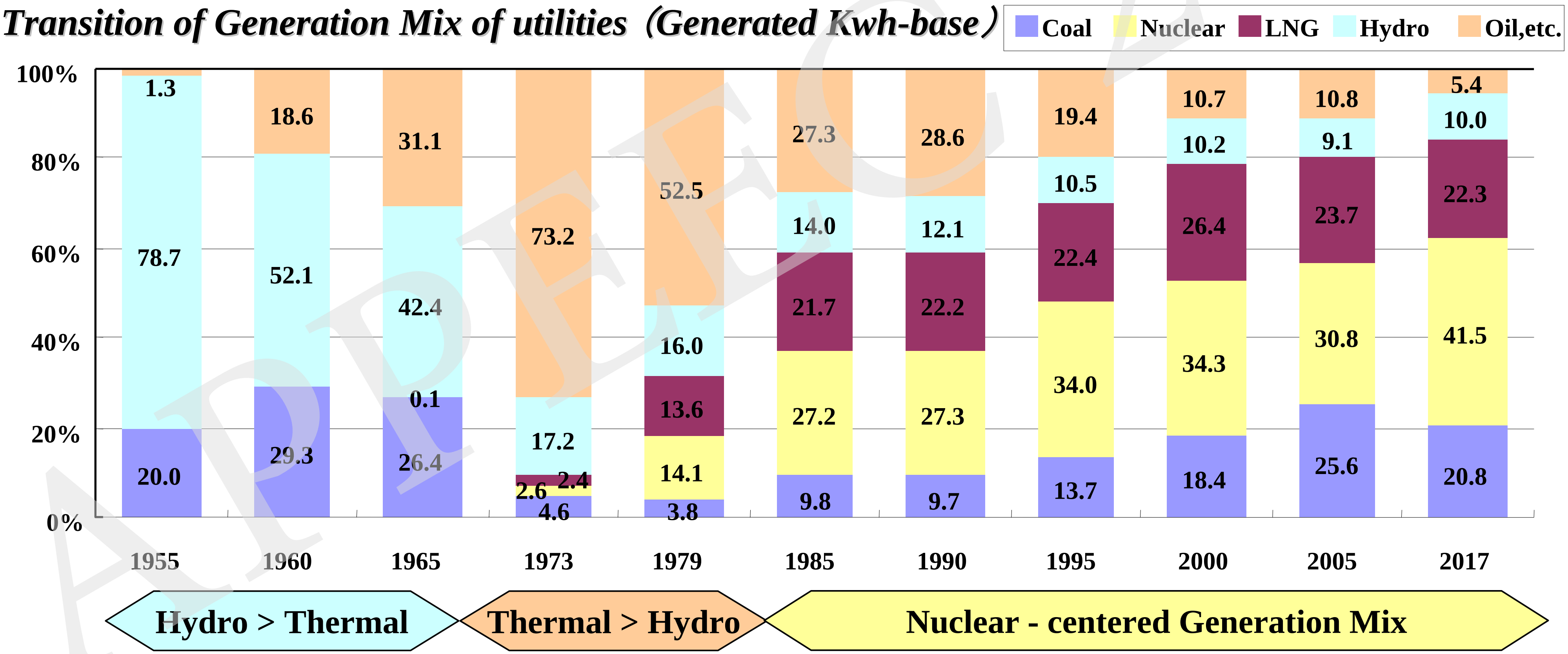


Reference:METI Electric Industry Council, 2004 January,
Assumption:Life time;40 years, The rate of operation;80%, Discount ration;3%

Transitions of Generation Mix in Japan

- The degree of self –sufficiency in primal energy is extremely low in Japan.
- In order to cope with the increase of electric demands, the generation mix has been shifted from hydro plants, thermal plants and nuclear plants by going through repetitive energy crisis.
- Now, nuclear plants and sustainable energy are the key technology against Global Warming

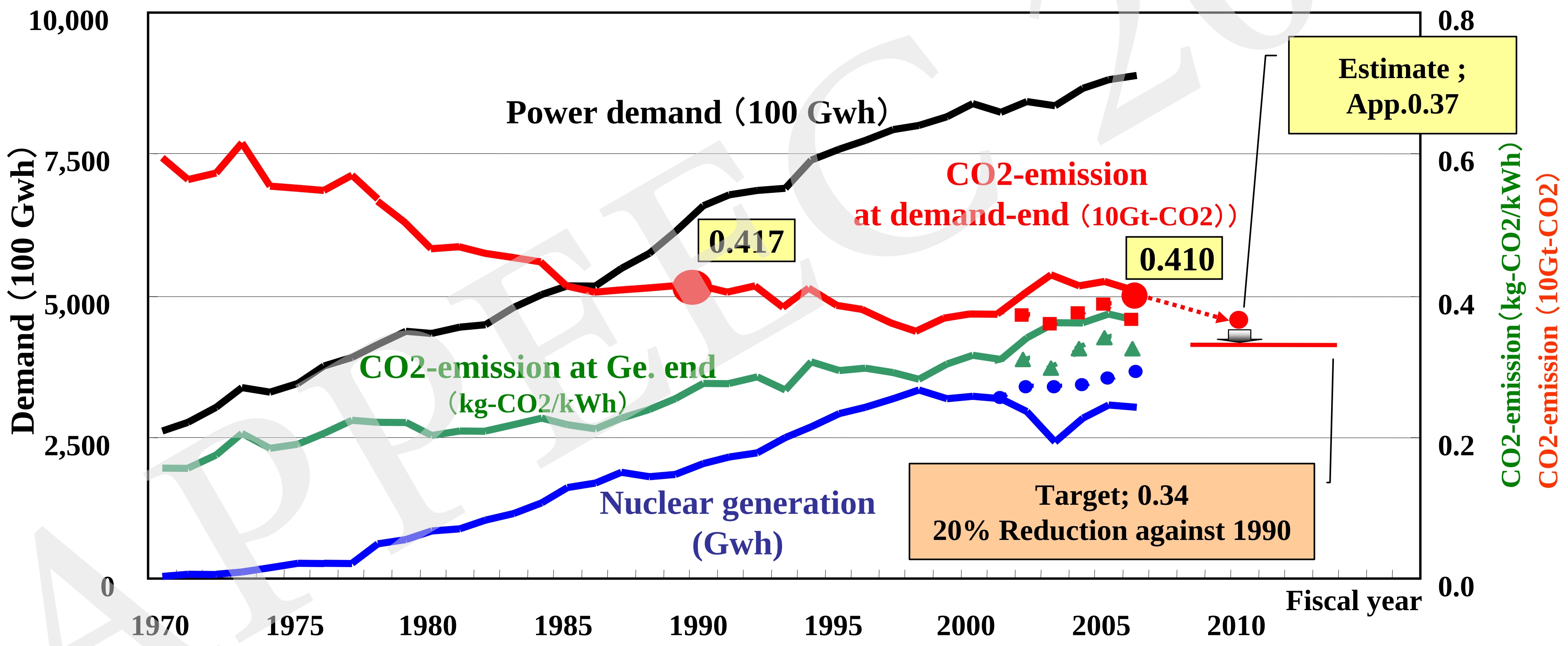
Transition of Generation Mix of utilities（Generated Kwh-base）



Reference: Blue Paper of Generation Developments in Japan

Significance of Nuclear Generation for CO_2 Reduction in Japanese Utilities

- In spite of remarkable increase of demand (Kwh), CO_2 emission (Kg CO_2/Kwh) has been lowered by Nuclear-centered generation mix in Japan

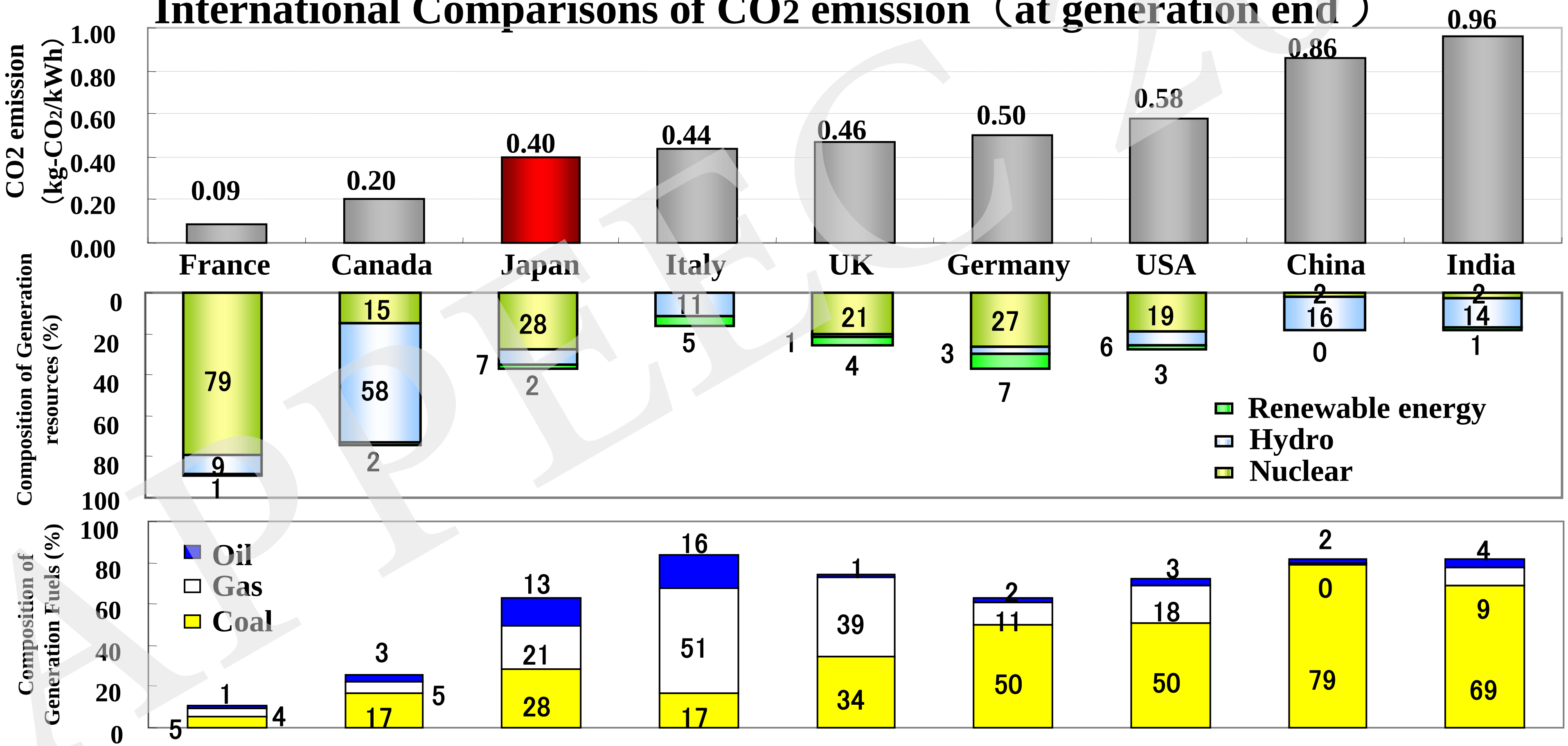


- Goal and Estimate of CO_2-emission Through 2008 to 2012, 5 years average
- Dotted lines show CO_2 emission estimates without long term Nuclear stoppages

Comparison of CO2 Emission among 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.

International Comparisons of CO_2 emission （at generation end ）



＊CHP Plants include

＊Data in 2005

＊Reference:Energy Balance of OECD Countries 2004-2005

New Dimensions for Reduction of CO2 Emission in Electric Power Sector

Contribution of Electric Utilities for Carbon Free Society

- Main streams of CO_2 reduction by electric utilities 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 under cooperation among government, industries and academic organizations

Supply side

Enhancement of Efficiency
Reduction of CO_2

- Expansion of Nuclear
- Diffusion of Sustainable Energy

×

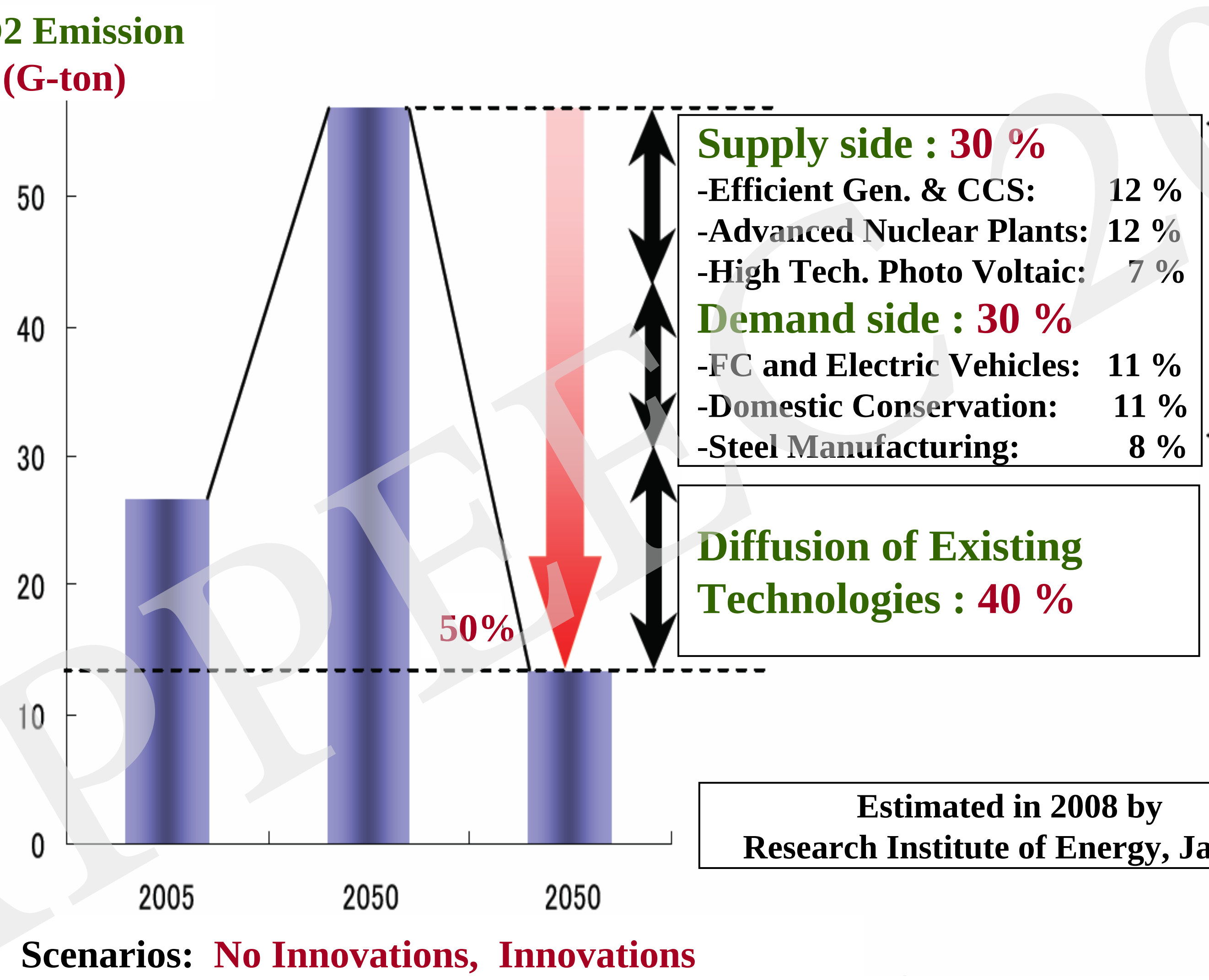
Demand Side

Efficient Facilities
Energy Saving by Electrification

- Energy Storage, Heat pump
- Electric Vehicles

Carbon-Free Society

Contributions of Advanced Energy Technologies to 50% CO_2 Reduction up to 2050



Possibility of 60% CO_2 Reduction by Technologies

Estimated in 2008 by
Research Institute of Energy, Japan

Contribution of Nuclear Plants for CO_2 Reduction

By installation of single nuclear plant (1.38 MW Unit）

⇒ Approximately 7.0 M-ton CO_2 reduction

・The ratio of operation is assumed to be 85%.

・Annual generation is about 10.3 T-Wh

・Generation as the substitution of Oil thermal plants

If the ratio of operation of whole nuclear plants could be enhanced by 1%

⇒ Approximately 3 M-ton CO_2 emission reduction

（APP. 0.3% for Kyoto Protocol Agreements）

By rising the average ratio of operation up to 90%、

⇒ App. 3% reduction of total CO2 emission from Generation sector

・Total capacity of Nuclear plants: ∴49.47 G-kW by 55 units（at the end of 2006）

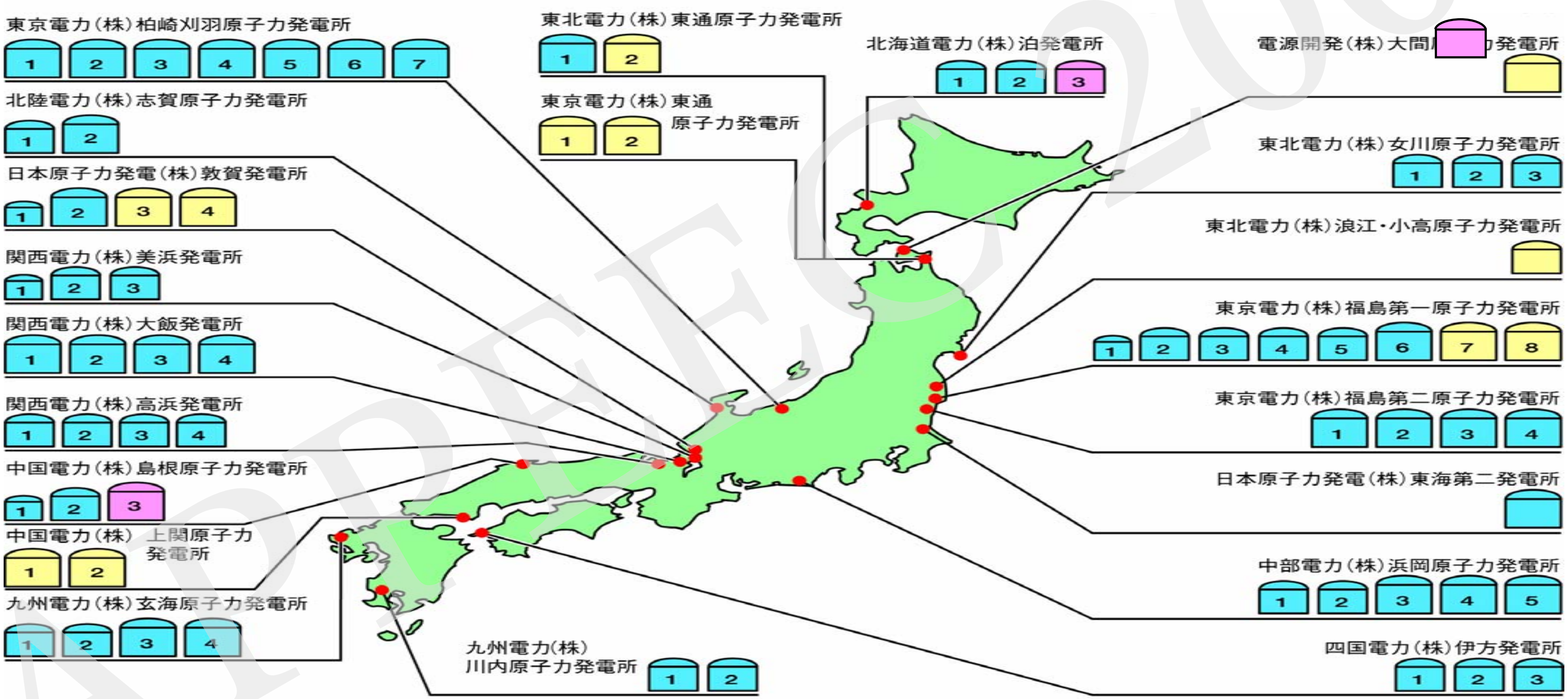
・Annual increase of generation ∴App. 4.3 T-Wh

・CO2 reduction: 3.0 M-ton×15% (90% - 75%)/1360 M-ton (Actual value at 2005）= App. 3 %

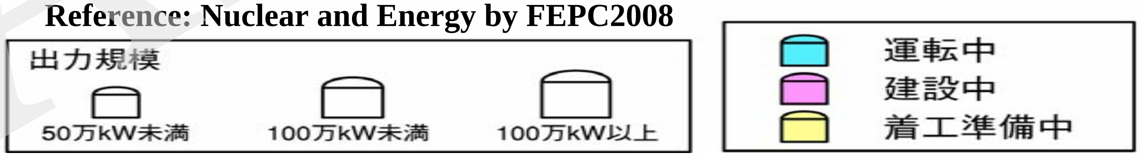
Nuclear Plants in Operation and Construction

○ **In operation (Commercial): ：55 Units（Total capacity 49.467 GW）at May, 2008**

○ **Under construction and Preparations ：13 Units（ Total capacity 17.23 GW ）**

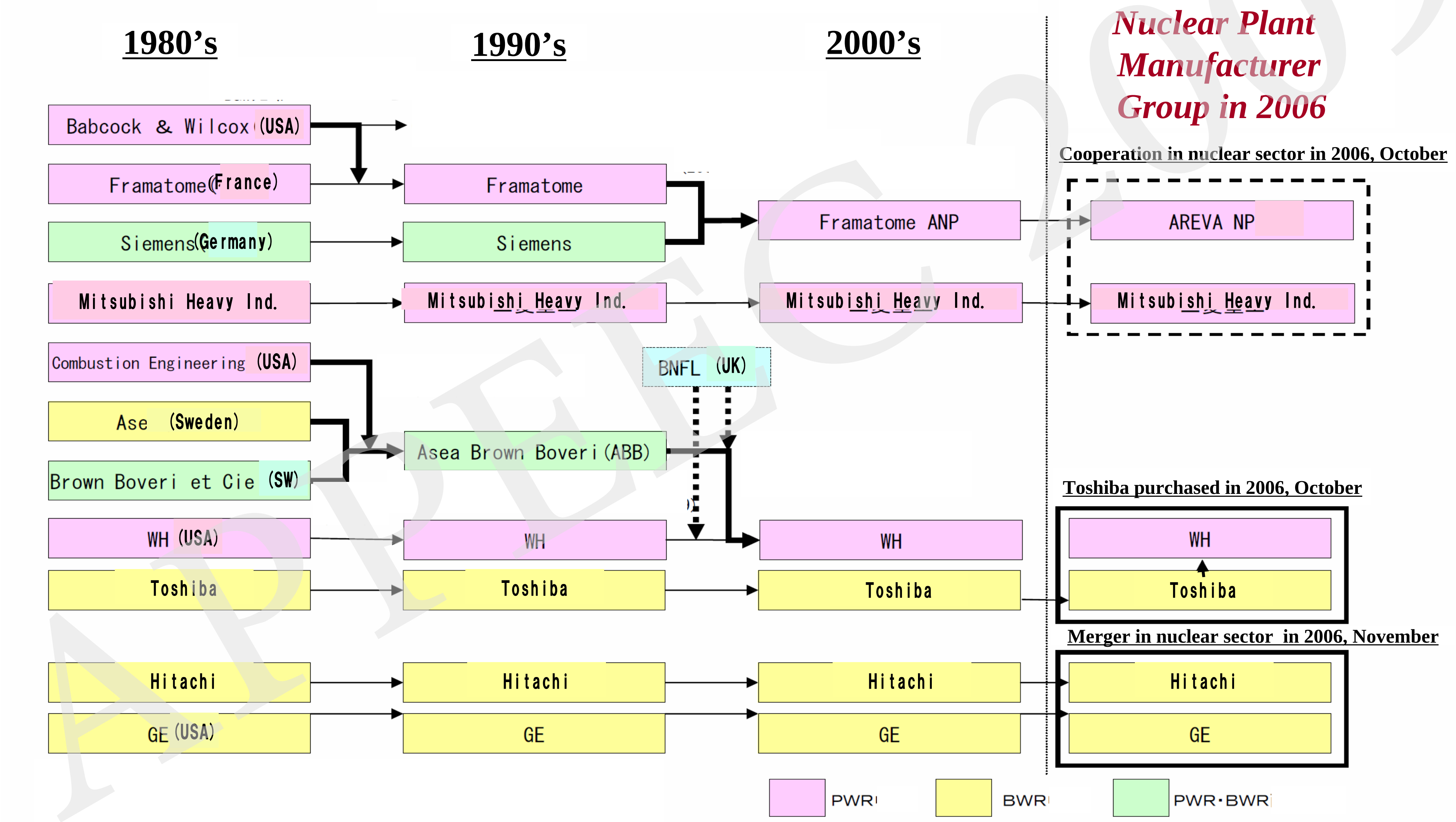


Reference: Nuclear and Energy by FEPC2008



	基 数	合計出力(万kW)
運 転 中	55	4,946.7
建 設 中	3	366. 8
着工準備中	10	1,356. 2
合 計	68	6,669.7

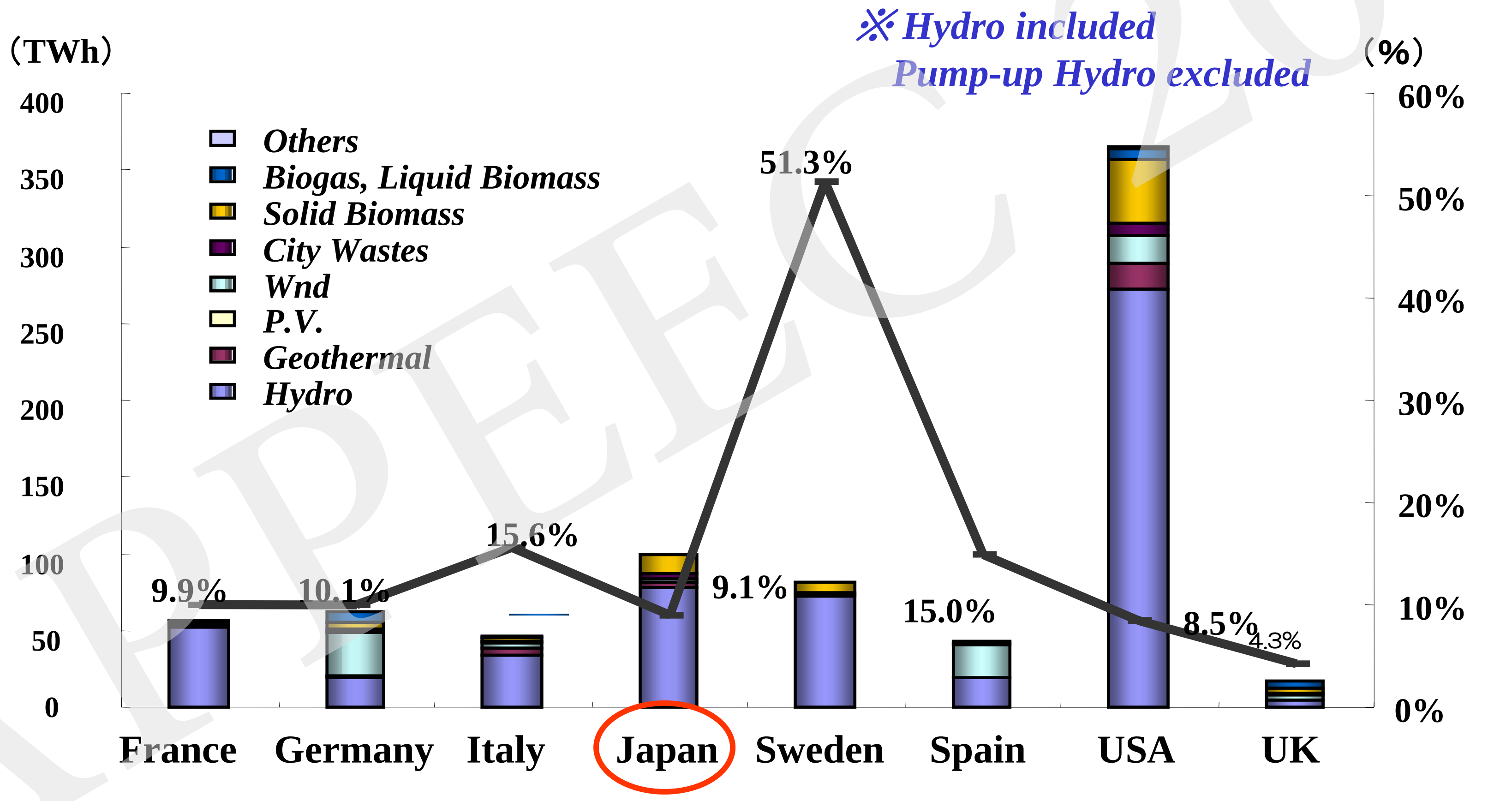
Transition of Nuclear Plant Manufacturers in the World and Japan



Practical Use of Sustainable Energy and Future Electricity Delivery Systems for Reliable Power Supply

Introduction of Renewable Energy in Countries

- *The ratio of renewable energy against total generation in Japan is 9.1%*
- *The ratio in Germany is 10.1%.   (Hydro energy included)*



※Generation capacity; TWh,   The ratio of Renewable energy in primal energy; %

Reference :I EA, ENERGY BALANCES OF OECD COUNTRIES, 2004-2005

Targeted Installation and Benefits of Sustainable Energies in Electric utility Sector

Benefits of Sustainable Energy

- ***Improvement of the degree of self-sufficiency in domestic energy:***
  Enhancement of energy national security
- ***Environmentally friendliness:***
  No emission of pollution and CO_2 emission in Generation
- ***Expected reduction of generation cost:***
  Numerous diffusion of sustainable energy lowers the generation cost of new energy

Target of Installation

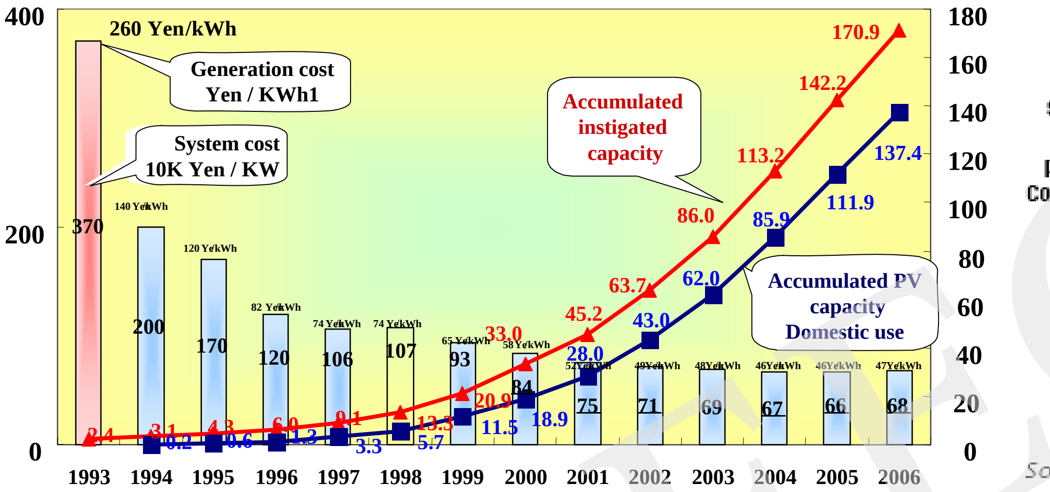
(Unit: G-kl Oil Equivalent)

	2005	2020	2030
The ratio of sustainable Energy with regard to Primal Energy Supply	5.9%	8.2%	11.1%
New Energy	1,160	2,036	3,202
Hydro	1,732	1,931	1,931
Geothermal	570	631	679

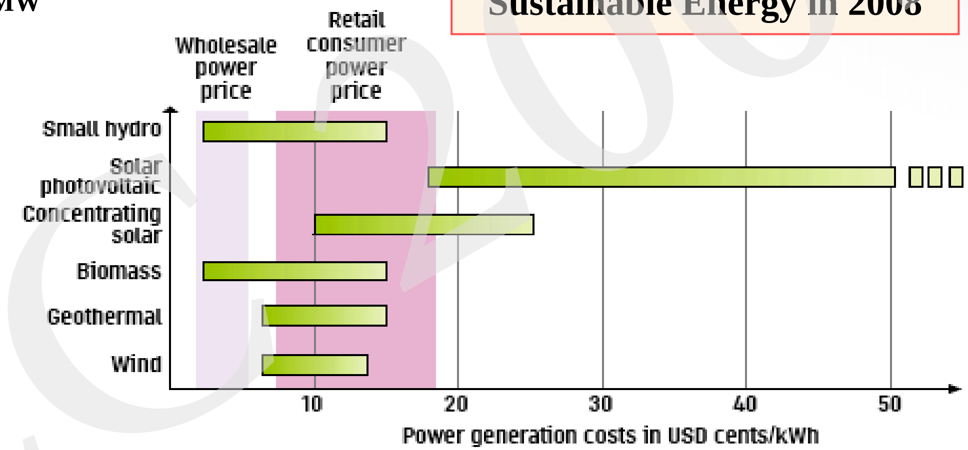
Reference: Long term demand/supply prospects 2008, METI, Japan

Economic Issues of Sustainable Energy and Markets

Cost Transition of Photo Voltaic Generation in 1993 - 2006



Cost Competitiveness of Sustainable Energy in 2008



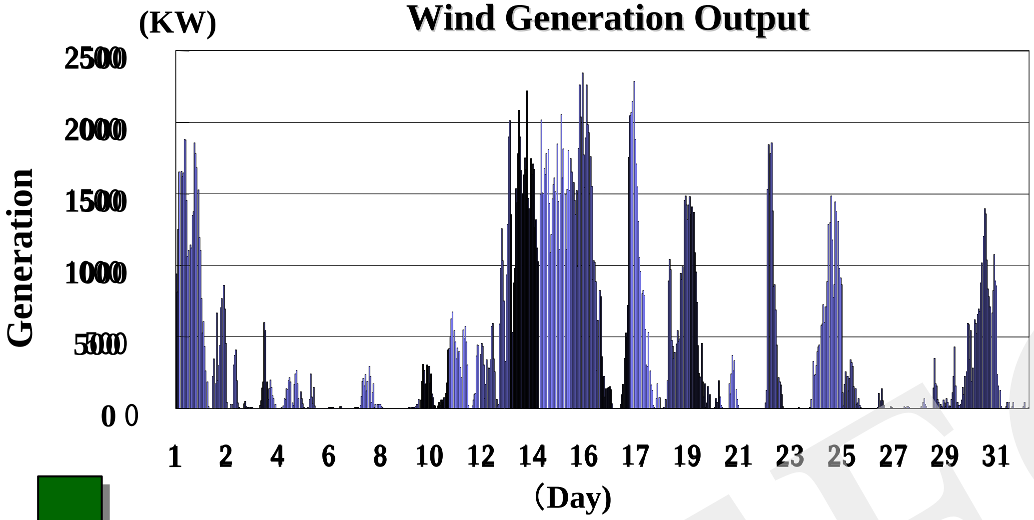
Source: Renewable Energy: RD&D Priorities, OECD/IEA 2006.

Economical Issues

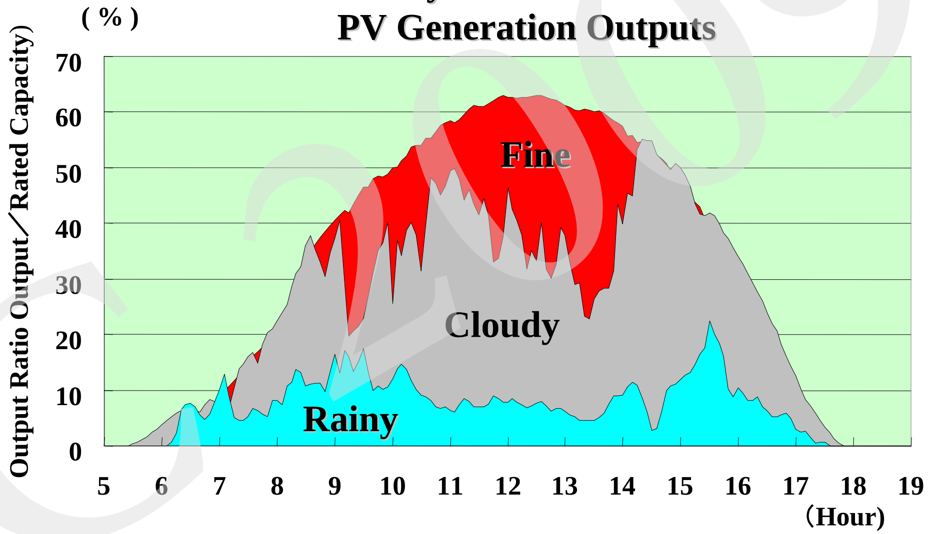
- **High Initial Installation Costs**
- **Large scale diffusion leads to a large amount of power system operation cost for mitigating output fluctuations**
- **As diffusion of generation using sustainable energy, the generation cost is expected to become lower and the sustainable energy market itself will expand remarkably.**
- **Too many installation of sustainable energy generation brings about high cost, since generation in less economic sites would come into the markets.**

Output Fluctuations of Sustainable Energy

Monthly Fluctuations of
Wind Generation Output



Daily Fluctuations of
PV Generation Outputs



Various countermeasures such as , installation of BESS (Battery) must be taken for Large scale and centralized introduction of sustainable energy generation

Big Issue ; Who pays the cost for stabilizing the output of sustainable energy generation, Utility, Producers, or Customers ?

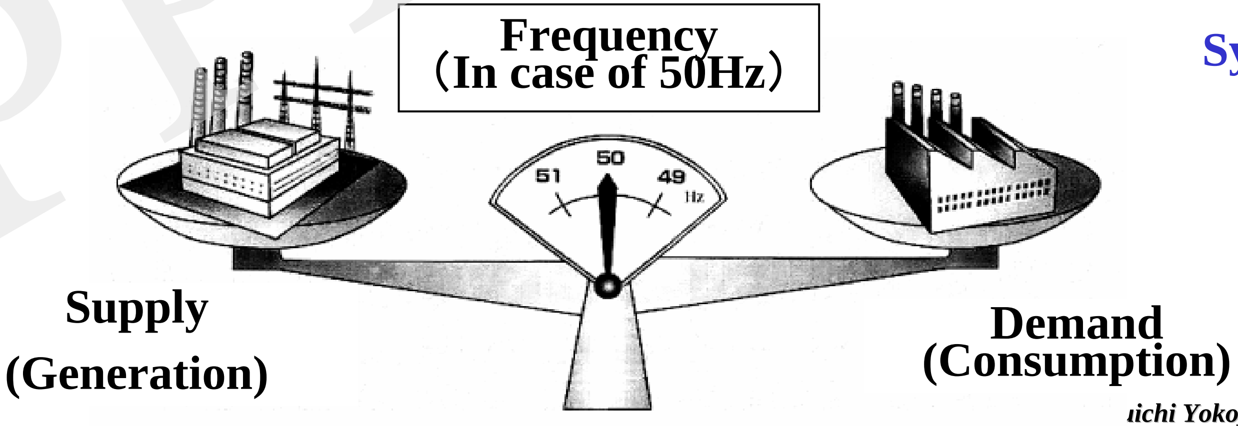
Reference: New Energy Council,
METI, Japan

- **Outputs of sustainable energy are influenced by meteorological conditions, such as wind velocity and weather, then electricity is not available all day long and imbalance of generation and consumptions of electric power cause the deviations of frequency and voltages**
- **As Large scale storage of electricity is not possible, utilities carry out real-time control to keep supply-demand balance.**
- **Due to no controllability of out puts for sustainable energy generation, in case of large scale installation of utilities have to regulate by using oil-fuel thermal generation plants.**

Estimated Frequency Deviation by Fluctuations of PV and Wind Generation Outputs

- Frequency is kept by the balance of Supply (Generation) and Demand (Consumption) within a permissible range.
- More than ± 0.2 Hz deviations deteriorates industrial activities and products
- Frequency deviation is in inverse proportion to power system capacity
(Larger system is, the smaller the deviation becomes)

	Japan-East Area（50Hz）	Japan-West Area（60Hz）	UE（UCTE）
Capacity of the Power System	80 GW	100 GW	360 GW
Maximum Capacity of PV and Wind Installation to keep Frequency within Permissible range : ± 02.Hz	1.6 GW	2.0 GW	7.2 GW



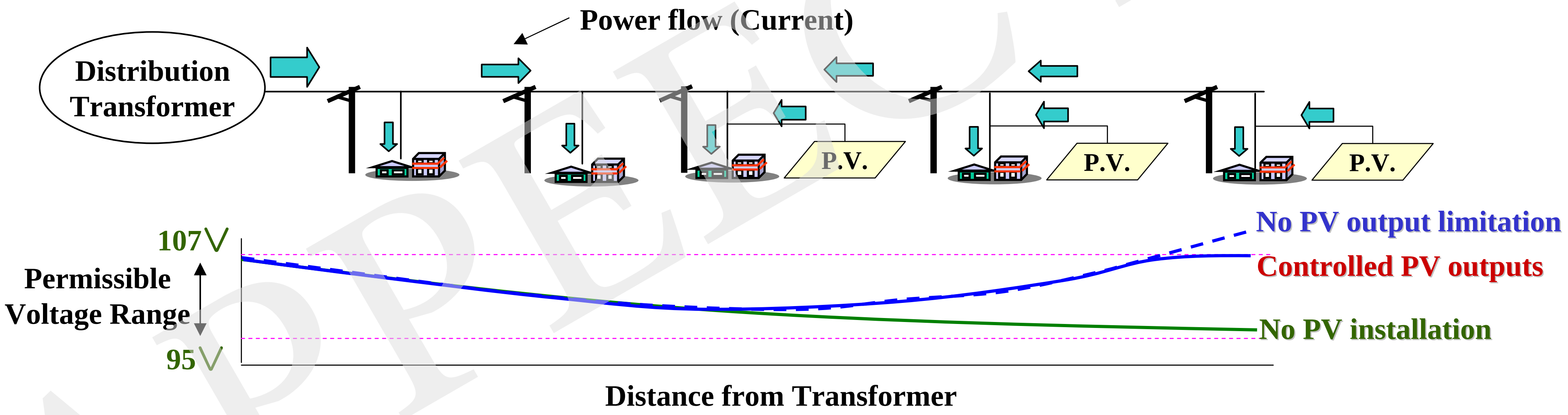
System coefficient：

1%MW／0.1Hz

ıichi Yokoyama, Waseda University, Japan,

Influence of Photo Voltaic Generation to Distribution Networks

- Voltage increase by reverse power flows from PV generators to Utility distribution networks
- In out step of voltages from the permissible range, PV outputs are regulated or PV generators are disconnected automatically (Output limitation scheme)
- The permissible range of voltages is 101±6V（202 ± 12V at 200V lines）

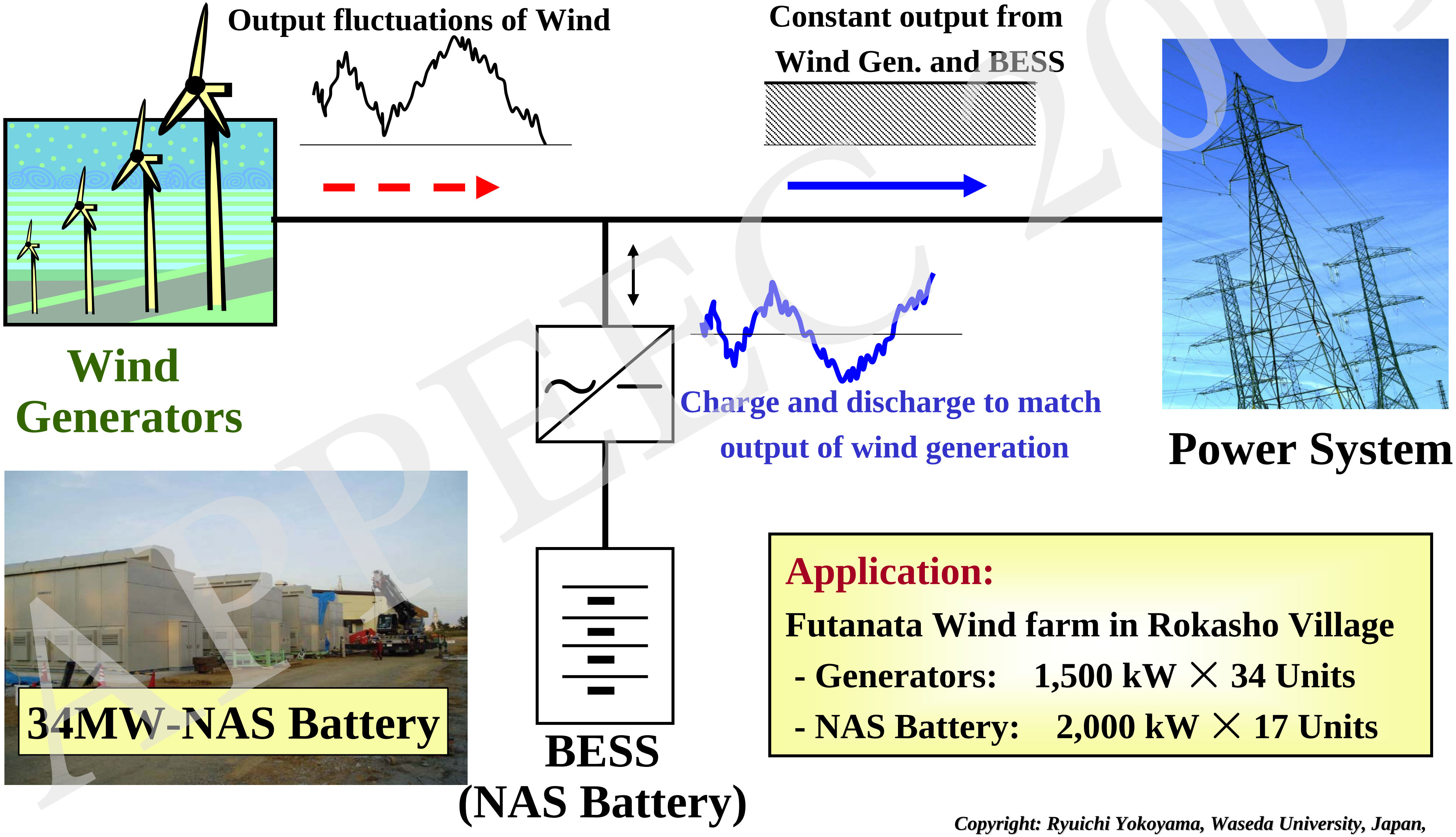


- Necessity to take proper countermeasures to prevent from voltage deviations by controlling or disconnecting outputs of PV and Wind for widely introducing PV and Wind generation.

In case of countermeasures from utility side:

Who pays ?

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



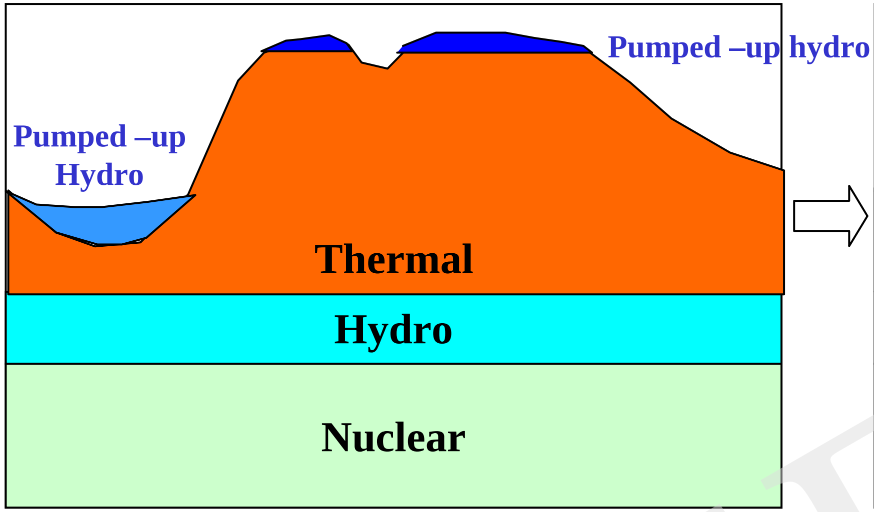
Application:

Futanata Wind farm in Rokasho Village

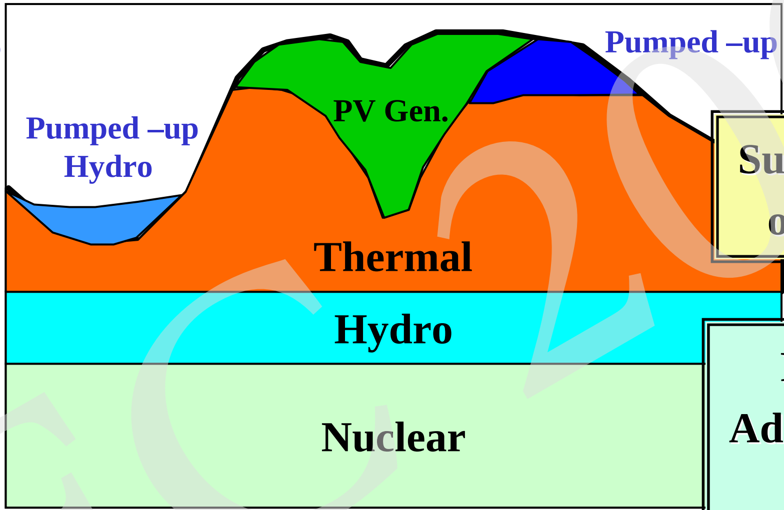
- **Generators: 1,500 kW × 34 Units**
- **NAS Battery: 2,000 kW × 17 Units**

Influence of PV Generation to System Operation

Present situation



After Large scale Installation of PV Generation



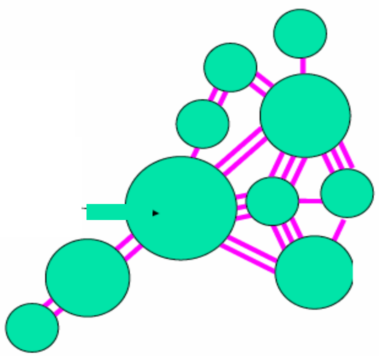
Sudden Decrease of PV Outputs

Provision of Additional Supply by Grid

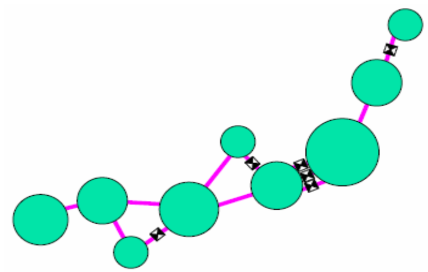
Problem（After PV installation）

- In case of sudden decrease of PV outputs, it is necessary to provide additional power form utility grids.
- As Japanese girds are radial structures, it is difficult to transfer deficient power from adjacent areas
- On the other hand, as European grids are mesh structure, there are many interconnections between areas.

European Grid（Mesh Structure)



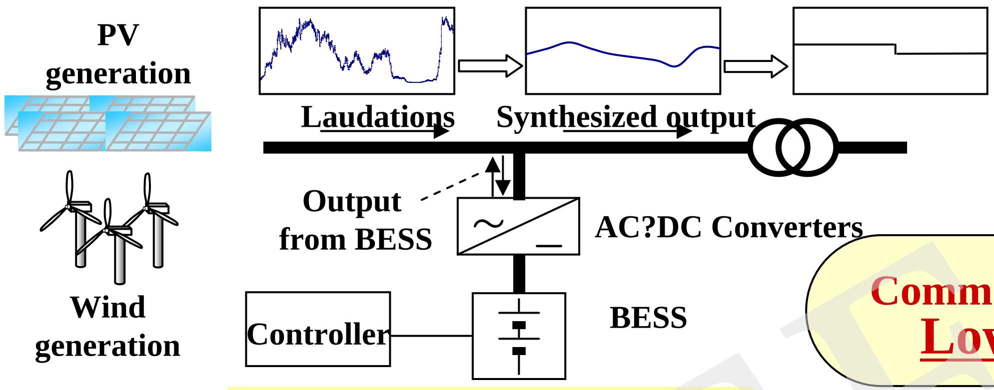
Japanese Grid（Radial Structure）



Strategic Technology Developments for Next Generation Battery and BESS

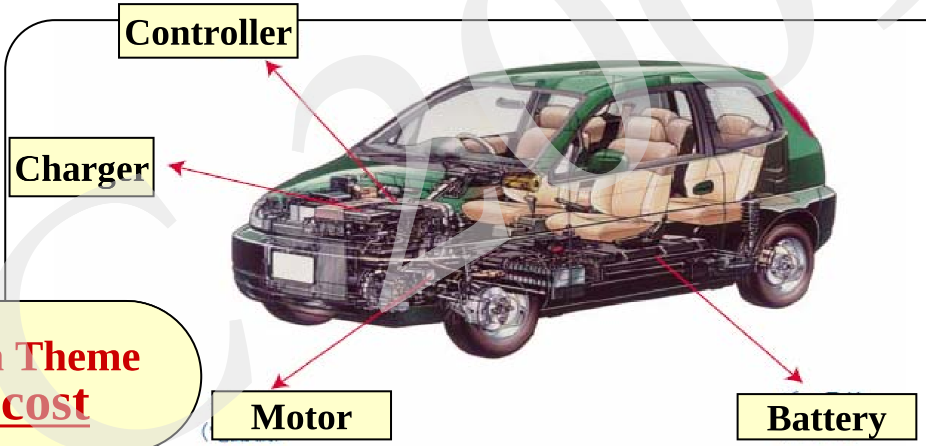
Large scale BESS for Grid Interconnections

Stabilization of Sustainable energy generation



Direction: ：Large scale, Longevity

High Performance Battery for Electric Vehicles



Direction: High density, High power

Common Theme
Low cost

Practical implementation

MWh class BESS, Low cost, Longevity, Heat control for thousand-module battery, High voltage battery, DOC control, Maintenance free

Next Generation BESS

New materials for electrodes and electrolytes for new specifications to use sustainable energy, n[New Battery systems with low cost and performance to be able to expect break through

Basic Technology

Life time estimation for sustainable energy based BESS, Durability, Testing method of safety and standards.

High Performance Elements

Li-ion Battery, its new Materials, Auxiliary devices (Motors, Controllers, etc.)

Next Generation Battery

Innovative batteries and storage systems based on new concept and their materials and battery response control schemes

Basic Technology

Extension of battery life cycle, Analysis of deterioration mechanism, Enhancement of performance, Testing method of battery safety and safety standards.

New Business Models and Technical Developments for Future Energy Delivery Networks

Virtual Power Plant : *System operation and ancillary service by integrated control of numerous DG s*

① Virtual Power Plant (Encorp)
② Dispatching Backup Generation (Electrotec)
③ Virtual Utility (ABB, Edison-Project)

Micro Grid : *Power supply network for a specific area*

① CERTS
Consortium for Electric Reliability Technology Solution
② Micro Grid (Encorp)

Power Park : *Multi quality and multi menu power supply*

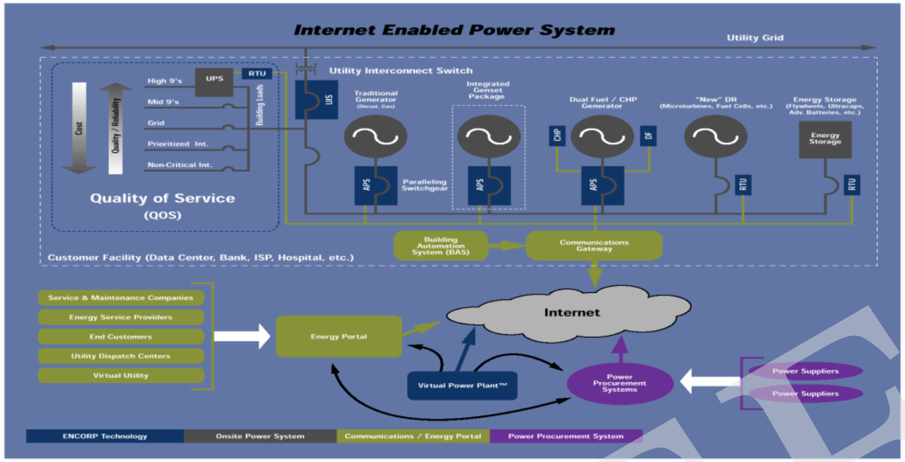
① Delaware Premium Power Park (AEP, EPRI, Siemens)
② Pleasanton Power Park (Real Energy)
③ Custom Power Park（Westinghouse Elec. Co, EPRI）

Others

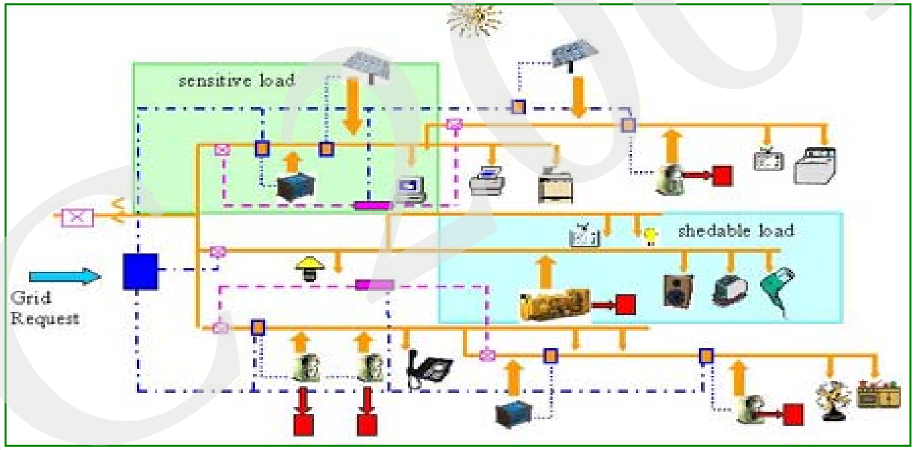
①Energy Web, Smart Grid, DisPower, etc.

Features of Proposed Energy Delivery Networks

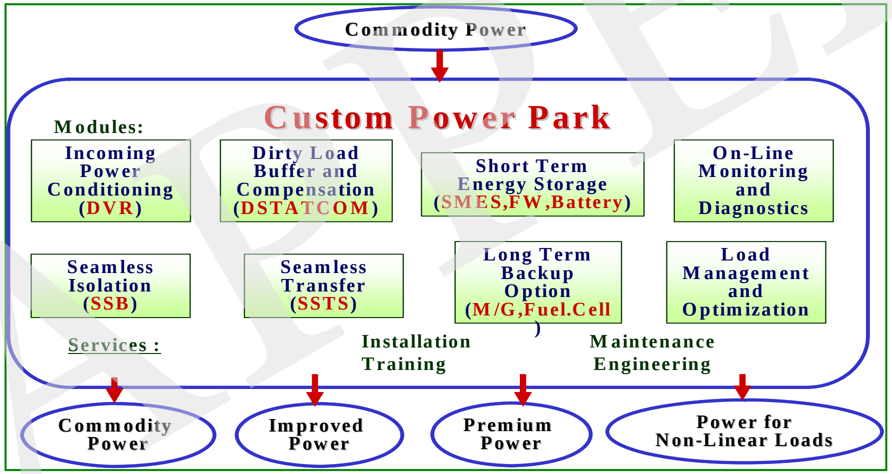
Virtual Power Plant (ENCORP）



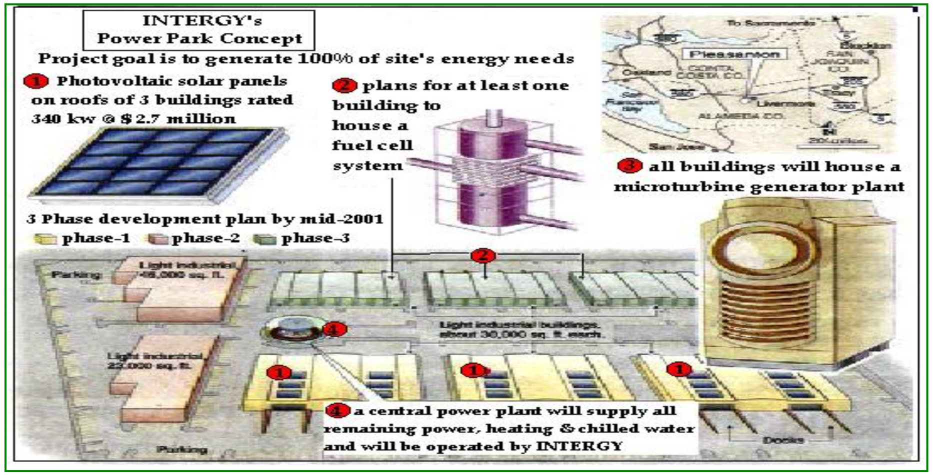
Micro-Grid (EOLBNL)



Custom Power Park (Westinghouse)



Pleasanton Power Park (Real Energy)



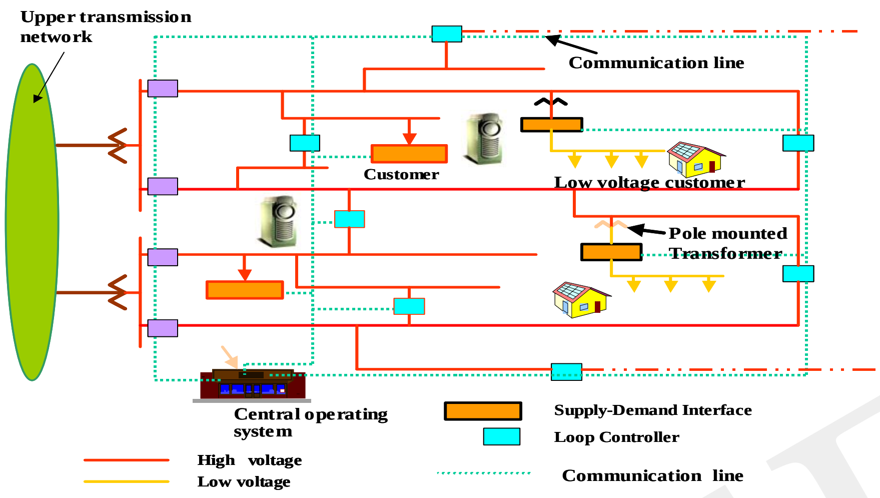
Reference: Chris Marney, Lawrence Berkeley National Laboratory

Implemented NEDO Projects in Japan for Energy Delivery Systems up to 2008

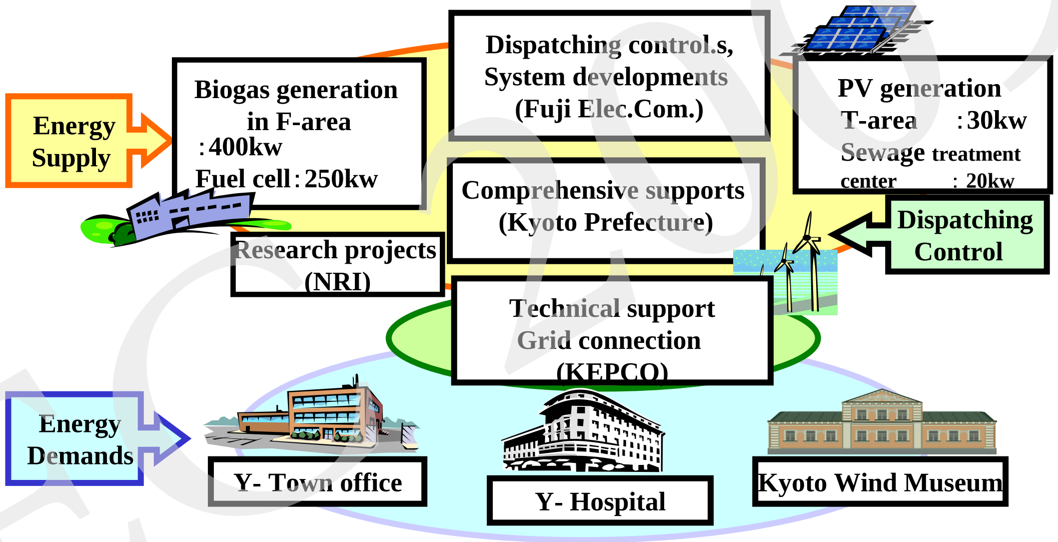
Projects	Current status (at Oct. 2008.)
EXPO-2005 Chubu Area Centralized New Energy Installation Demonstrative Research Project	Implemented in Nagoya
Hachinohe Municipal Project on Restoration of Electricity from Water Stream	Implemented in Hachinohe
Kyoto Eco-energy Project	Implemented in Kyoto
Roppongi Hills Urban Area Energy supply System	Implemented in Roppongi
Demand Area Power System (CRIEPI) FRIENDS Project	Implemented in Akagi Implemented in Sendai

Features of Future Energy Delivery System

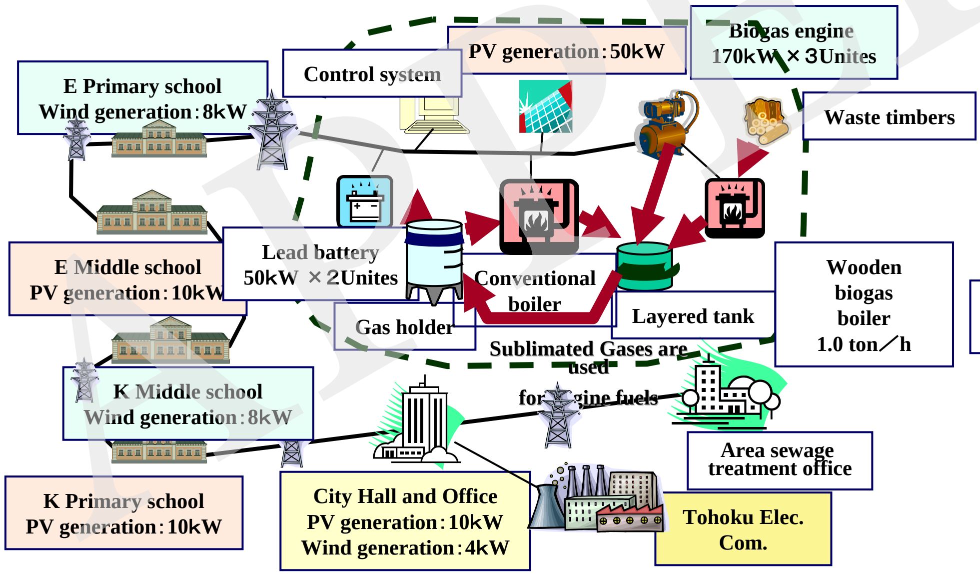
Demand Area Power System (CRIETI)



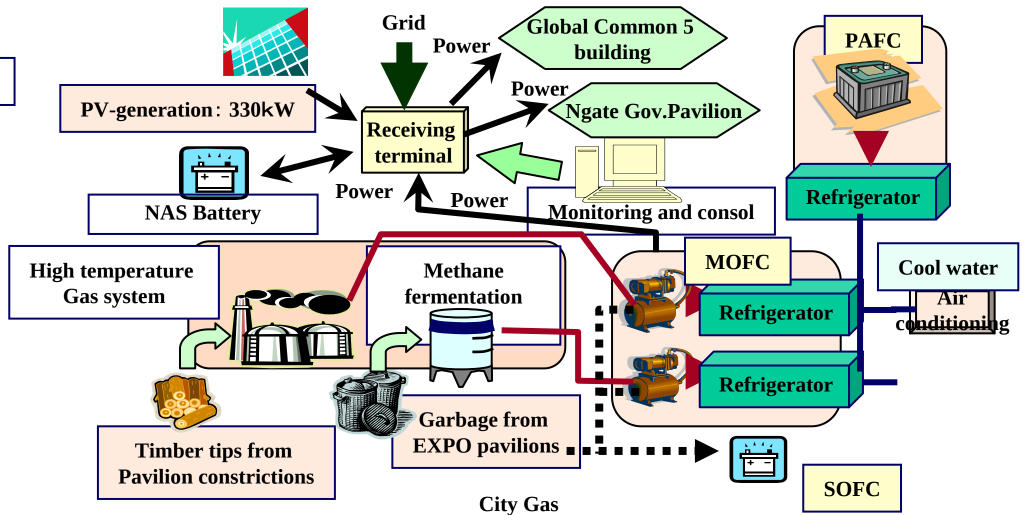
Kyoto Eco-energy Project (Kyoto, Fuji Elec. Co.)



Hachinohe Municipal Microgrid Project



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



Undergoing Implementation Projects in Japan for Future Energy Delivery Systems

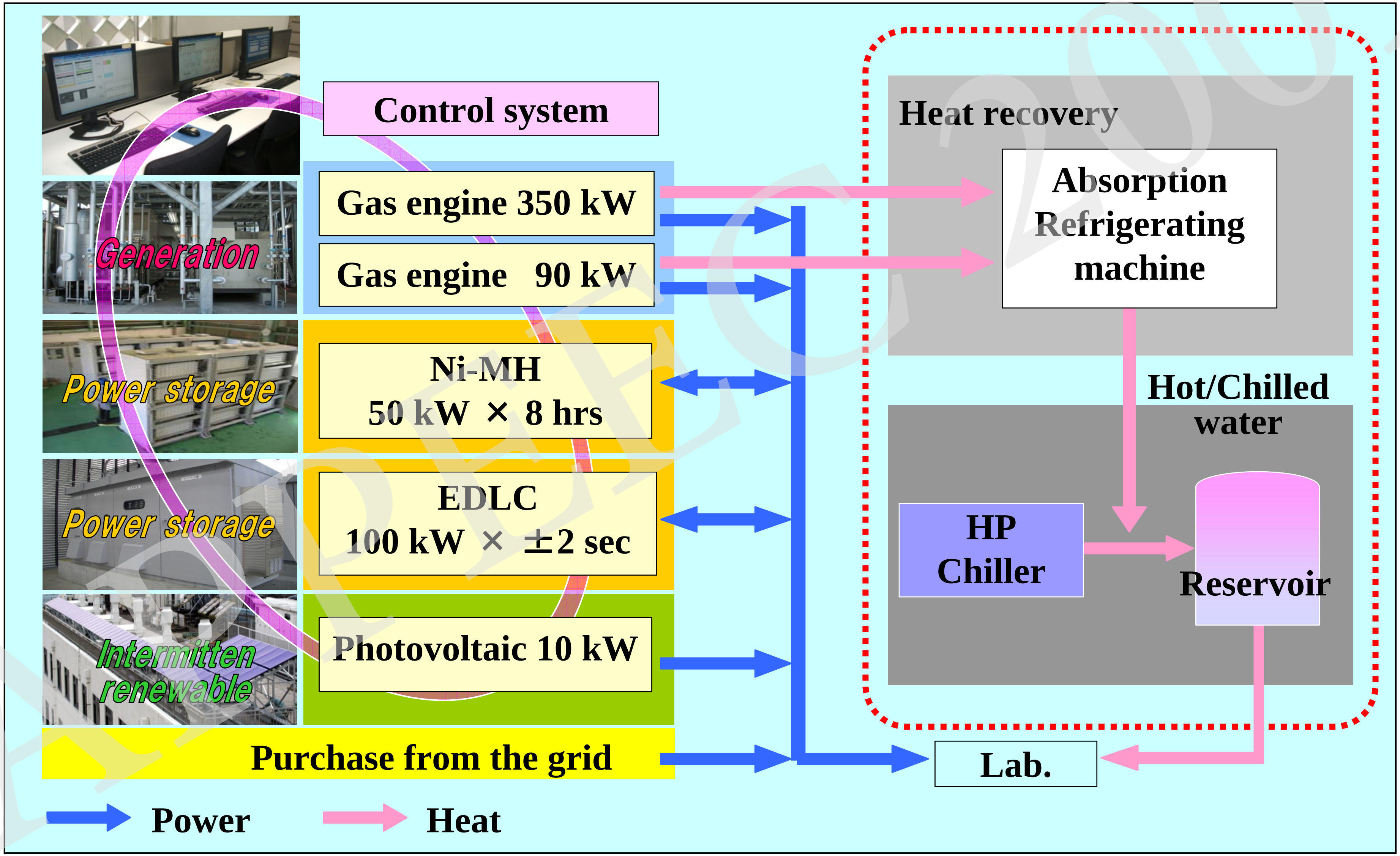
Projects	Current status (at Oct. 2008.)
Shimizu Microgrid : *Control tech. using several types of distributed generators* Shimizu Institute of Technology (SIT), Shimizu Corporation	Practical Operation in Tokyo area since 2005
Holonic Energy System: *Contribution to Grid Voltage Control and Isolated Operation with Distributed Energy Resources* Yokoyama Research Center, ,Tokyo Gas Company	Practical Operation in Yokohama area since 2005
Multi Menu Electricity supply Project *Tohoku Welfare University*	Under Implementation in Sendai since 2007
Others (by NEDO, JICA)	Under Implementation in China, Thailand, etc.

Shimizu Microgrid

Control Technology using Several Types of Distributed Generators

Shimizu Institute of Technology (SIT), Shimizu Corporation

Components and Structure of Microgrid installed in Shimizu Laboratory



Targets of Shimizu Microgrid

Microgrid in Urban Area

CO_2 reduction,

Power supply system in case of emergency

- **Production facilities**
- **Hospitals, Bank**
- **IT data center, Office…**
- **Urban development**

Microgrid in Rural Area

Promotion of

- **Renewable energy,**
- **Biomass energy**

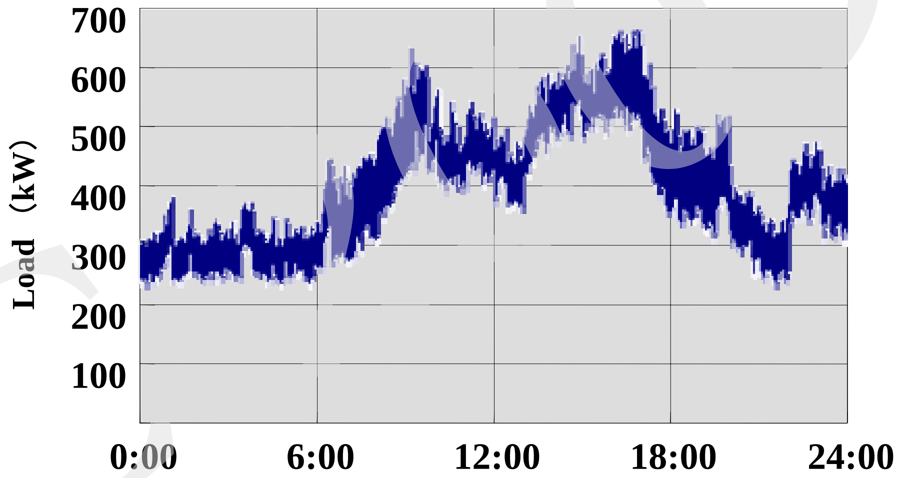
To

- **Islands**
- **Solar park or Wind farm**
- **Un-electrified villages in developing countries**

Analysis and Measurements of Load and Fluctuations

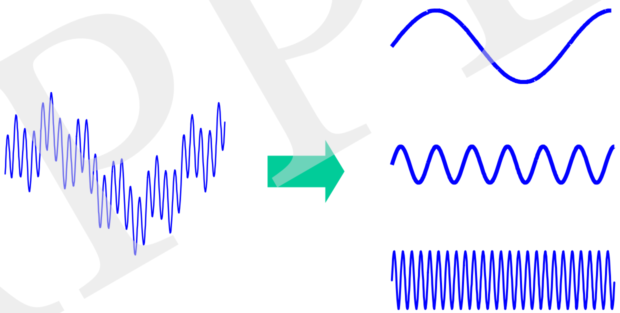
Measurement of Load Profile

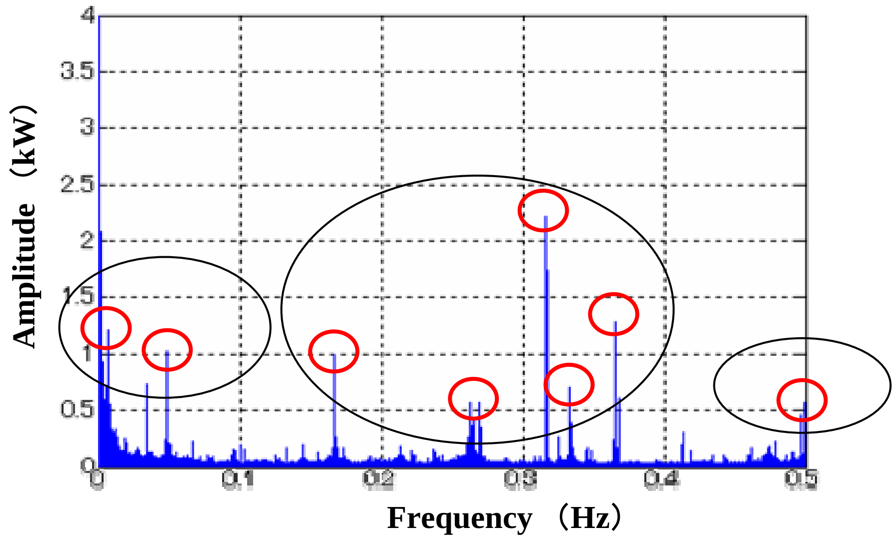
- Analysis of Load Change Characteristics
- Decision of Power Supply Devices and Capacity



Frequency analysis of Load Fluctuations

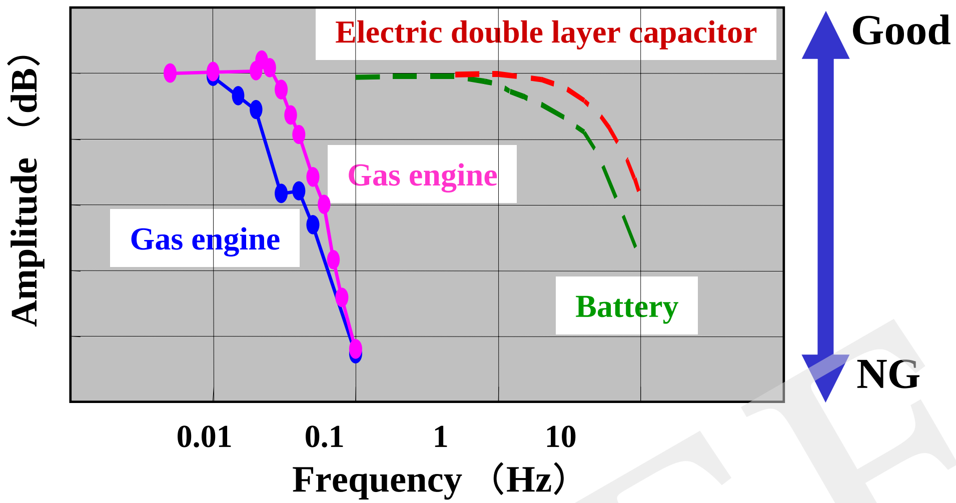
- Frequency Decomposition on Load Fluctuations

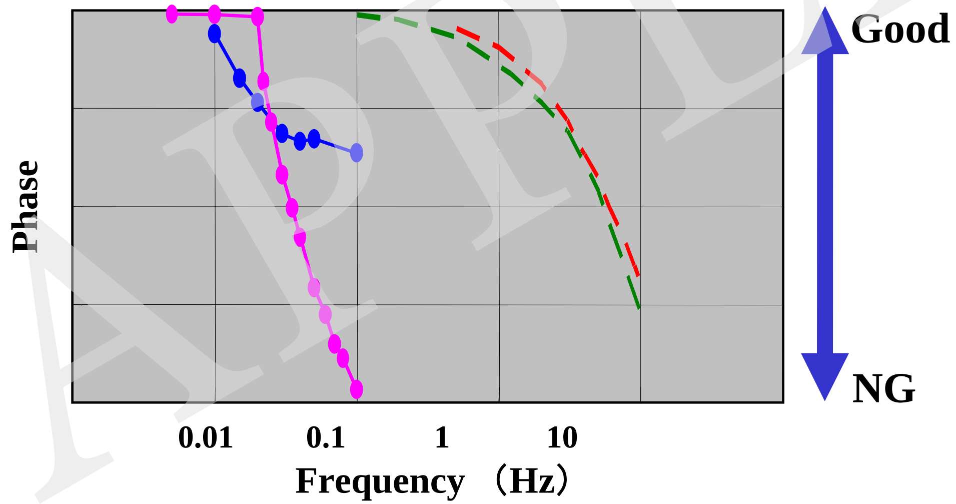


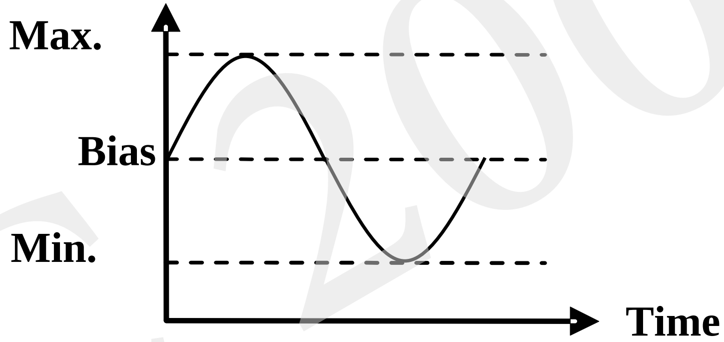


Spectrum analysis of frequency to be compensated by each device

Frequency Response and Load Following Ability of Active Power Resources







Load following ability

Gas engine

for fluctuations with a period 100 sec

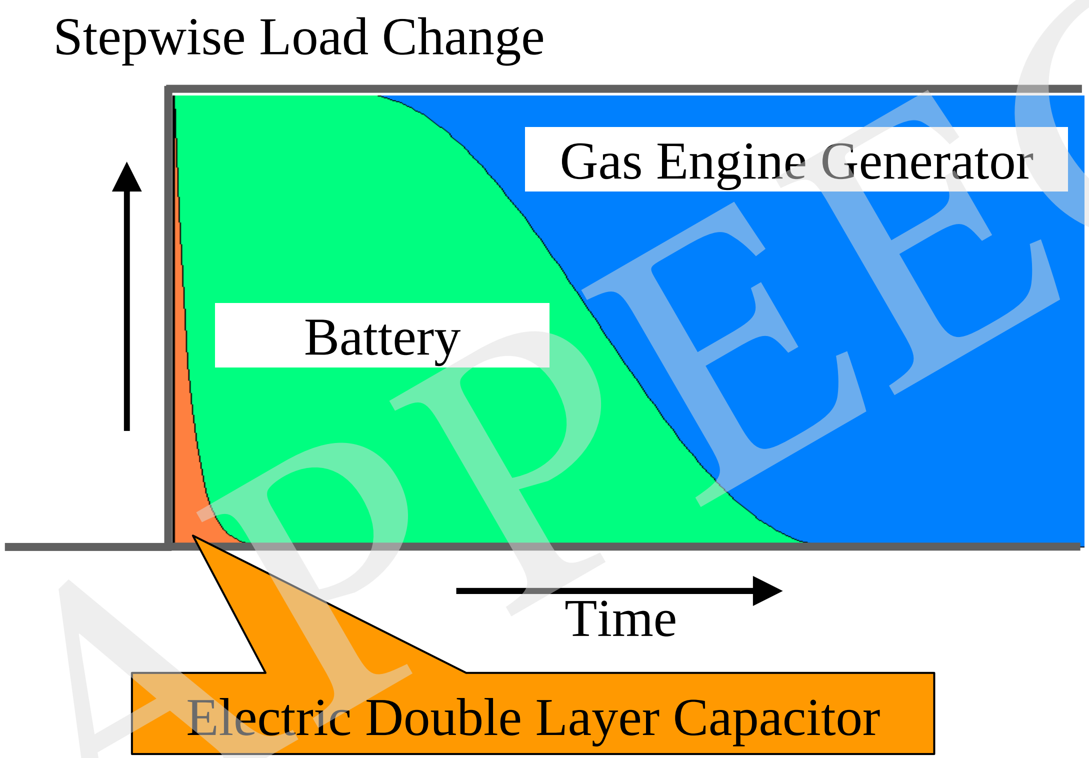
Battery

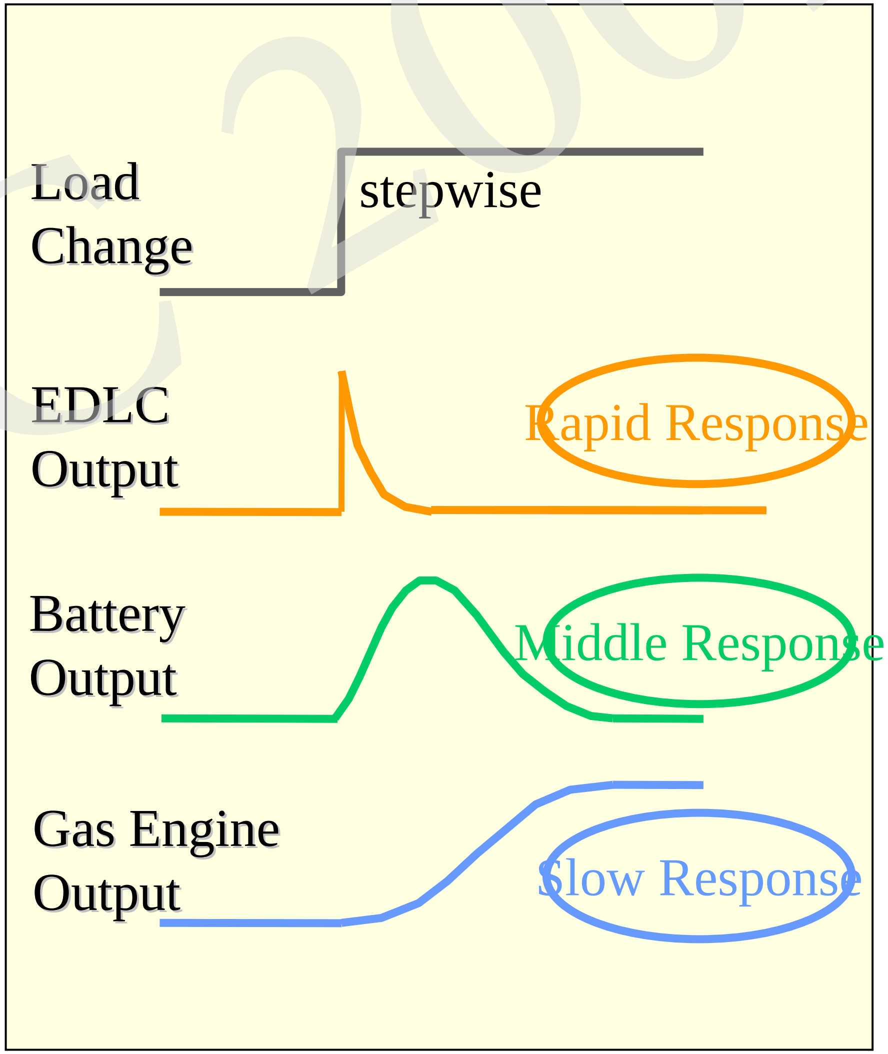
for fluctuations with a period 1 sec

EDLC (Capacitor)

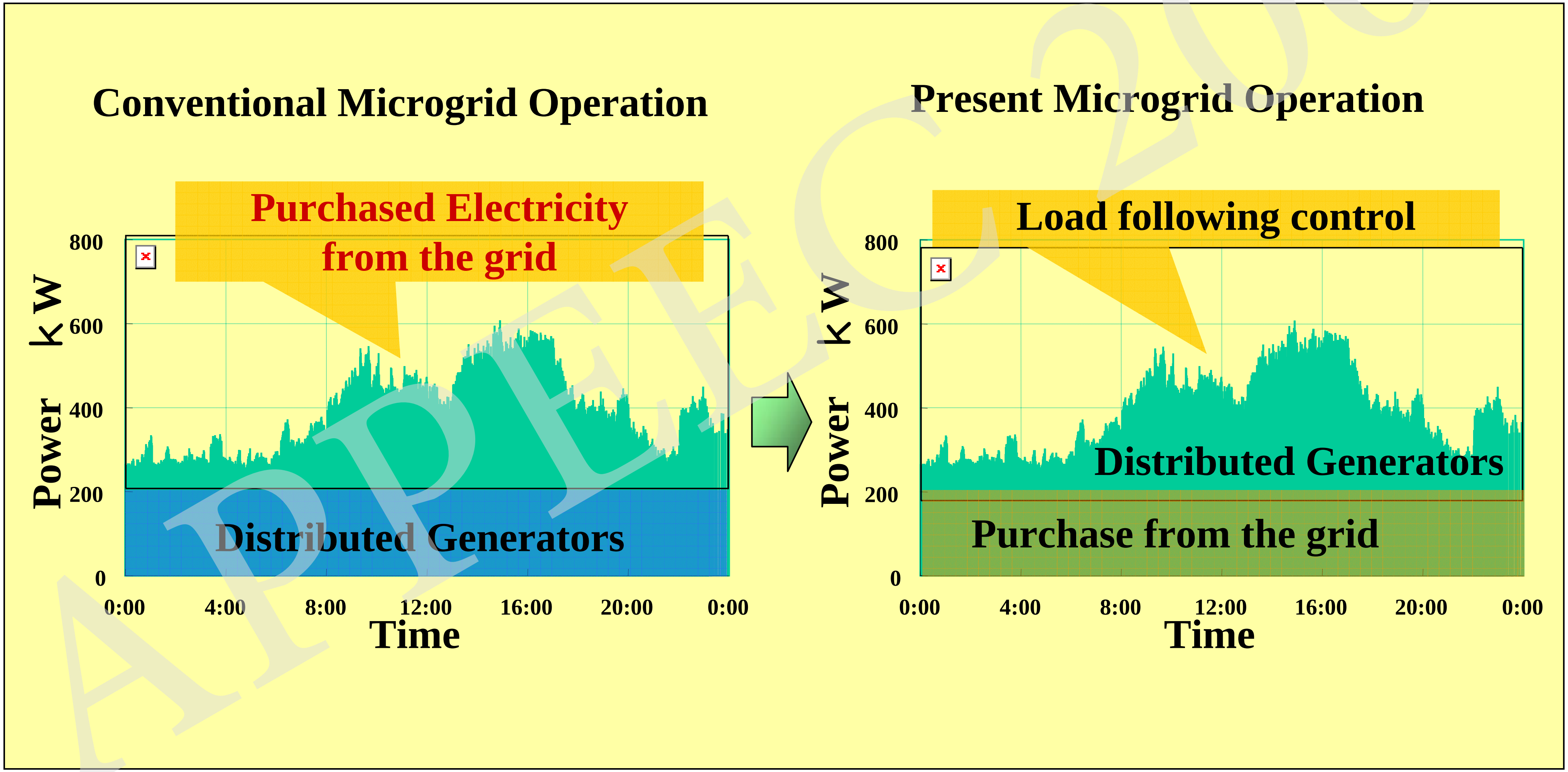
for fluctuations with a period 0.5 sec

Operation Scheme for Compound Generation According to Each Device Response Speed

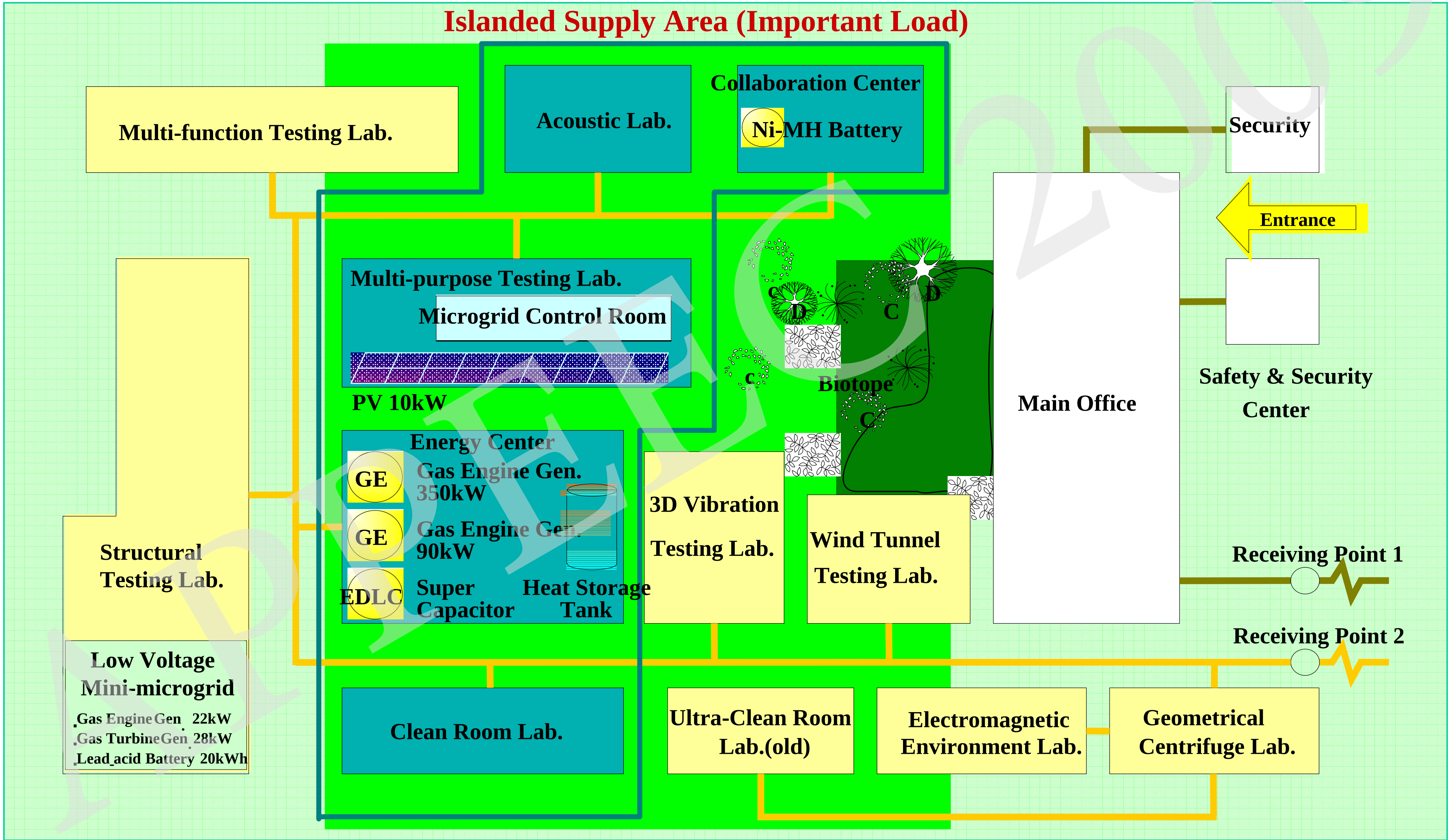




Contribution of Proposed Microgrid to Load Following Operation and Cost Reduction



Overview and Future Plan of Microgrid in Shimizu laboratory

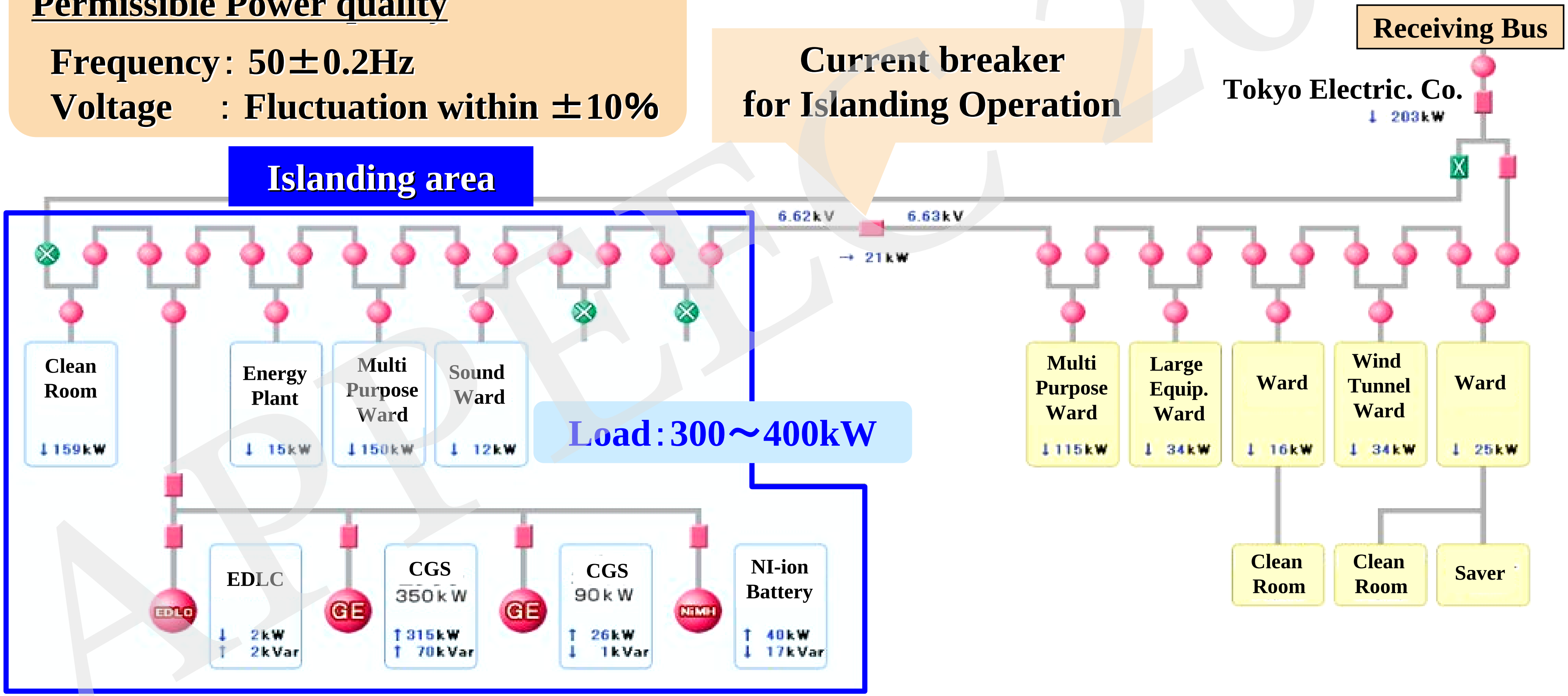


Demonstration of Islanding operation

Connecting → Islanding → Connecting

Permissible Power quality

Frequency : 50±0.2Hz
Voltage : Fluctuation within ±10%



Copyright: Ryuichi Yokoyama, Waseda University, Japan,

Microgrid at Hangzhou Dianzi University, China

中国浙江省 杭州電子科技大学

Microgrid enhancing PV proportion up to 50%

PV Generators：120kW
Diesel generator ：120kW

- **Compensation of PV output fluctuation in case of Connecting operation**
- **Power quality stabilization in case of Islanding operation**

International Cooperative Demonstration Project for Stabilized and Advanced Grid-connection PV Systems（NEDO)

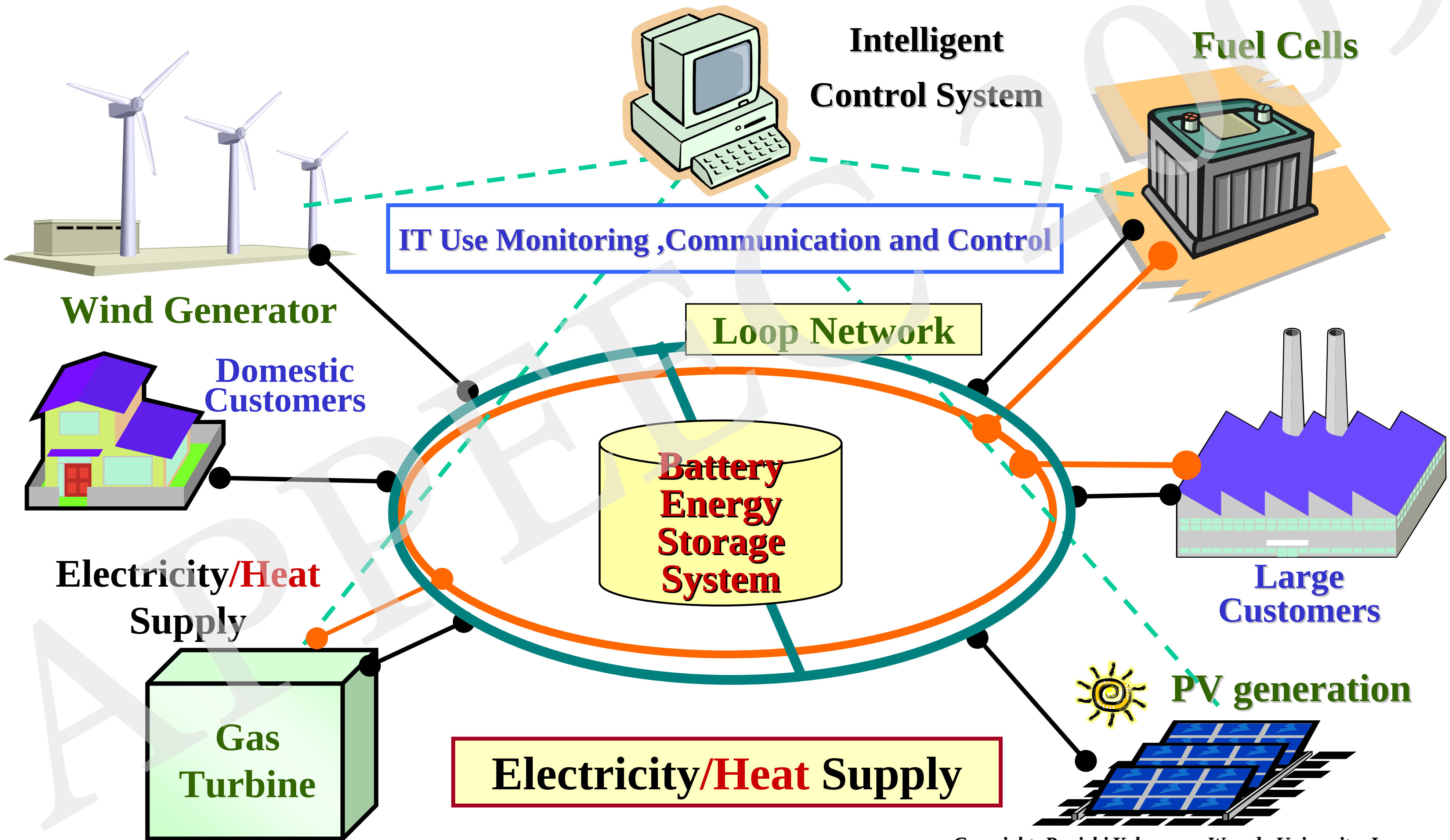
Microgrid at Hangzhou Dianzi University, China

Diesel generator

Lead acid battery

Start construction：Dec., 2007
Completion：end of Sept., 2008
Start operation：Oct., 2009
Demonstration： End of Sept.,2009

Structure and Components of Autonomous Energy Delivery Networks



The Role of Battery in Power Supply

Utility Applications

Load Leveling
- Efficiency/Economic
- Overload Reliving
- Deferment of Facility

Spinning Reserve

Voltage & Frequency Control

Customer Applications

Load Leveling
- Contract Keep
- Peak Cut

Power Quality

Power Supply in Emergency

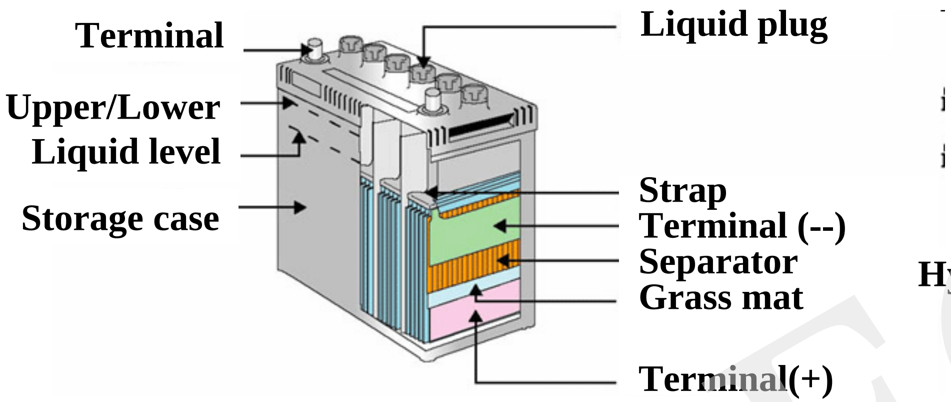
Utility and Customer Applications

Substitution for Distributed Generators

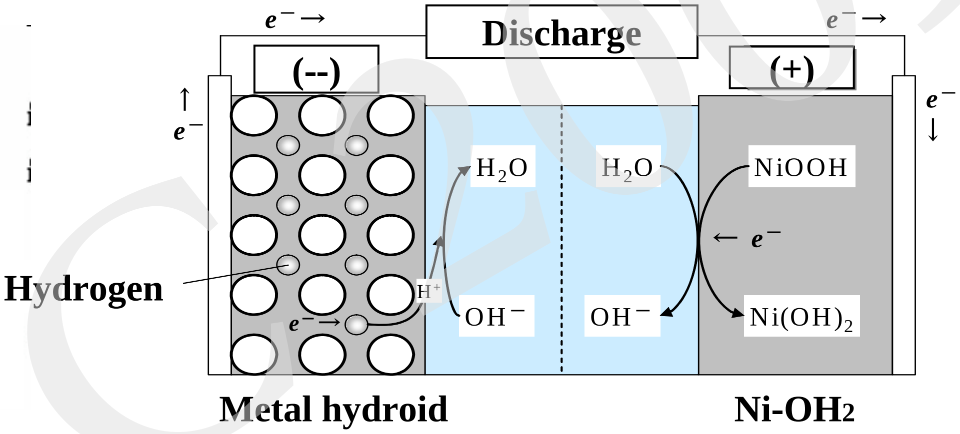
Wide Utilization of Renewable Energy

Structure of New Energy Storages in Practice

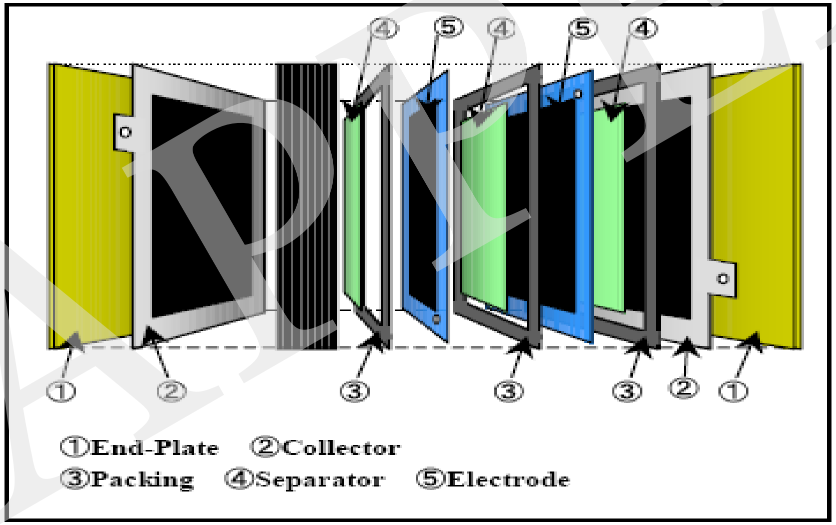
High Performance Lead Battery



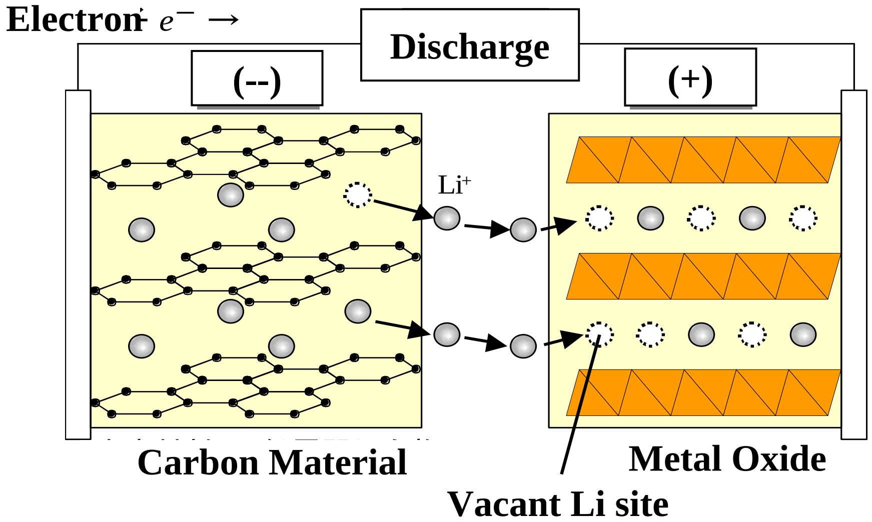
Ni-MH Battery



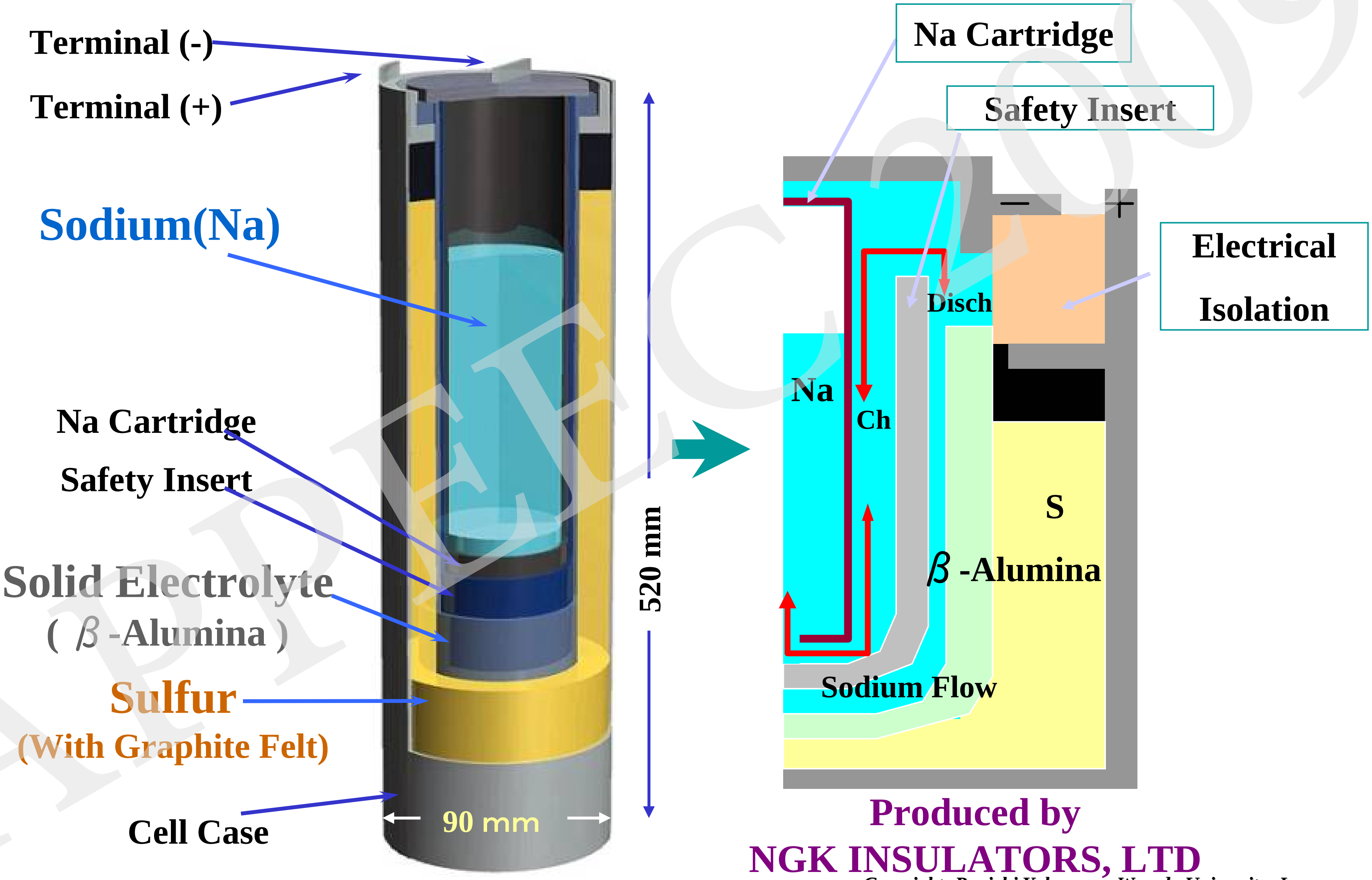
Electric Double Layer Capacitor (EDLC)



Li-ion Battery



Cell Structure of NAS (Sodium/Sulfur) Battery



Produced by
NGK INSULATORS, LTD

The Role of Large Scale Energy Storage in Practical Use of Sustainable Energy for Stable Power Supply

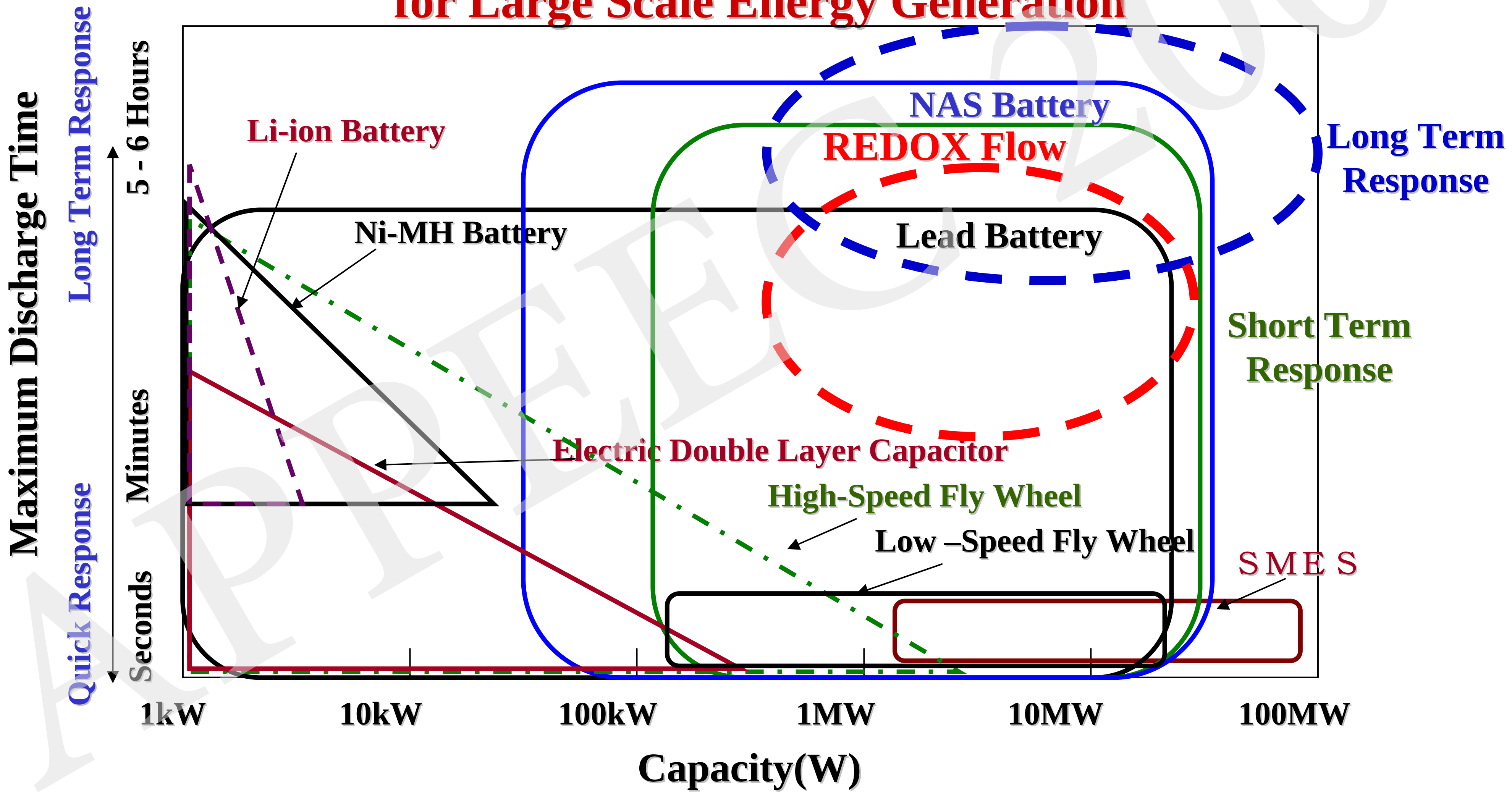
Performance of Batteries Energy Storage Systems in Practice

Battery		NAS	REDOX Flow	Lead	Zinc-Br
Voltage	V	2.08	1.4	2.0	1.8
Energy Density	Wh/kg	780	100	110	430
	Wh/l	1,000	120	220	600
Efficiency	%-DC	87	80	85	80
Temperature	C deg	280～350	40～80	5～50	20～50
Auxiliaries		Heater	Pump	Water	Pump
Self Discharge		No	Medium	Large	Medium

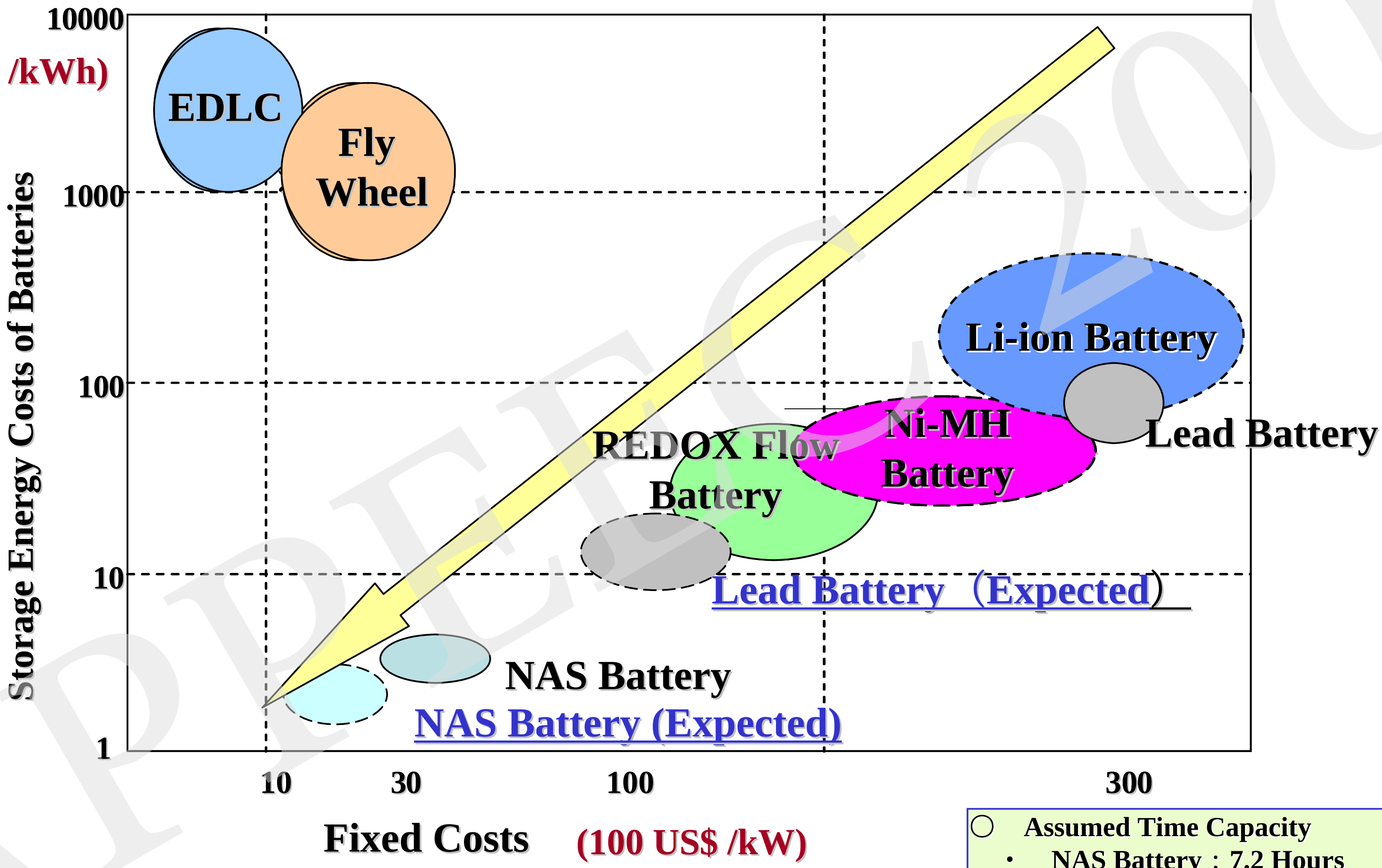
Reference: NGK INSULATORS, LTD

Capacity and Characteristics of Practical Energy Storage Systems

○ Necessity: Capacity be MW Scale, Discharge for 5 – 6 Hours for Large Scale Energy Generation



Present Costs and Prospects of Practical Energy Storage Systems



＊Storage Energy Cost (100 US$ /kWh)
＝ Fixed Cost (100 US$ /kW) ÷Time Capacity

○ Assumed Time Capacity

- NAS Battery：7.2 Hours
- REDOX Flow Battery：1～8 Hours
- Lead Battery：5 Hours
- EDLCｸ：6～8 Seconds
- ｱFly Wheel：15 Seconds

Features and Instillation of NAS Battery

Features of NAS Battery

- High Performance Battery
- Sodium (Na) & Sulfur (S) with β-Alumina Solid Electrolyte
- Target: Load Leveling → Quality Enhancement
- Cost → Same Level as Pumped Storage Hydro
- Totally 139MW has been Installed to Customers

Performance of NAS Battery

Energy Density	: About 3 times that of Lead-Acid
Energy Efficiency	: 87% (Battery)
	: 95% (Inverter/Converter One Way)
	: 78% (Total include heater loss)
Maintenance	: Periodical Inspection (3 years)
Characteristic	: No self-discharge, No memory-effect
Cycle Life	: 4500 Cycles = 15 years
Construction Period	: Few Months

Installation

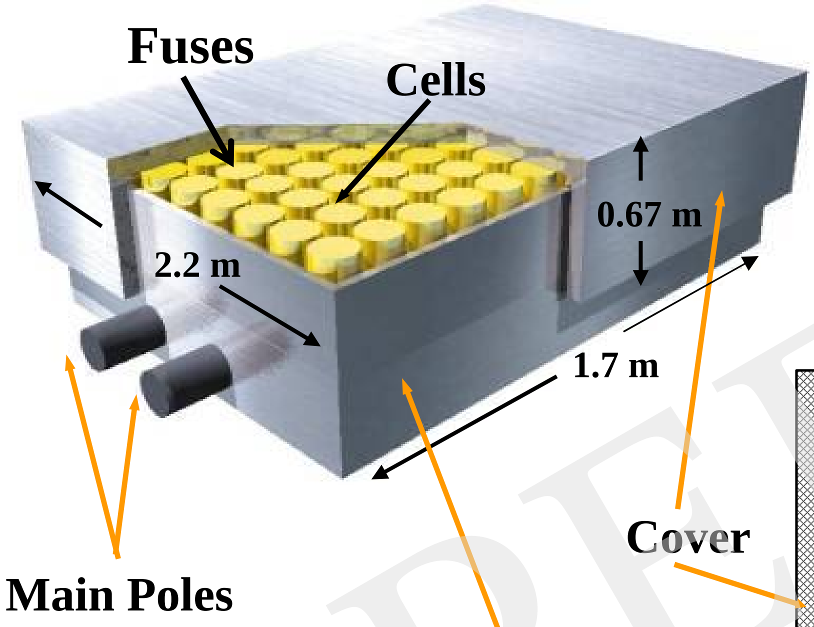
Commercial Installation : 139 MW at 83 sites (2007.6 :TEPCO)
Commercial Installation : 270 MW at 200 sites (2009.1 :NGK)

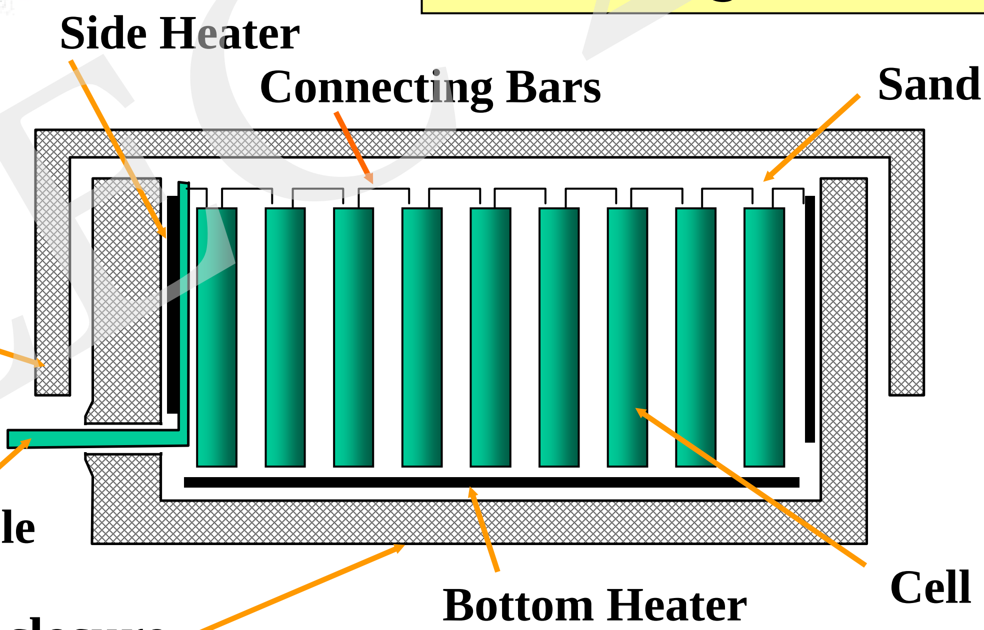
Rapidly Increase in Overseas

Structure and Component of Cell and Module

Output Power : 50 kW
Storage Capacity : 360 kWh

Charge: 8 hours
Discharge: 7.2 hours

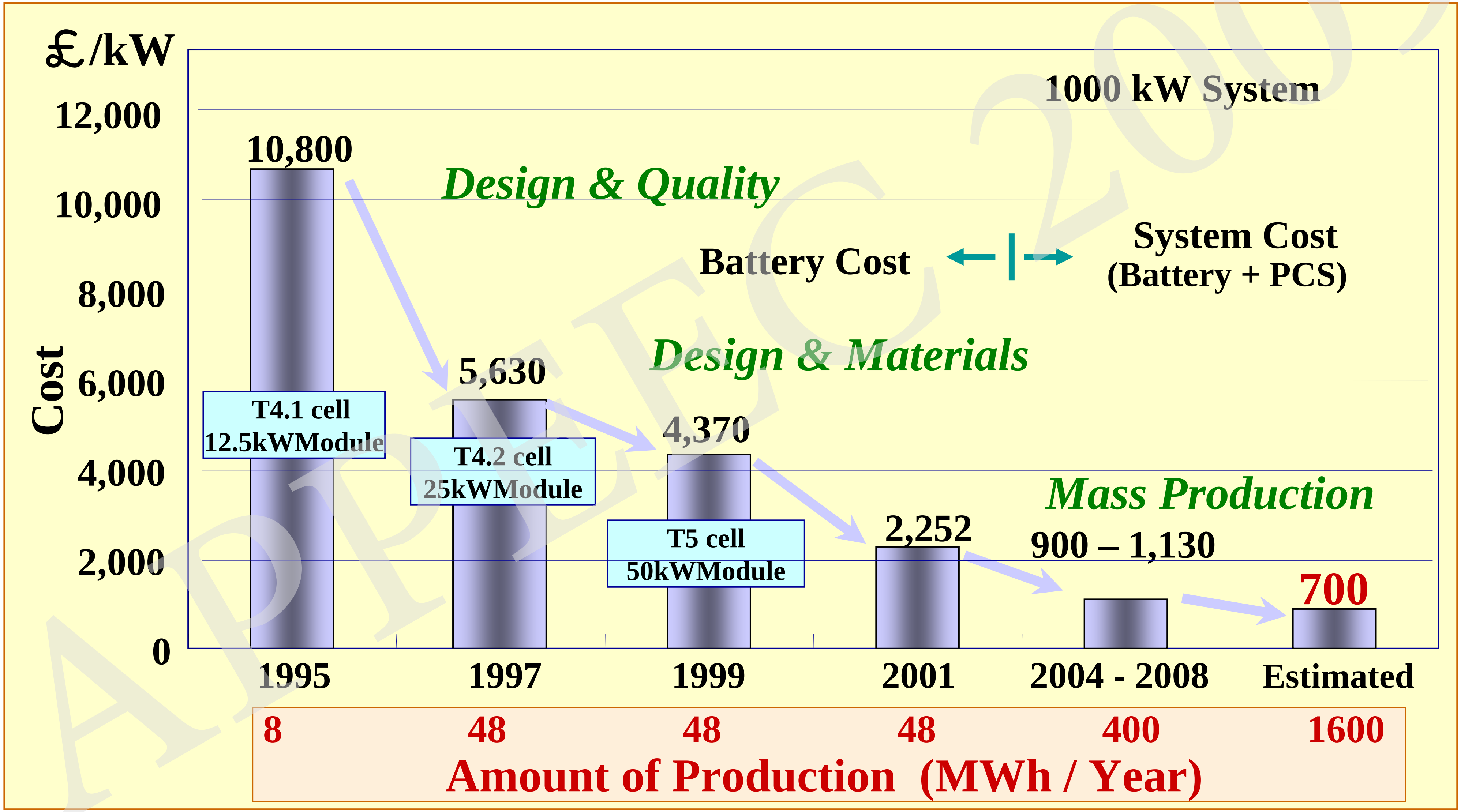




320 Cells/module

Remarks: Heater is required to keep the Temperature of 300 Degree C
Sulfur and Sodium are abundant, but dangerous to treat

Remarkable Price Redaction of NAS Battery System



Reference: NGK INSULATORS, LTD 2008

The Role and Use of BESS
(Battery Energy Storage System)

- *The uncertainty and perturbation of outputs from Renewable Energy should be leveled using BESS.*
- *It is indispensable for islands and remote areas, unlike urban area, as their generation capacity is small.*
- *Flat load has advantage to get inexpensive energy.*
  - *Power market reveals the difference of tariff between day and night. Economical benefit became clear.*
- *Micro Grid: Countermeasure for Energy Imbalance*
- *Request for High Power Quality: Quality - Sensitive Loads*
  - *Honda introduced 12MW NAS battery in a R&D Center.*
  - *Fujitsu introduced 2-4 MW NAS batteries in three sites.*

Instillations by Companies of NAS Batteries

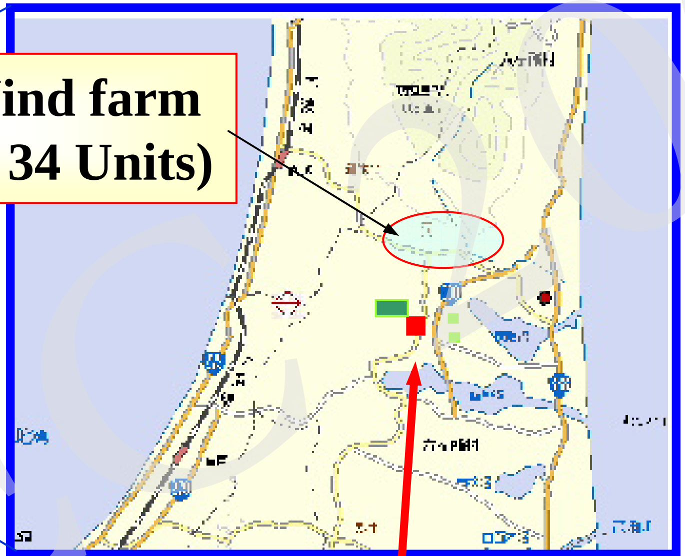
Honda

Fujitu Electric Co/

- ***For high performance of CO_2-emission Reduction by NAS battery, Installed companies appeal the " Clean and Green Corporation ".***
- ***The advantage will become obvious when CO_2-emission trade starts.***

Output Stabilization of Wind Generation by NAS Battery at Futamata Wind Farm

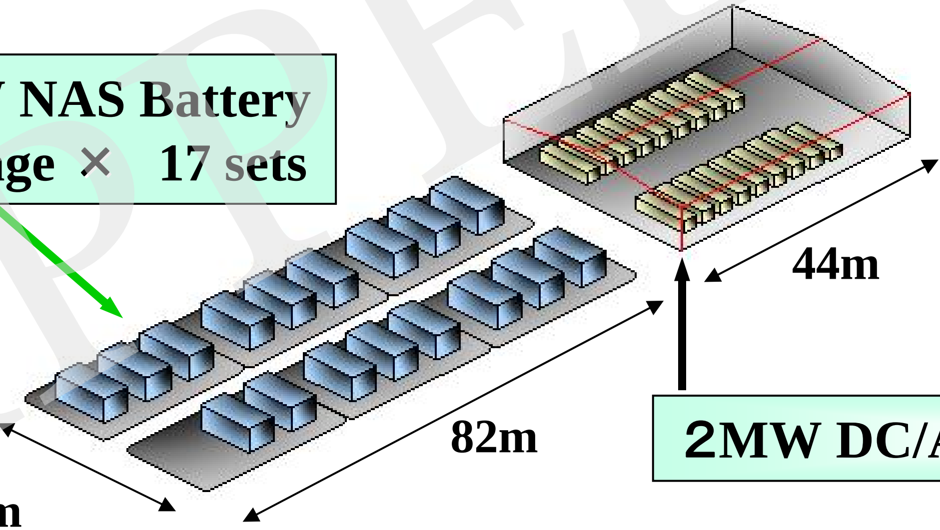
50 MW Wind farm
(1.5 MW × 34 Units)



34MW – NAS Battery
（2MW × 17 sets）

In Rokkasho Village

2 MW NAS Battery
Package × 17 sets



2MW DC/AC Converter × 17 sets

Reference:Japan Wind Development Co.

Wind Power and NAS Battery Hybrid System with Output Stabilization

34 MW NAS equipped in 51 MW Wind Farm

Present Price of NAS Battery System
(In Committal)

1,000 kW (1 MW)

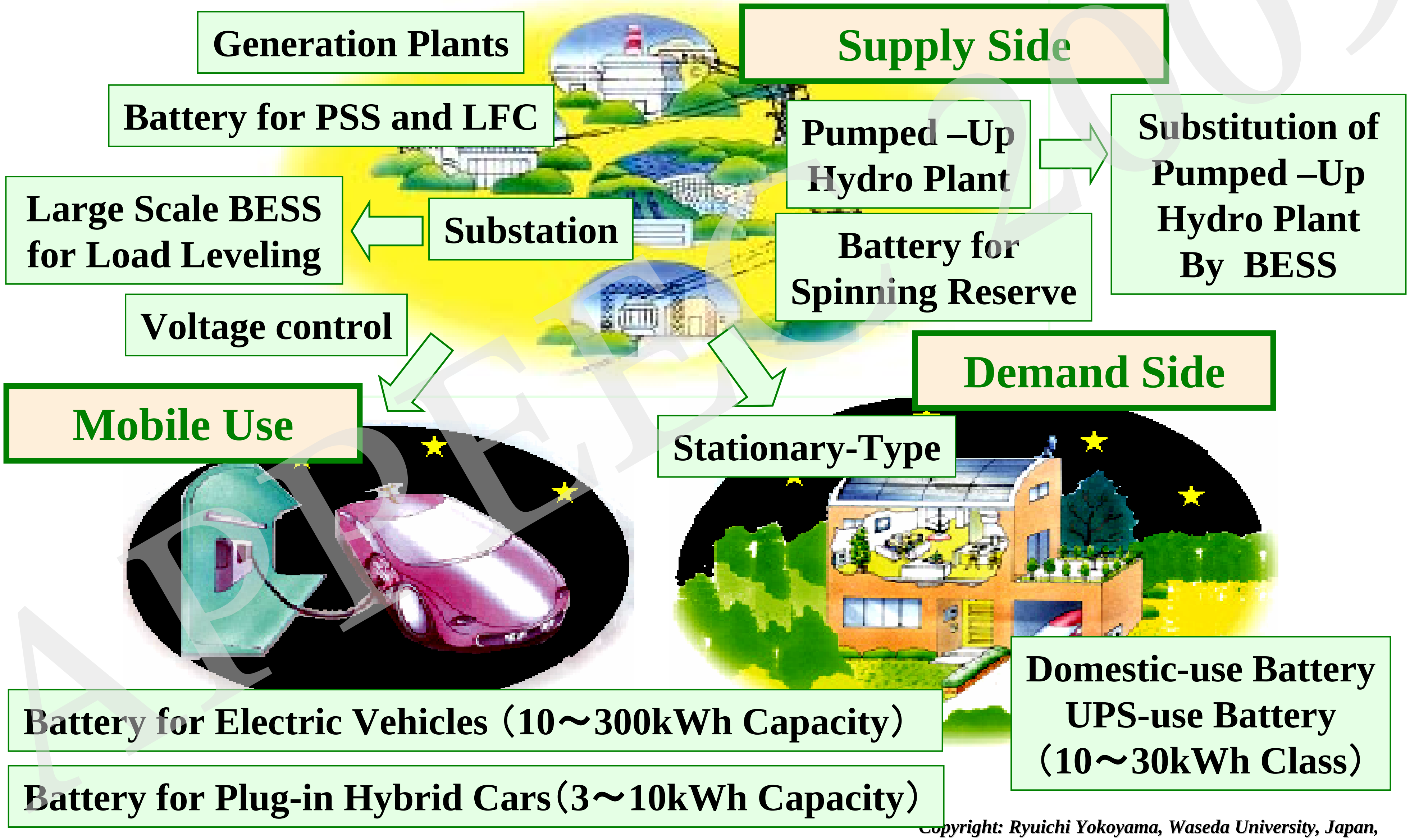
NAS System Cost

(Battery + Power Conditioner)

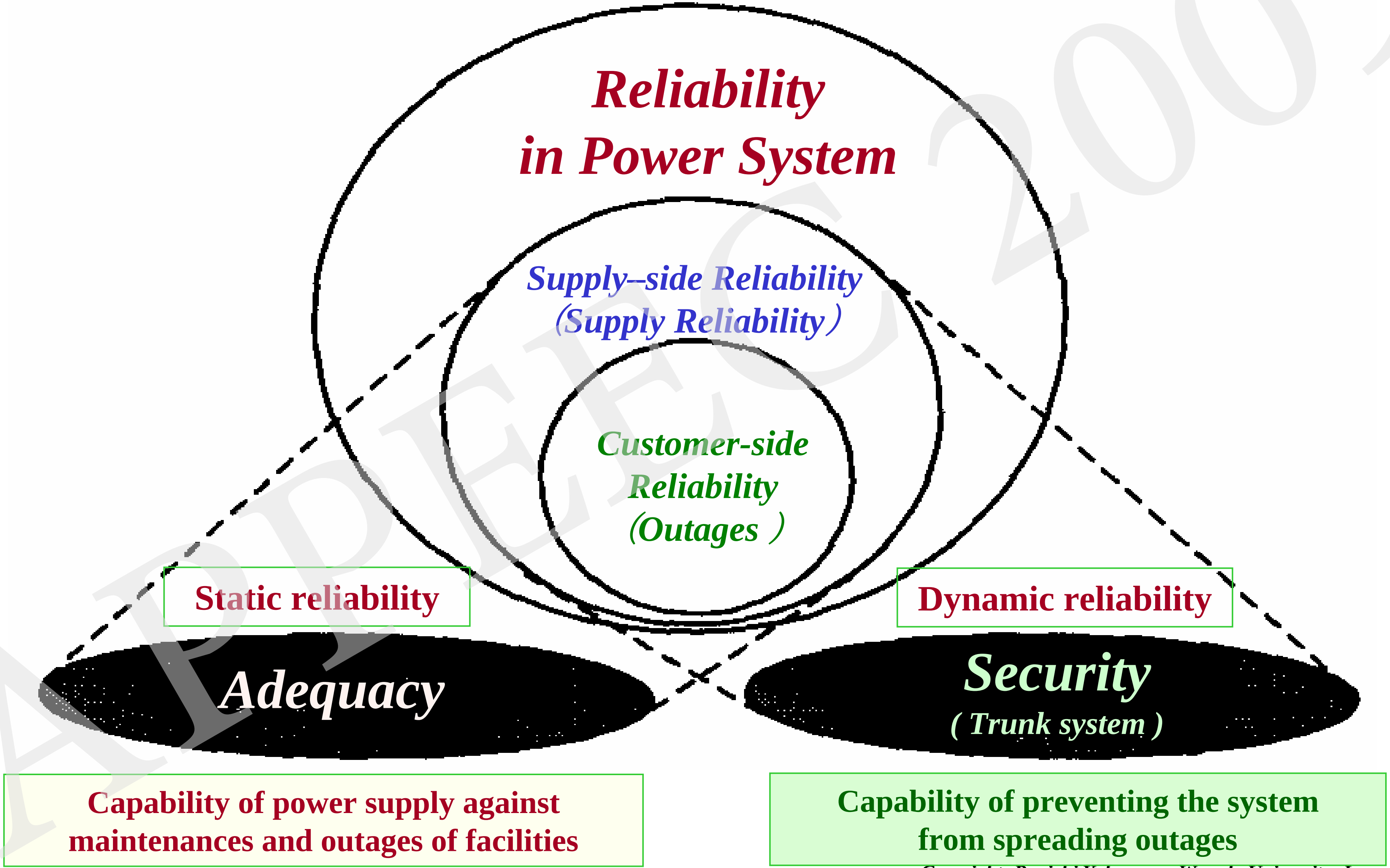
USA $/kW	GB £/kW	Europe €/kW	China Y/kW	Japan Y/kW
1,400 - 1,900	700 - 900	900 - 1200	10,000 - 13,000	15,0000 - 20,0000

Back to the Basics toward Reliable and Efficient Power Supply

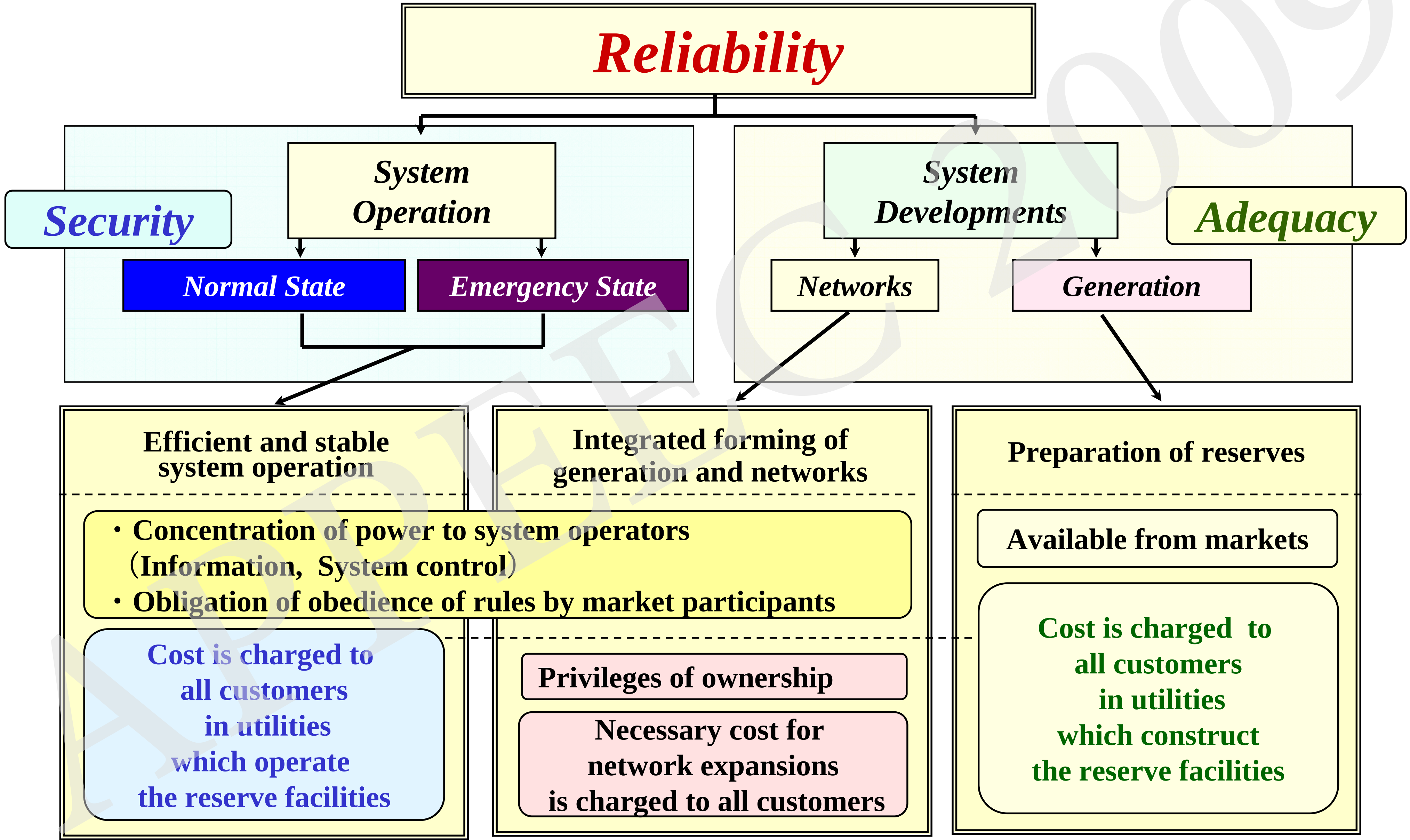
Future Diversity of Uses of Battery Energy Storage Systems



Concept of Adequacy and Security in Power System Reliability

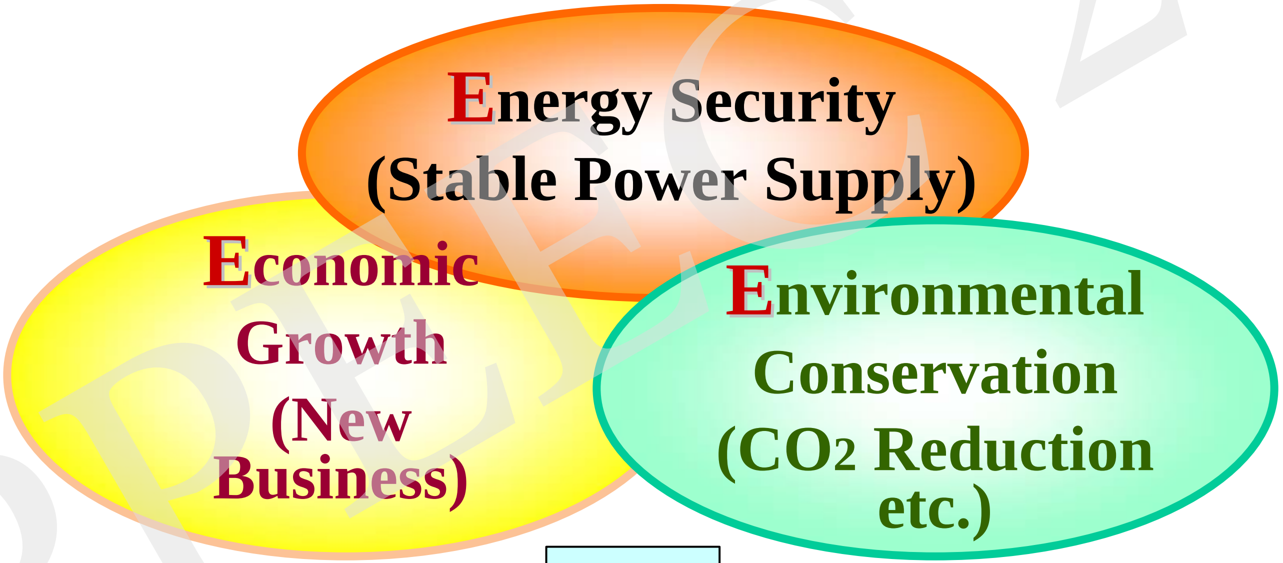


Fundamentals for keeping Supply Reliability



Coordination of Goals of Electric Power Utilities against Global Warming

Premise: *Stable, Reliable, and Clean Power supply for All Customers with Reasonable Price*



- *Promotion of CO_2 Reduction by coordinating Major Goals "3E"*
- *Contribution to create the Efficient Energy Use Society*

Back to the Basics
Toward Reliable and Efficient Power Supply

Reliable Supply and Environmental Preservation

- Diversification of power supply (Generation best mix)
- Development of nuclear and new/sustainable energy technologies
- Adequacy of energy delivery networks and supply margins

Increase in Efficiency of Management

- Improvement in profitability (Asset management for high return)
- Improvement of financial structure (Capital ratio versus investments)
- Installation of efficient and reliable facilities (Cogeneration management)

Strengthening and Upturn of a Profit Base

- Development of new business, such as ESCO, Solution and Information business, Distributed energy technologies, Foreign business etc.)
- Accurate forecasting of power demands and electricity price in markets

Back to the Basics for Reliable and Efficient Power Supply

Thank you for your attention

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