Roundtable on Science and Technology for Sustainability
Japan-U.S. Workshop on Sustainable Energy Futures

Energy System Integration

― Possibility of Smart Grid ―

Tuesday, June 26, 2012
The National Academy of Sciences, Washington, DC

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2. Issues of Future Energy System
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What happened to the power system ?

- In the Great East Japan Earthquake, Generation plants along the pacific coast in north from Chiba have been heavily damaged by the quakes and the tsunami.

- The damaged plants are:

In the Tohoku area,		In the Tokyo area,	
Hachinohe	250MW	Fukushima(1F)	4700MW
Sendai	440MW	Fukushima(2F)	4400MW
Shin-Sendai	950MW	Hirono	3800MW
Haramachi	2000MW	Nakoso*	1630MW
Shinchi*	2000MW	Hiatchinaka	1000MW
		Kashima	4400MW
		Kashima*	1400MW
		SumikinKashima	630MW

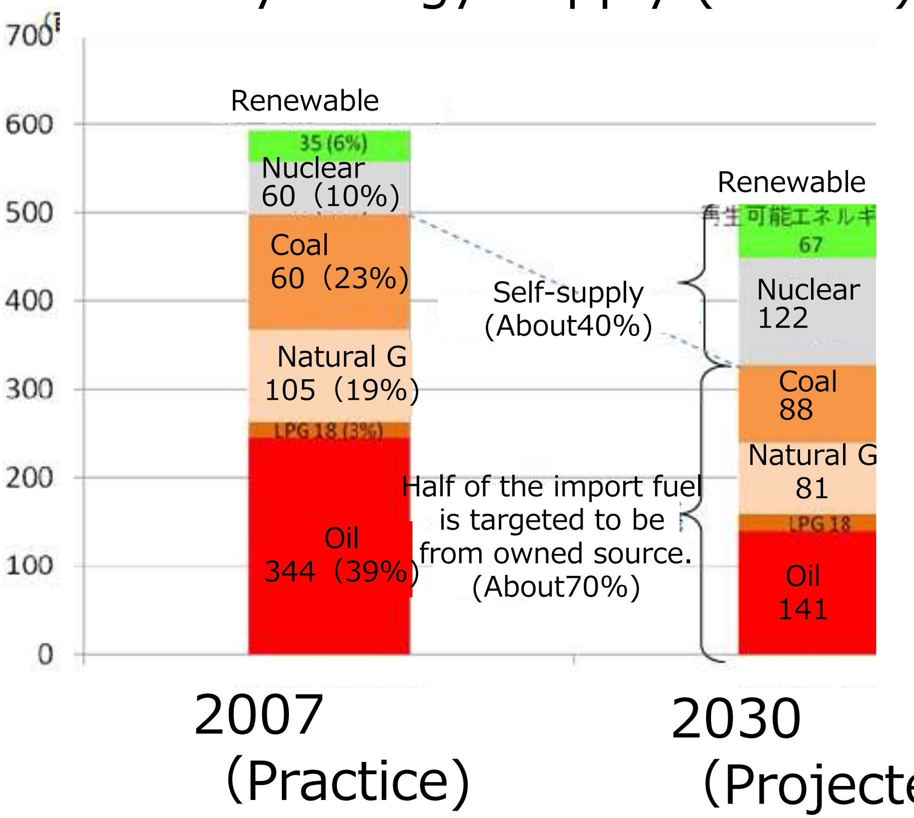
* Cooperative Thermal Power Company

- After March 11, we had severe shortage of power supply when the power demand was still high due to remaining winter demand for heating.

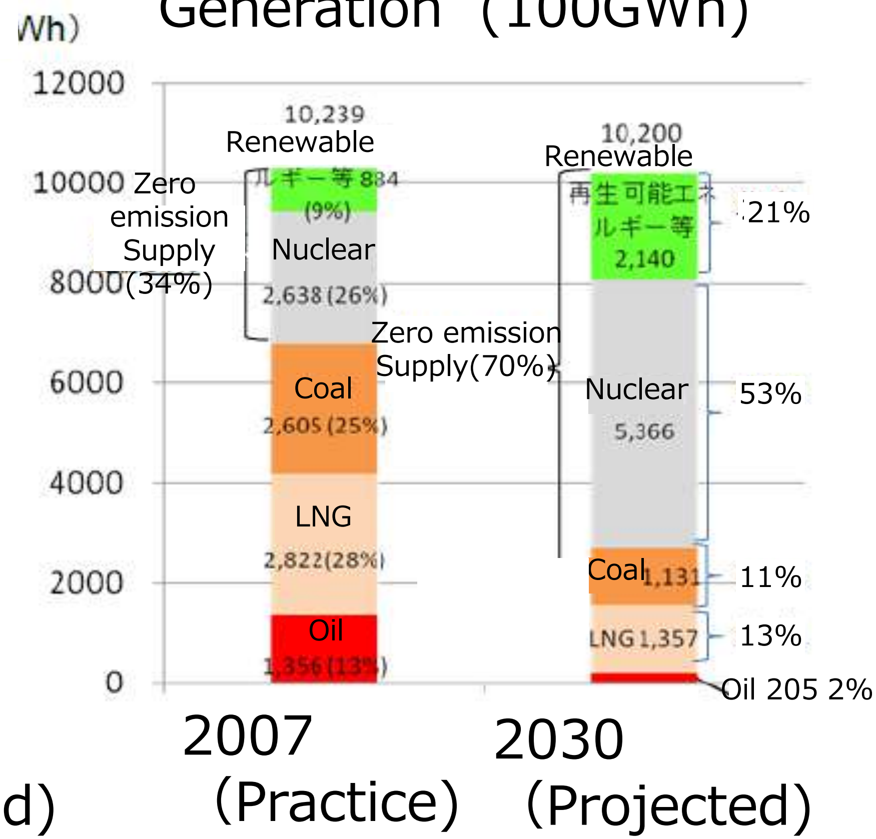
Japan's Energy Supply Prospect (METI 2010)

After the quake, in order to revise the Basic Energy Plan, there are broad discussions on the future energy mix of Japan including nuclear scenarios in several government committees and among various non-governmental entities.

Primary Energy Supply (G litter)

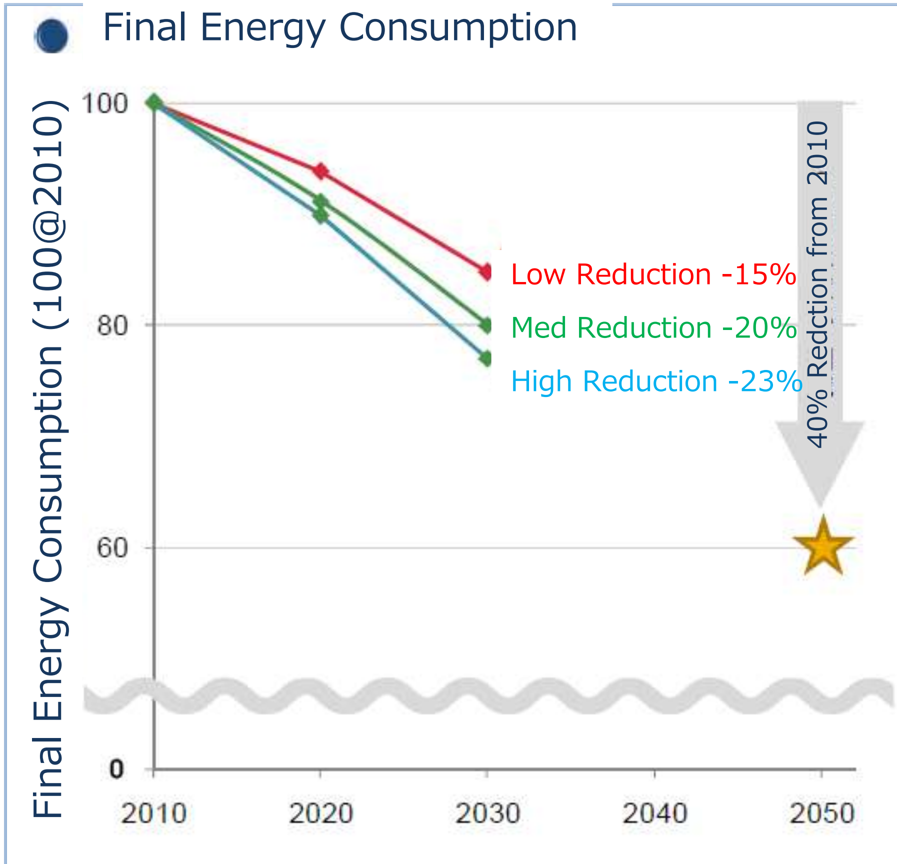


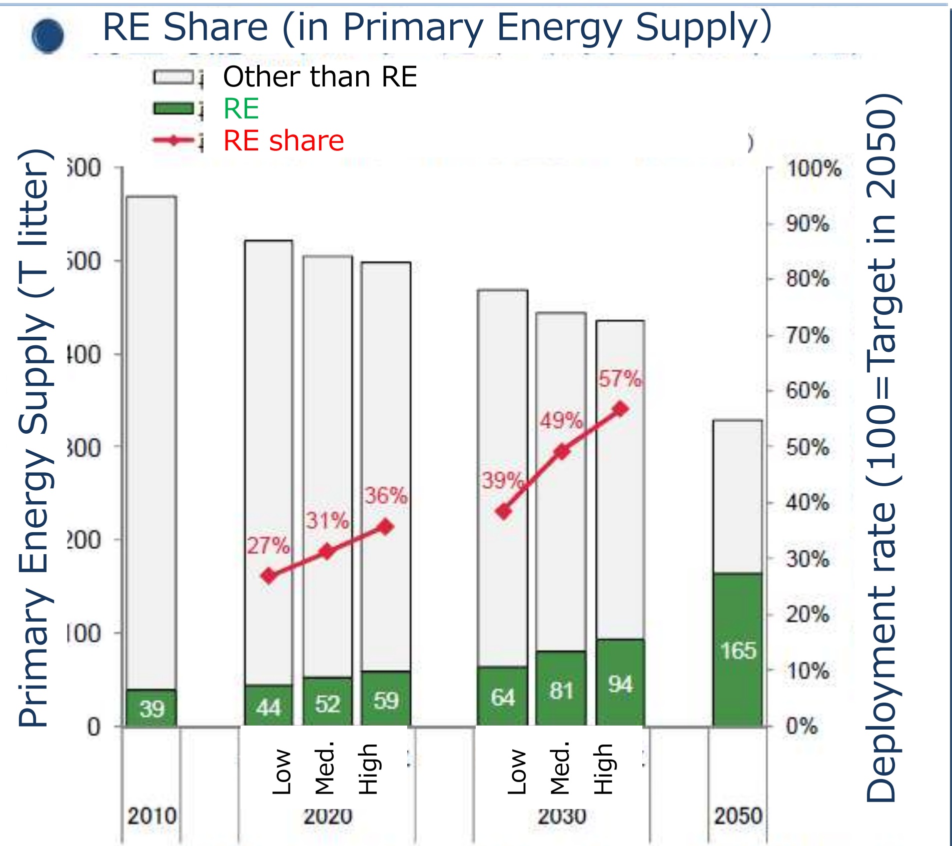
Generation (100GWh)



Japan's Energy Outlook in 2050 (MOE 2012)

- It is considered that 40% reduction of the final energy use and the 50% share of RE in the final use are necessary for the 80% CO_2 emission reduction in 2050.





Assumption for the analysis

- ◆Analysis Period: 2011-2030
- ◆Base Line toward 2030

  Japan Government's "Long term energy outlook (2009)" and "Basic Energy Plan (2010)"
- ◆Assumptions of Generation facilities and operation

  Power Supply Plans of Power utilities

  Demand: variation according to ambient temperature, EV, HPWH and Batteries

  Coal and NG Power Plants:40 year life, expansion with reserve margin criteria

  Oil fired power plants: No addition, no retirement excluding announced ones

  PV and, wind: Hourly variation of generation, reduced implementation cost for PV

  Hydro: Monthly variation of generation

  Interconnection: No expansion, fixed operation

  Fuel cost: assumed to be stable at the level in January, 2011
- ◆Analysis tool: ESPRIT

  For details, refer to *"Ogimoto et.al: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152, (2011)"*

Assumed Nuclear Scenarios

No.	Scenario	Shape in 2030
1	2010 Plan	The outlook before 3.11 disaster, which is based on the long-term energy outlook in 2008 and the basic energy published Plan in 2010.6. The nuclear development of fourteen units are assumed by 2030 with 90% utilization factor.
2a	Continued Development	Continued Nuclear development with some delay. PV80GW, Wind 28GW
2b	Continued Nuclear Development, 40 year life	Continued Nuclear development with some delay. Existing nuclear units are demolished after 40 year operation. PV80GW, Wind 28GW
3a	No Nuclear Development, 40 year life	No new nuclear development Existing nuclear units are to be demolished after 40 year operation. PV of 80GW, Wind of 28GW
4a	Abolition in 5 years	No new construction. Existing nuclear units are to be demolished in 5 years PV80GW, 風力 28GW
4b	Abolition in 5 years and aggressive thermal development	No new construction. Existing nuclear units are to be demolished in 5 years 37.5 GW coal and NG fired power plants are additionally developed to compensate the reduction of nuclear. PV of 80GW, Wind of 28GW
4c	Abolition in 5 years and aggressive PV and Wind development	No new construction. Existing nuclear units are to be demolished in 5 years. PV of 160GW and wind of 160GW to compensate the reduction of nuclear.

Fukushima Daiichi and Daini units are out of operation excluding Scenario 1.

National Energy Plan before the quake 53GW PV, 10GW Wind in 2030

Loss of ten nuclear units

40 year Life of N plants

No N dev.

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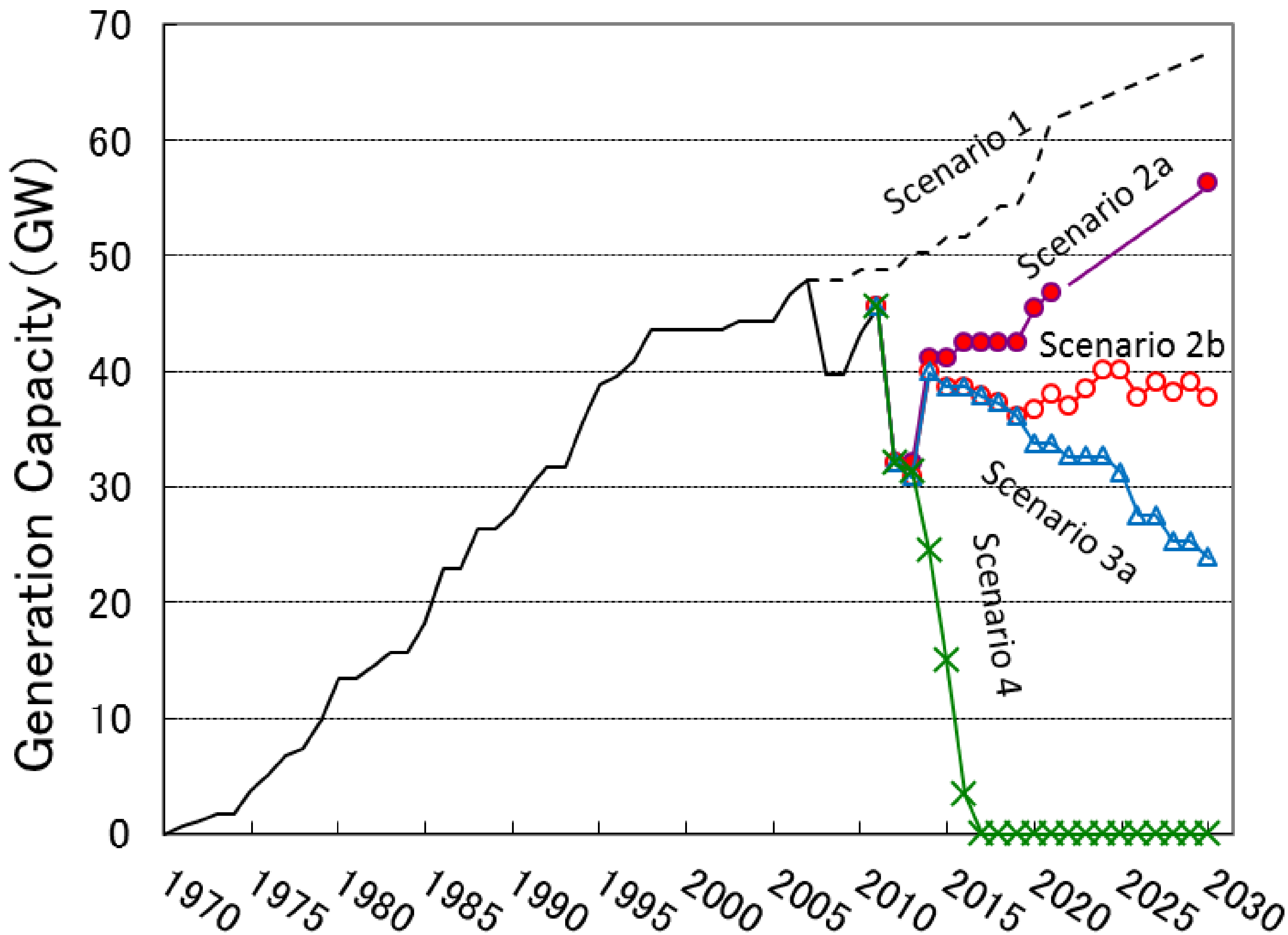
80GW PV, 28GW Wind

160GW PV, 160GW Wind

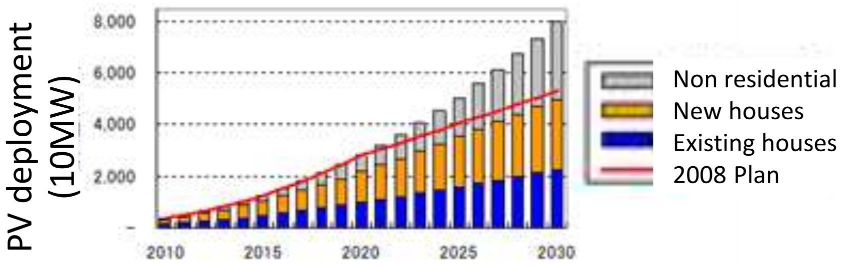
Assumed Nuclear Scenario



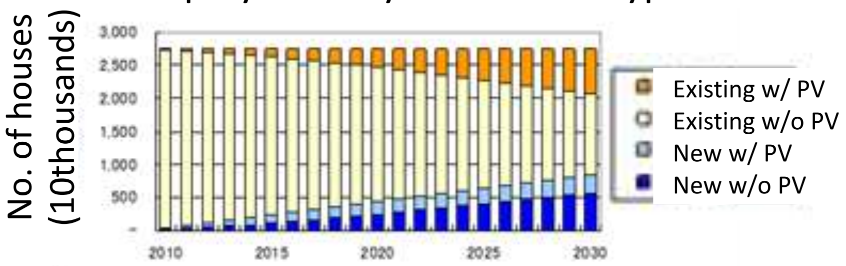
Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

Assumption of Cost of PV and Wind

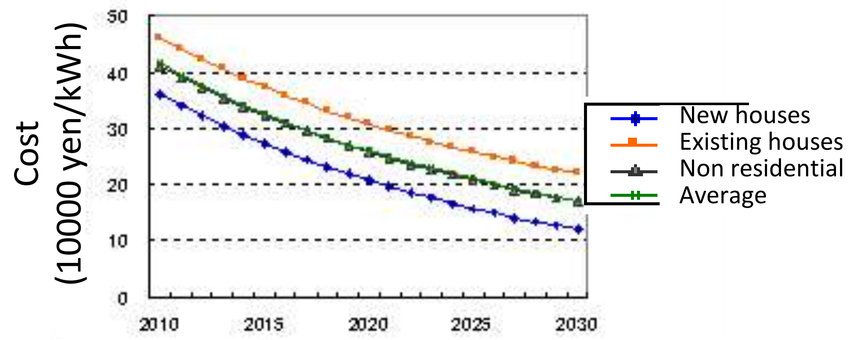
- PV deployment was assumed by existing and new houses, and large-building integration and Mega-solar.
- The cost of PV in 2030 is assumed to be :100 k¥/kW for new houses assuming building integration, 200 k¥/kW for existing houses including installation cost of 100 k¥/kW, for commercial buildings and mega-solar
- The cost of wind generation is assumed to be constant at 150 k¥/kW for wind assuming balance of cost reduction of equipment and cost increase due to site condition.
- The distribution of PV and Wind deployment among power system is assumed based on power demand for PV and resource availability for wind.



PV deployment by installation type



PV installation share in residential sector

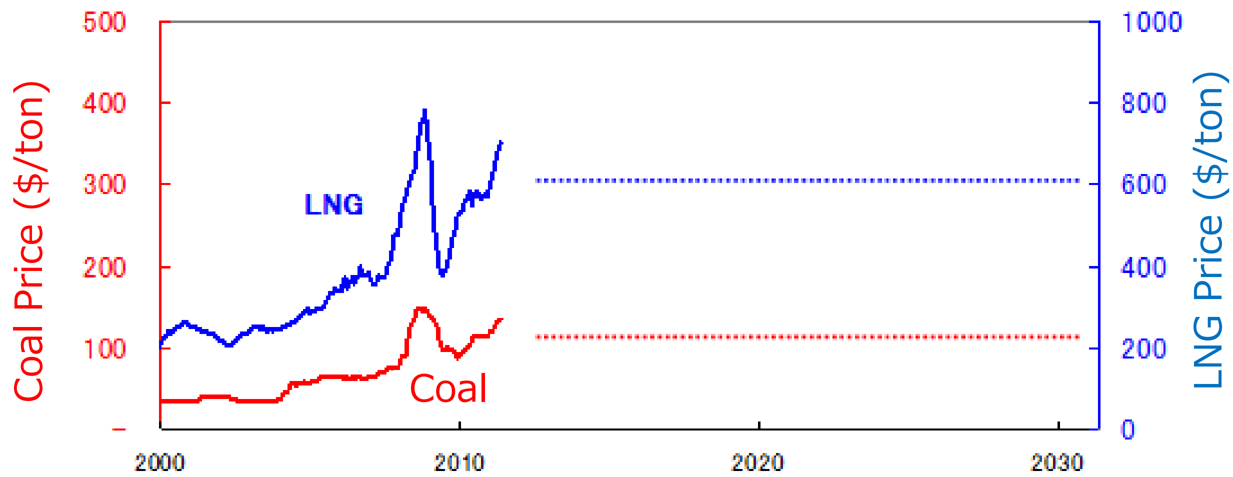


PV cost by installation type

Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

Assumption for thermal and nuclear

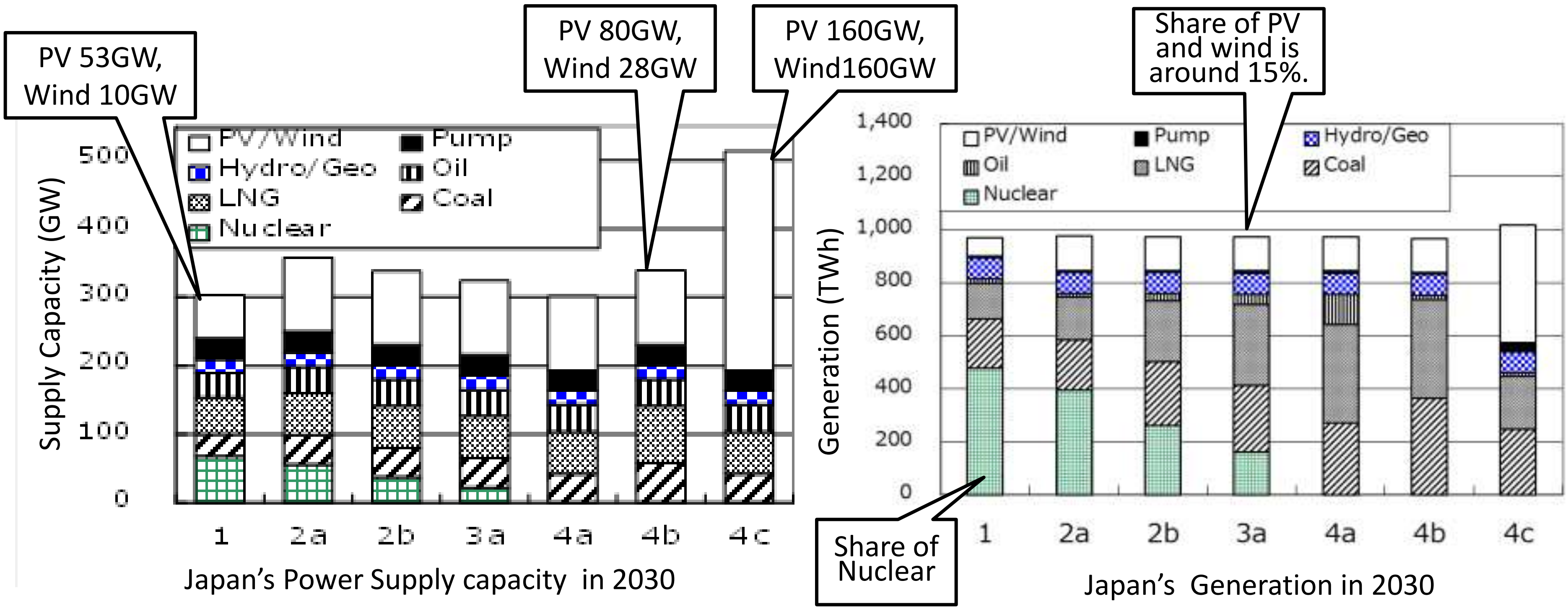
- The development cost of thermal power plants: 250000yen/kW for coal fired, 150000 yen/kW for NG fired
- The fuel cost of NG and coal: constant at the levels of January 2011. The price increase in the future is not included.
  (In the Japan government's Cost Verification Committee has adopted the fuel prices from the scenarios of World Energy Outlook 2011.)
- The fuel cost of nuclear : 1 yen/kWh



Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

Power Supply Capacity and Generation

- The figure of Supply Capacity indicates the assumed supply capacity scenario.
- When the nuclear generation decreases, thermal generation takes the major substitute, due to the limited contribution of PV, wind of around 15% share in scenario 2a through 4a.



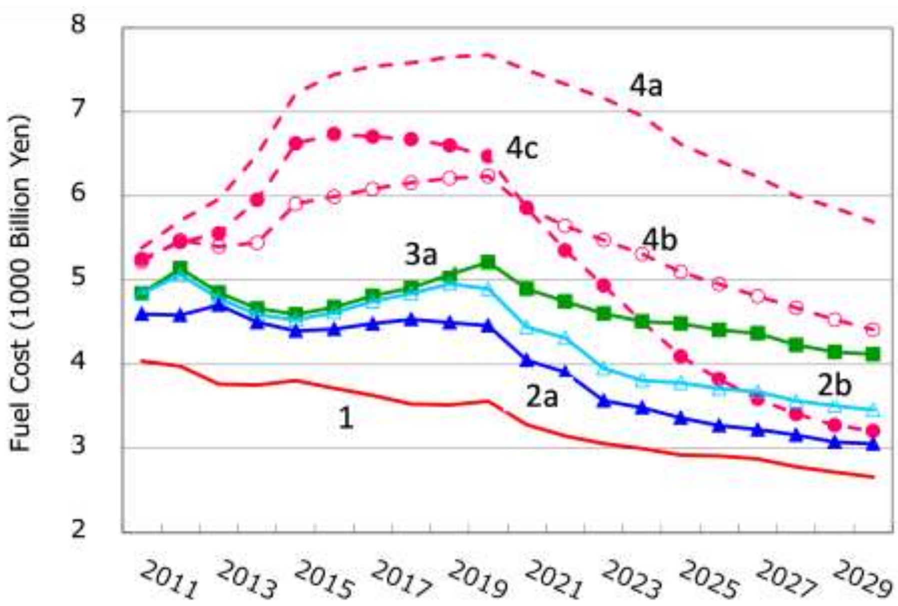
Japan's Power Supply capacity in 2030

Japan's Generation in 2030

Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

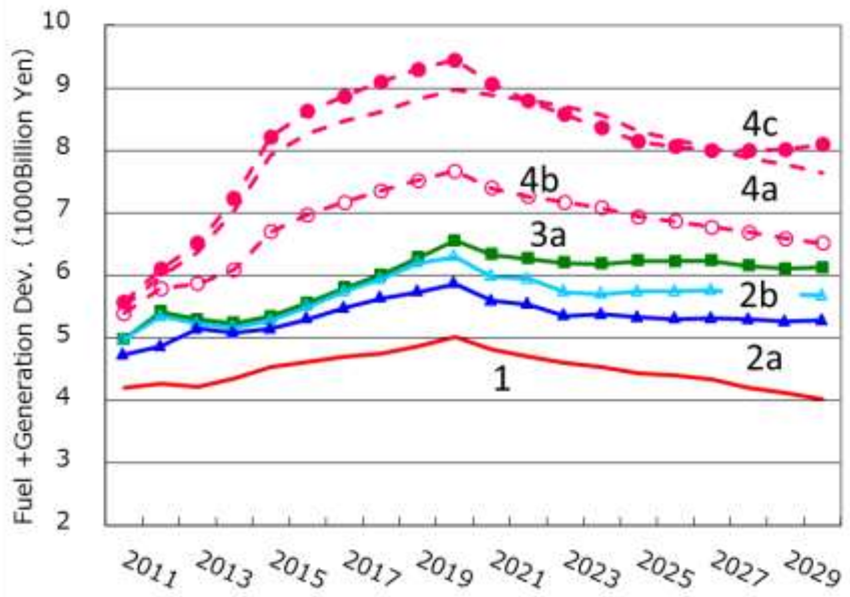
Generation cost: Fuel, Fuel+Capital

- Even with the assumed penetration of PV and Wind, reduced nuclear generation will cause a substantial increase of fuel cost for increased coal, natural gas, and oil.
- The total cost of fuel and annualized capital shows the pessimistic economy for aggressive RE penetration in 2030.



Annual fuel cost

(Fixed fuel prices as of spring, 2011)



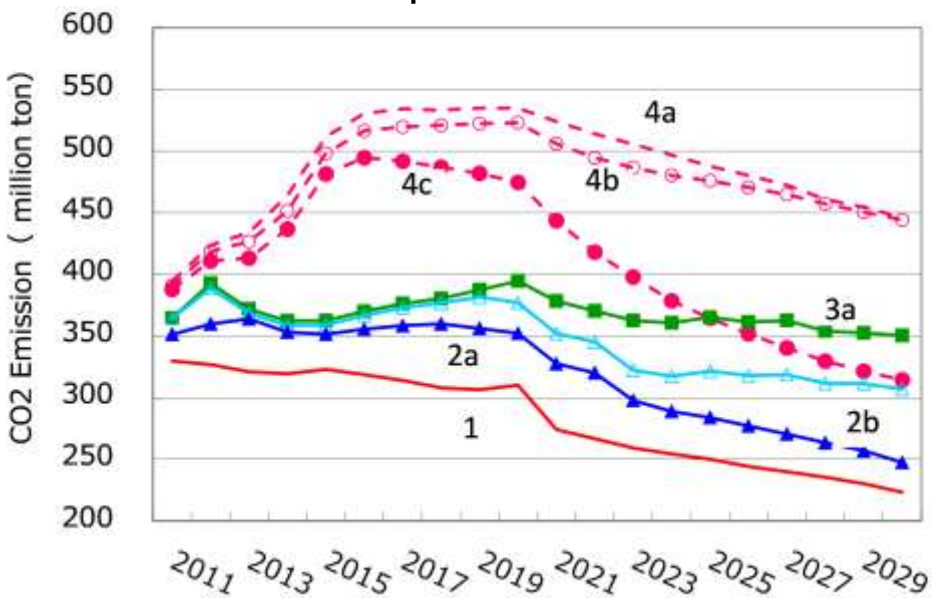
Annual fuel and capital cost

(IRR of 5%, Life of 10, 20,40 years for PV, wind and others)

Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

Outlook of Power System: CO2 Emission

- The CO2 emissions, indicating almost the same trend as that of fuel cost, increase between 50Mt-CO2/year and 250Mt-CO2/year in Scenarios 2a, 2b, 3a, and 4a for the year 2020.
- In 2030, as compared to Scenario 4a, Scenario 4b with reinforcement of thermal power plants shows no major improvement in emissions. CO2 emissions decrease drastically in Scenario 4c with huge RE deployment under the expense of the RE capital cost.



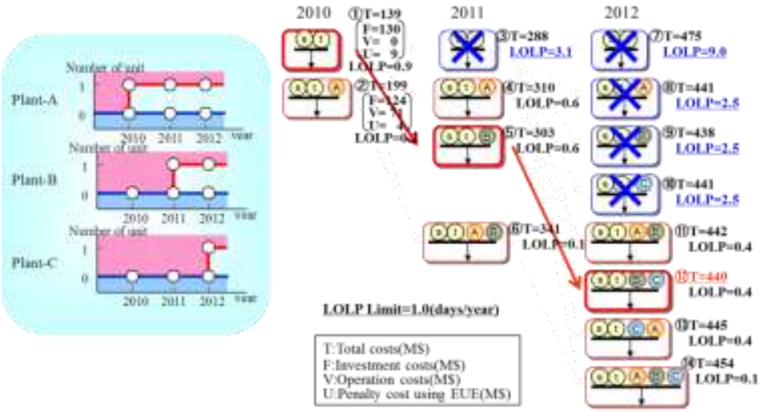
Annual CO2 Emission from Power Sector

Kazuhiko Ogimoto, Yuichi Ikeda, Kazuto Kataoka, Takashi Ikegami: A preliminary study of the long-term best-mix of power demand-supply in Japan, IEEJ Joint Technical Meeting on Power Engineering and Power Systems Engineering, PE-11-135 PSE-11-152 (2011)

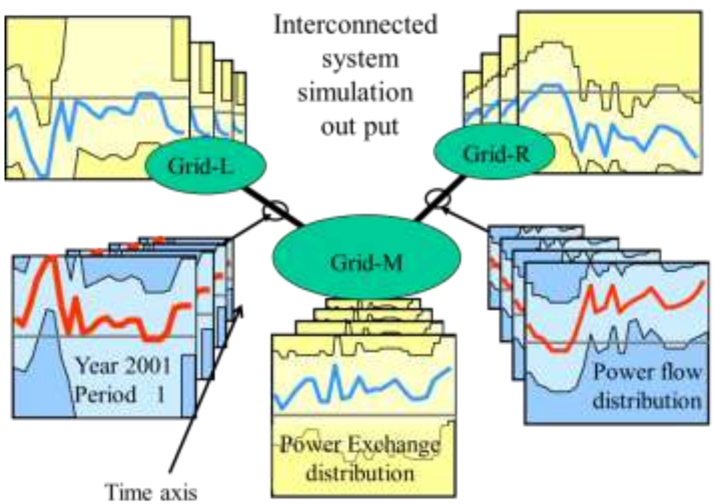
Long-Term Planning

- Demand and Generation option identification and analysis
- Transmission and distribution option identification and analysis including power system interconnection
- Demand activation option identification and analysis
- Best mix of demand and supply toward 2020, 2030 and further.
- Establishment of executable plan

Optimization of demand and supply structure



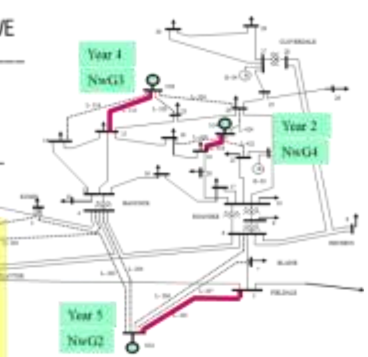
Optimization of interconnection



Optimization of transmission and distribution

NAME :	NwG1	NwG2	NwG3	NwG4			
CAP : YEAR	400	400	400	400	TOTAL DEV'T	LOLP (DAYS/ YEAR)	RESERVE (%)
2005	0	0	0	0	0	8.113	22.3
2006	0	0	0	1	400	2.998	28.6
2007	0	0	0	1	0	6.394	20.2
2008	0	0	1	1	400	2.918	24.8
2009	0	1	1	1	400	1.633	28.3
TOTAL	0	1	1	1	1200		

- 電源投入地点
  - N34(2年目):需要地に近い
  - N33(4年目):同上
  - N32(5年目):N31より需要地に近い
- 送電設備
  - L-419(2年目):重負荷地点に接続
  - L-315(4年目):重負荷地点に接続
  - L-205(5年目):重負荷地点に接続



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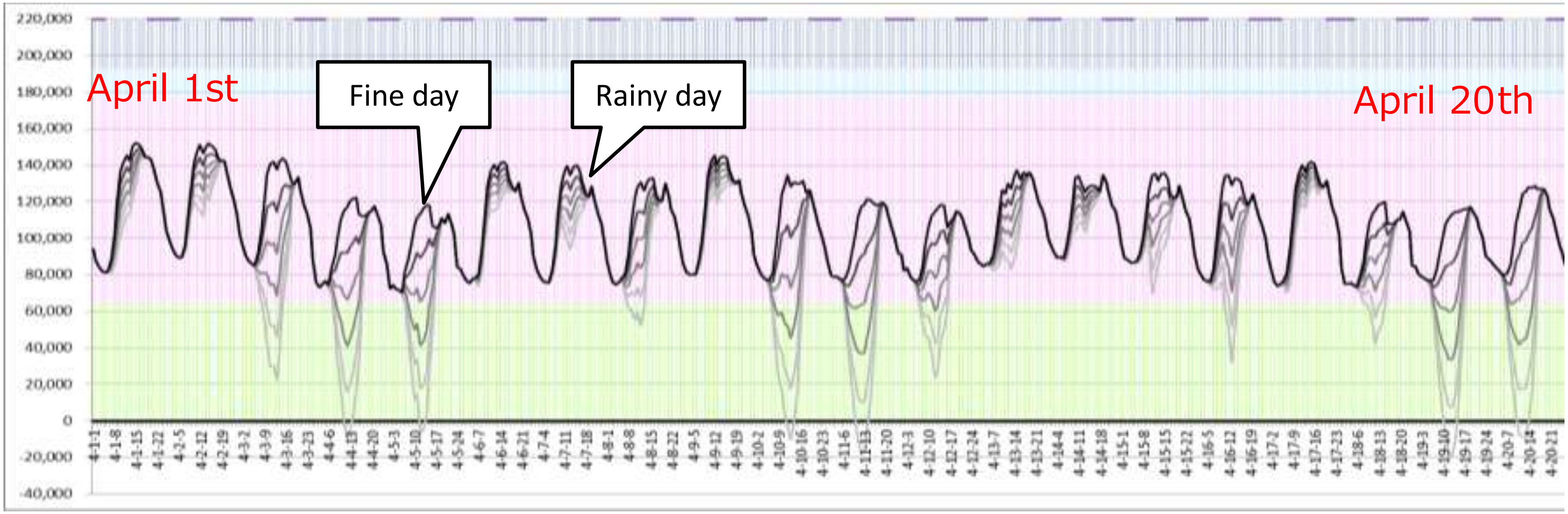
The Implication by an Extreme Case

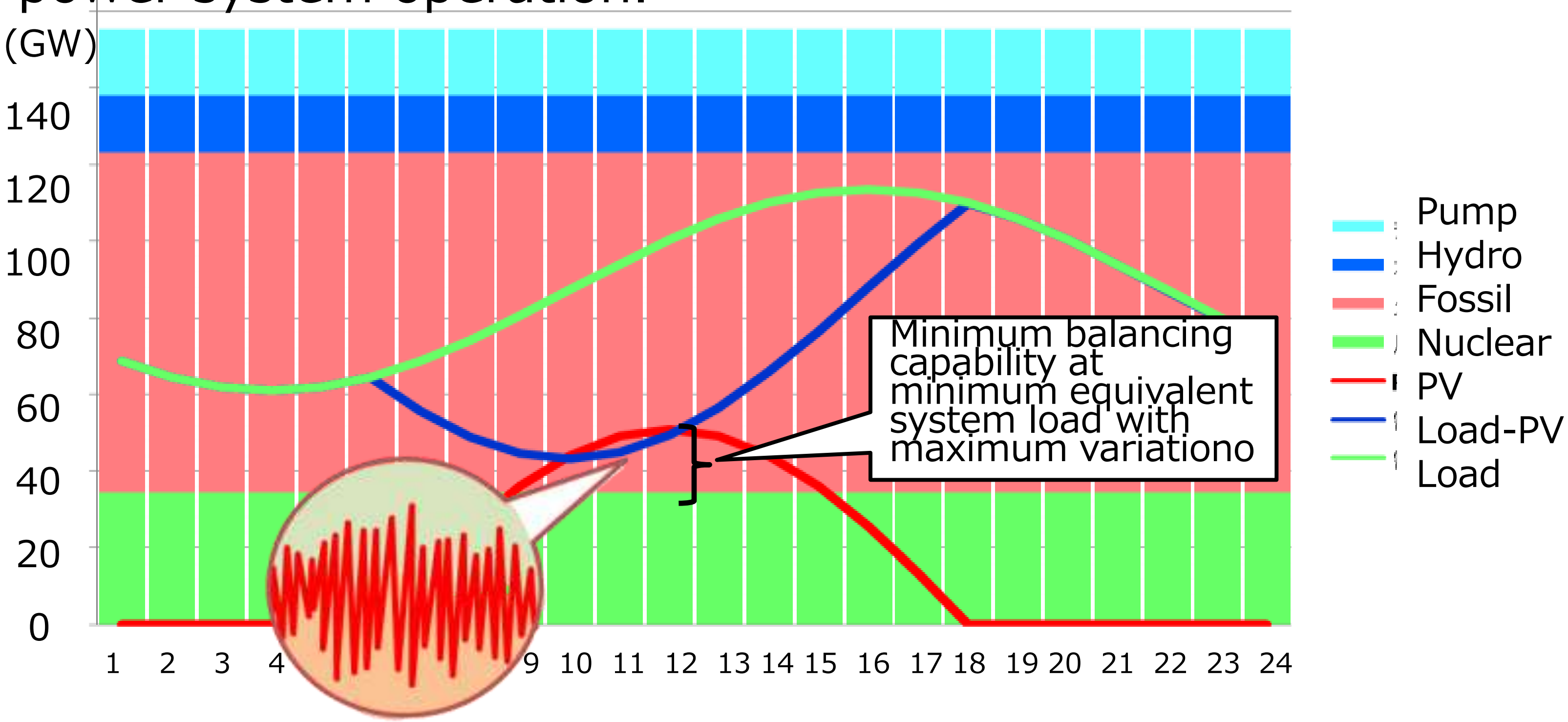
- Image of equivalent system demand under PV penetration of 4,8,12,16,20% of the assumed total generation of 2030



- The variation of RE generation brings about the issue of demand-supply balance.
- The countermeasures for the issues are more sophisticated operation existing and new technologies in operation and new asset portfolio.

Two Factors of Reduced Balancing Capability

- ✓ The ultimate impact of PV Penetration on a power system is the difficulty of supply and demand balance.
- ✓ Increased variation under reduced regulation capability and Increased variability are the two risk factors of the stable power system operation.



Hourly system load, PV generation, and an equivalent load

Issues of Balancing Capability: Common issues in Low Carbon Energy Supply

- ✓ Reduction of fossil fuel utilization for sustainable energy supply the share of power in the energy demand and supply and the share of non-dispatchable power supply in a power system will increase.
- ✓ The requirement for additional supply-demand balancing resources in a power system is universal in all the countries in the world.

Nuclear

IGCC, IGFC

Gas combined generation

PV, Wind

Source of figures：CoolEarth Innovative Energy technology Program

Counter measures for Balancing issues

- Supply side :
  - Reinforced balancing capability by flexible thermal plants
  - Reinforced balancing capability by flexible hydro operation plants
- Demand side (⇒Demand Activation) :
  - Tariff System
  - Building demand activation
    Day-ahead scheduling, real time control
  - G2V and V2G of PHEV/EV
    Day-ahead scheduling, real time control
- Energy Storage
  - Pumped Storage, Variable speed pumped storage
  - Battery
  - Other energy storage technology
- Operation
  - RE Generation forecast
  - RE Generation curtailment
  - Centralized (transmission) system

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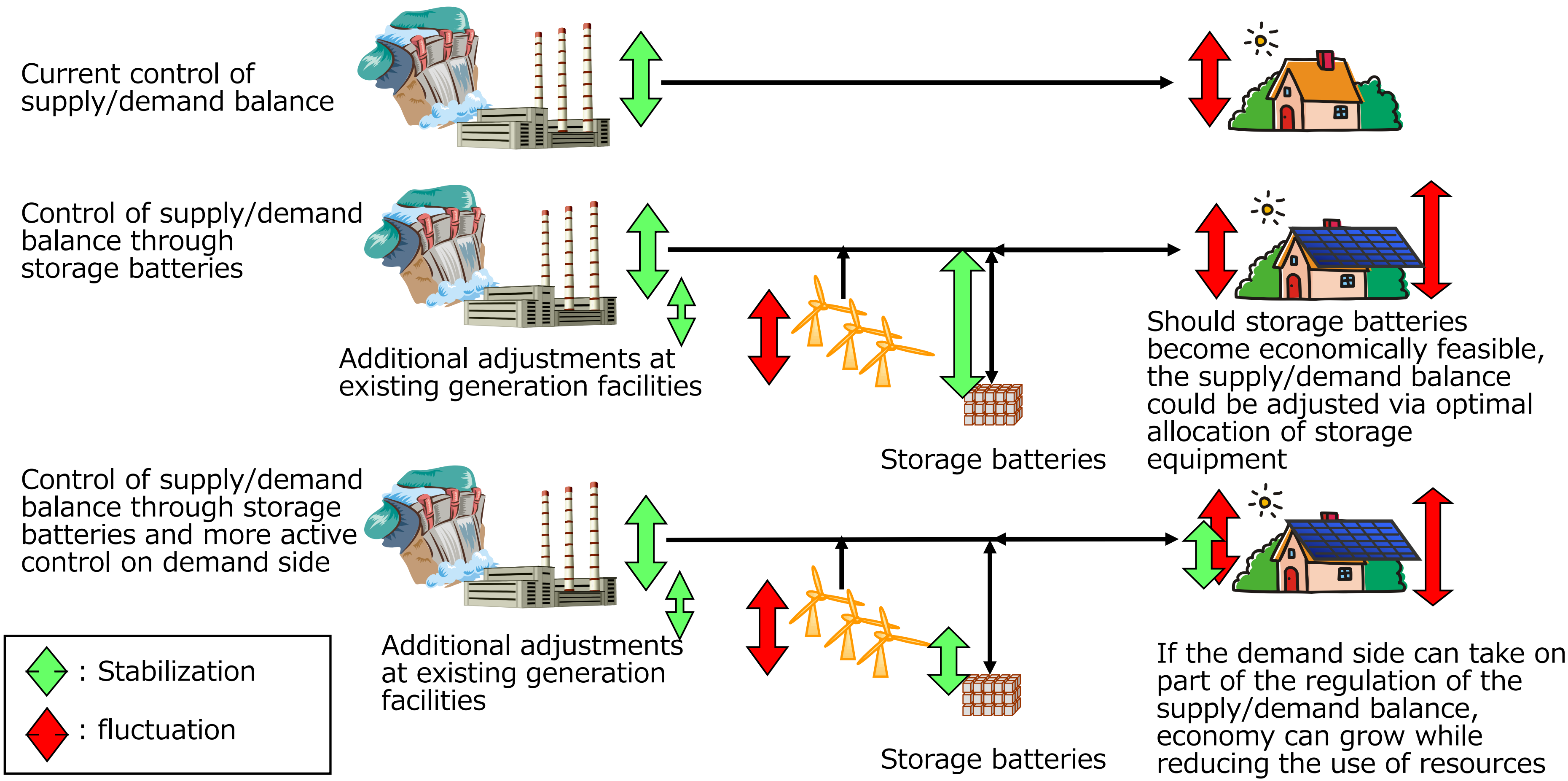
Demand Activation by Distributed EMS

The power supply/demand balance is currently regulated by centralized EMS using major generators. When RE penetrates into the system, distributed EMS will take a part of the balancing capability at the demand side through demand activation, or auto-demand-response.



Distributed EMS
Home, Building, and Area Energy Management

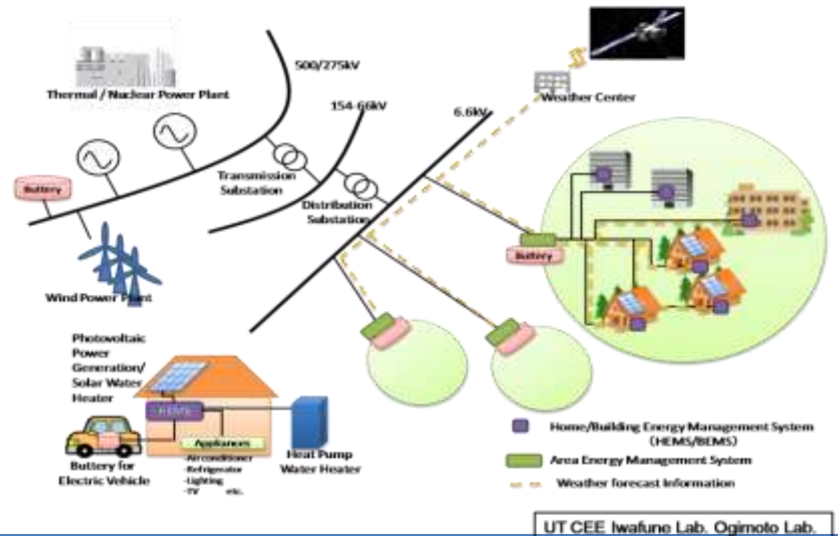
- ✓ HEMS and BEMS, distributed energy management systems, are the appropriate hub for the demand activation because they can totally pursue three targets:
  1) enhancement of quality of life and work environment in buildings,
  2) reduction of cost and environmental footprints, and
  3) balancing capability for a power system in harmonization with centralized EMS.

HEMS: Home Energy Management System

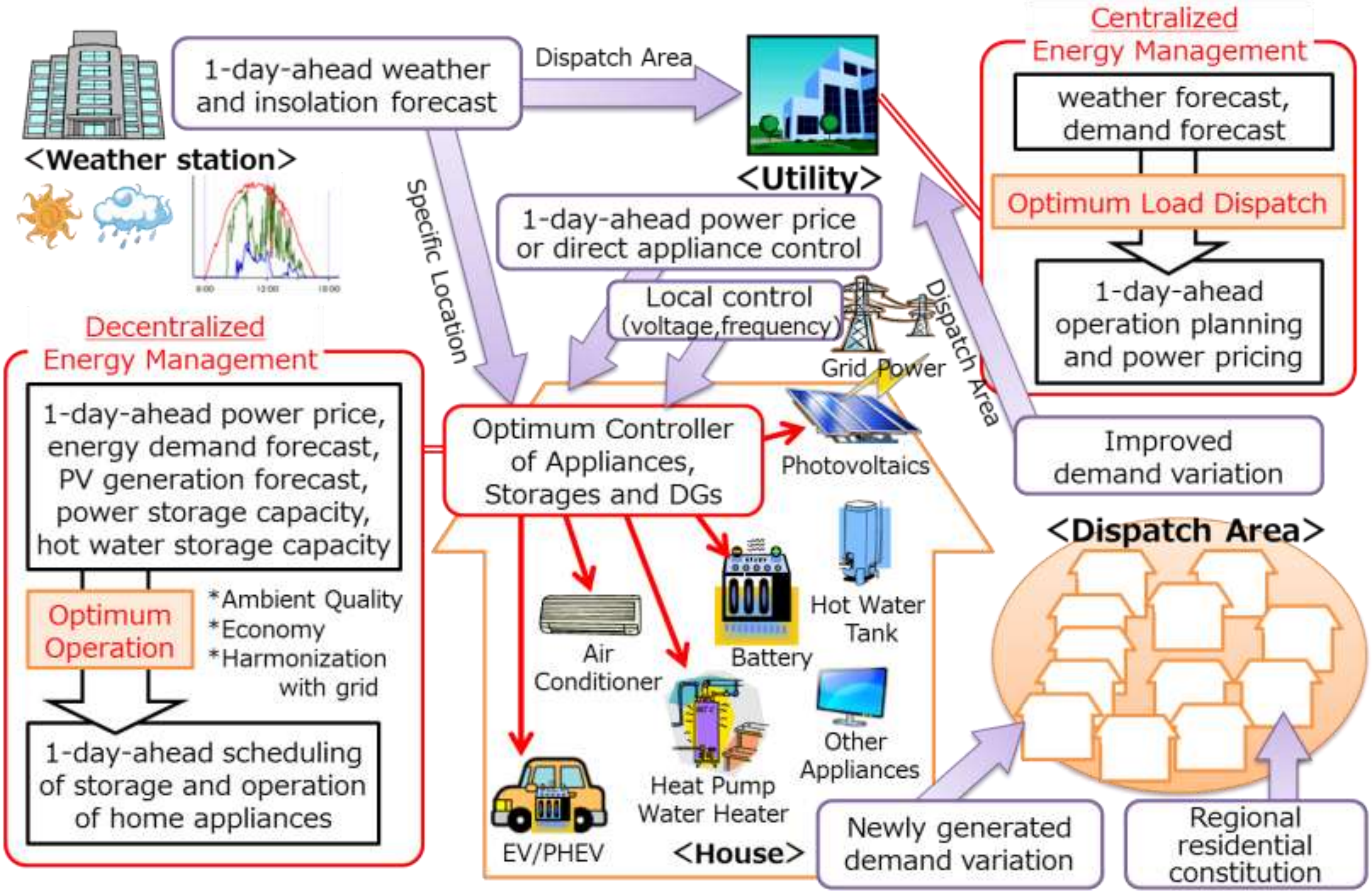
BEMS: Building Energy Management System

- ✓ The distributed EMS such as HEMS and BEMS autonomously control demand, energy storage and others.
- ✓ Area EMS will be effective to enhance the control capability of demand side with more resources in the area.

Autonomic Cooperative Energy Management System
Including Renewable Energy Resources and Sophisticated Butteries



Harmonization of centralized and distributed energy management



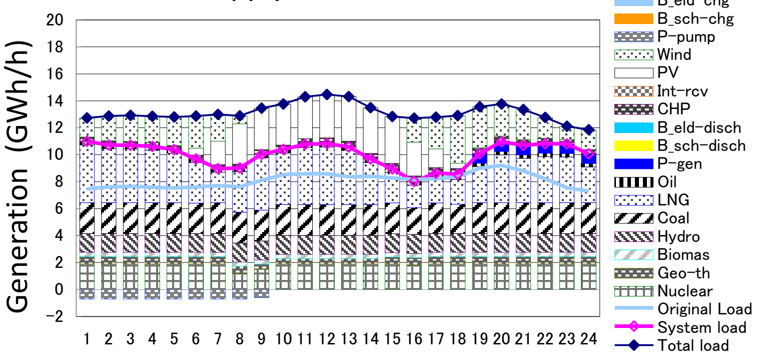
Kazuhiko Ogimoto*, Yumiko Iwafune, Kataoka Kazuto,Takashi Ikegami, Yoshie Yagita: Cooperation Model of Centralized and Decentralized Energy Management for the Supply-Demand Adjustment in a Power System, IEEJ Power and Energy Society Conference, 8-16, (2011)

Balancing capability: Unit commitment

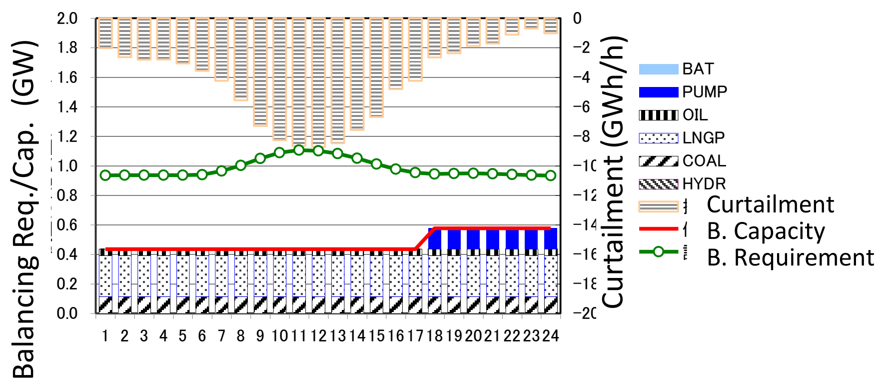
- Generation is scheduled to meet the system demand including variable generation of PV and wind, and activated demand by one-day ahead scheduling.
- Additional balancing capability from demand activation can be useful as well as all the other countermeasures such as generators, energy and storage so as to minimize generation curtailment of PV and wind.

W/O BATTERY

Demand Supply Balance of 24 hours

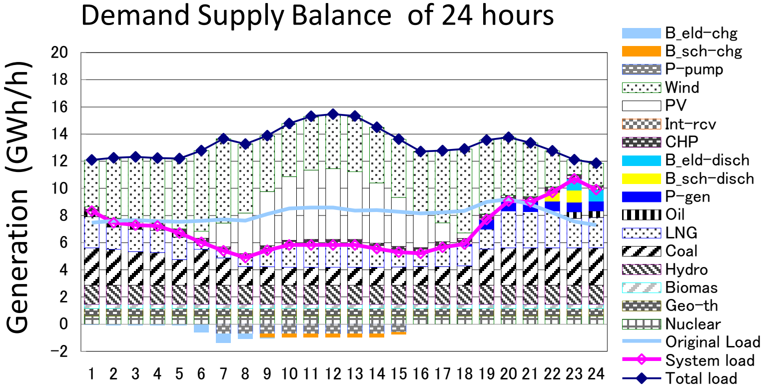


Balancing requirement /capability and curtailment

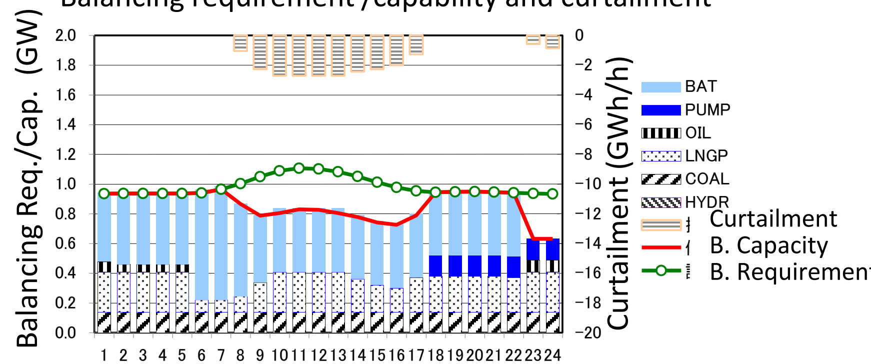


With BATTERY

Demand Supply Balance of 24 hours



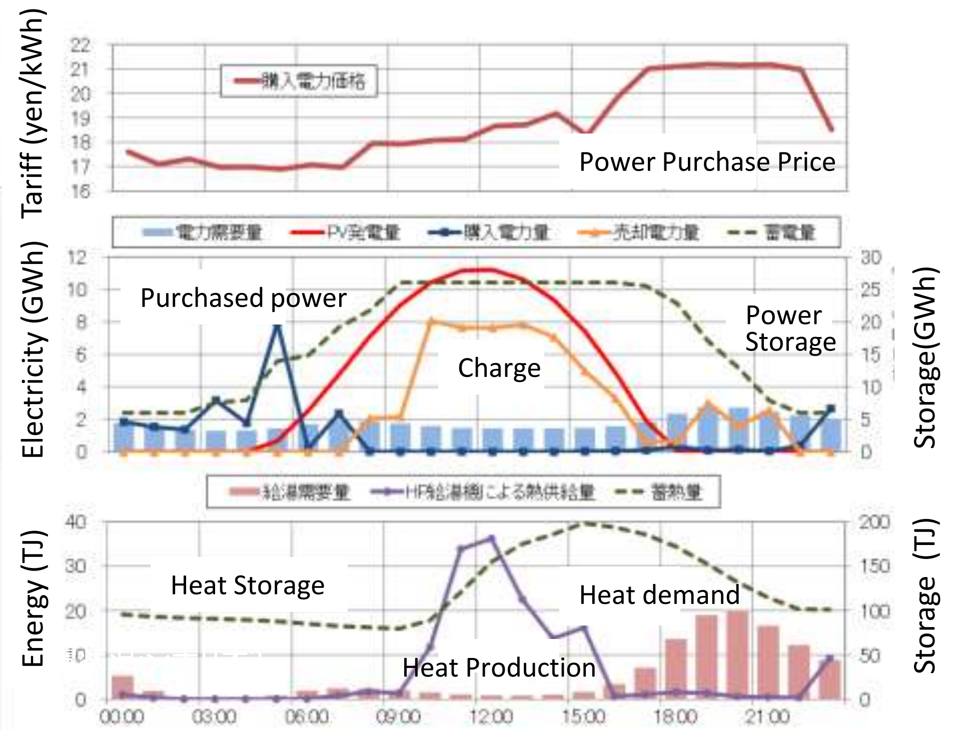
Balancing requirement /capability and curtailment

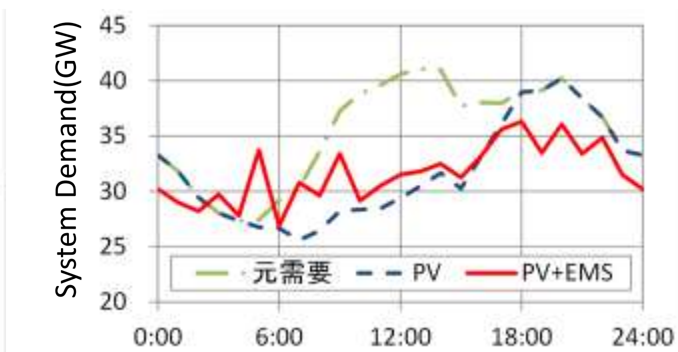


Scenario 2b Tohoku-System, Max generation of PV+Wind, w/ and w/o BATTERY

Activation of Heat Pump Water Heater

- Under the dynamic pricing reflecting the variation generation and generation forecast of RES, the operation of heat pump water heaters can be optimized to minimize power cost.
- Sophisticated control of HPWH can contribute to level the residual power system load to minimize the total system cost without disturbing the hot water use of houses.





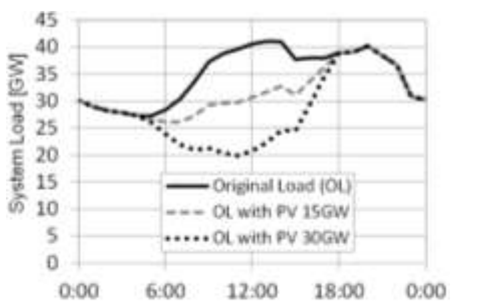
Original, residual, and new loads

PV : 17GW PV systems of 3 to 4 kW, 3.4 kW on average, are deployed in a power system.
Battery: 7.5GW-30GWh Battery systems of 1 to 2 kW, 2 to 12 kWh, 1.5kW and 6kWh on average, with the round trip loss of 2 15 to 20%, 16% on average
HPWH: 20 GW HPWH of rated Heat output of 3, 4, and 12 kW, 4 kW on average, with a hot water tank of 200 L for 3kW system and 370 L for others.

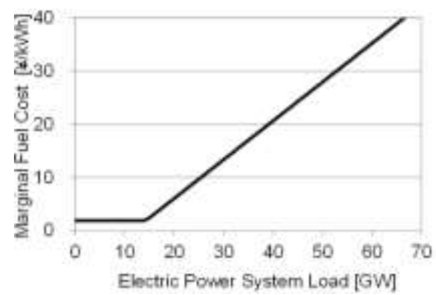
Takashi Ikegami,Kazuhiko Ogimoto,Hitoshi Yano,Koji Kudo,Hiroto Iguchi: Balancing Power Supply-Demand by Scheduled Smart Charging of Numerous Electric Vehicles, IEEJ Annual Conference, , (2012.3)

Activation of EV Charging

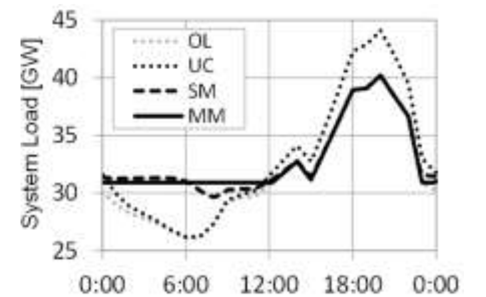
- Under the dynamic pricing reflecting the variation generation and generation forecast of RES, the charging of EVs can be optimized to minimize charging cost.
- Sophisticated control of EV charging can contribute to level the residual power system load to minimize the total system cost without disturbing the EV use for driving.



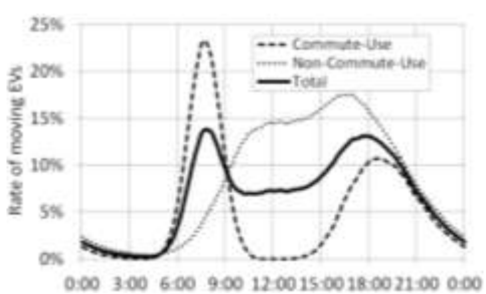
Residual load with PV15GW, 30GW



Marginal Cost of Power System

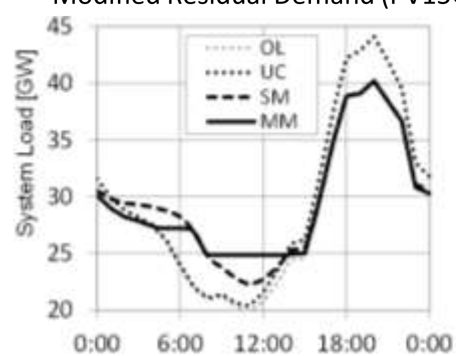


Modified Residual Demand (PV15GW)



Ratio of EV on duty

Simulate 10 million EVs with a battery of 24 kWh, 3.0 kW.
EVs are assumed to drive on an average speed of 21km/h with power use of10 km/kWh.

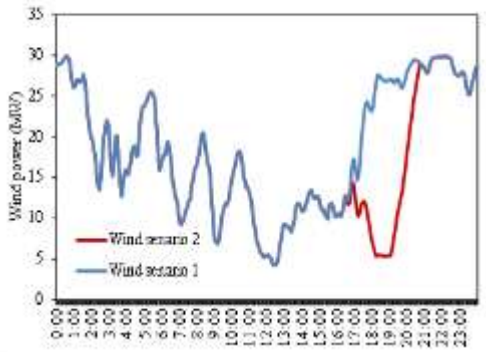


Modified Residual Demand (PV30GW)

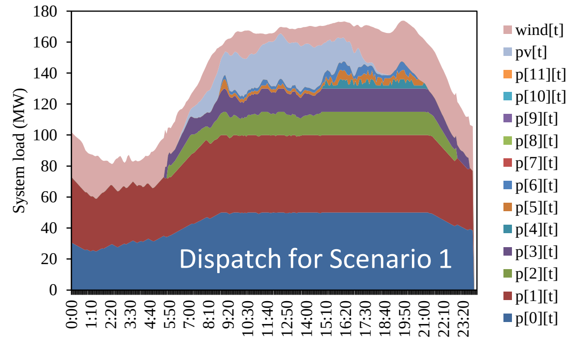
Takashi Ikegami,Kazuhiko Ogimoto,Hitoshi Yano,Koji Kudo,Hiroto Iguchi: Balancing Power Supply-Demand by Scheduled Smart Charging of Numerous Electric Vehicles, IEEJ Annual Conference, , (2012)

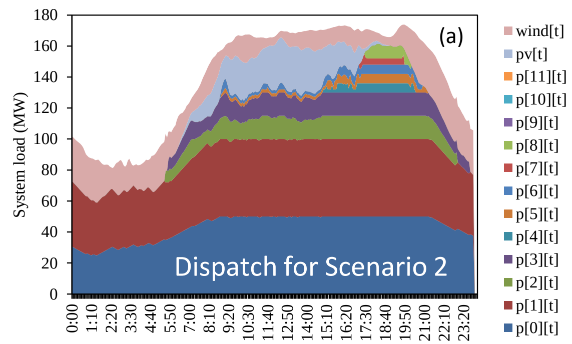
Demand Activation in a wind-rich Power system

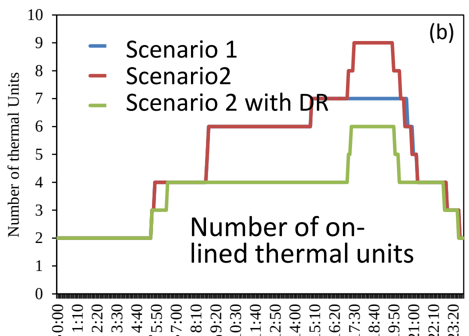
- The variation of RE generation affects unit commitment schedule of system generators.
- With larger RE variation, a power system must have more dispatchable generators on line to keep system balancing capability, which decreases the economy of the system due to lower utilization of more efficient generators and higher utilization of less efficient ones.
- With demand activation, the leveling of load for dispatchable generator recover the reduced economy of the system.



Wind generation scenario 1 and 2 (one day)



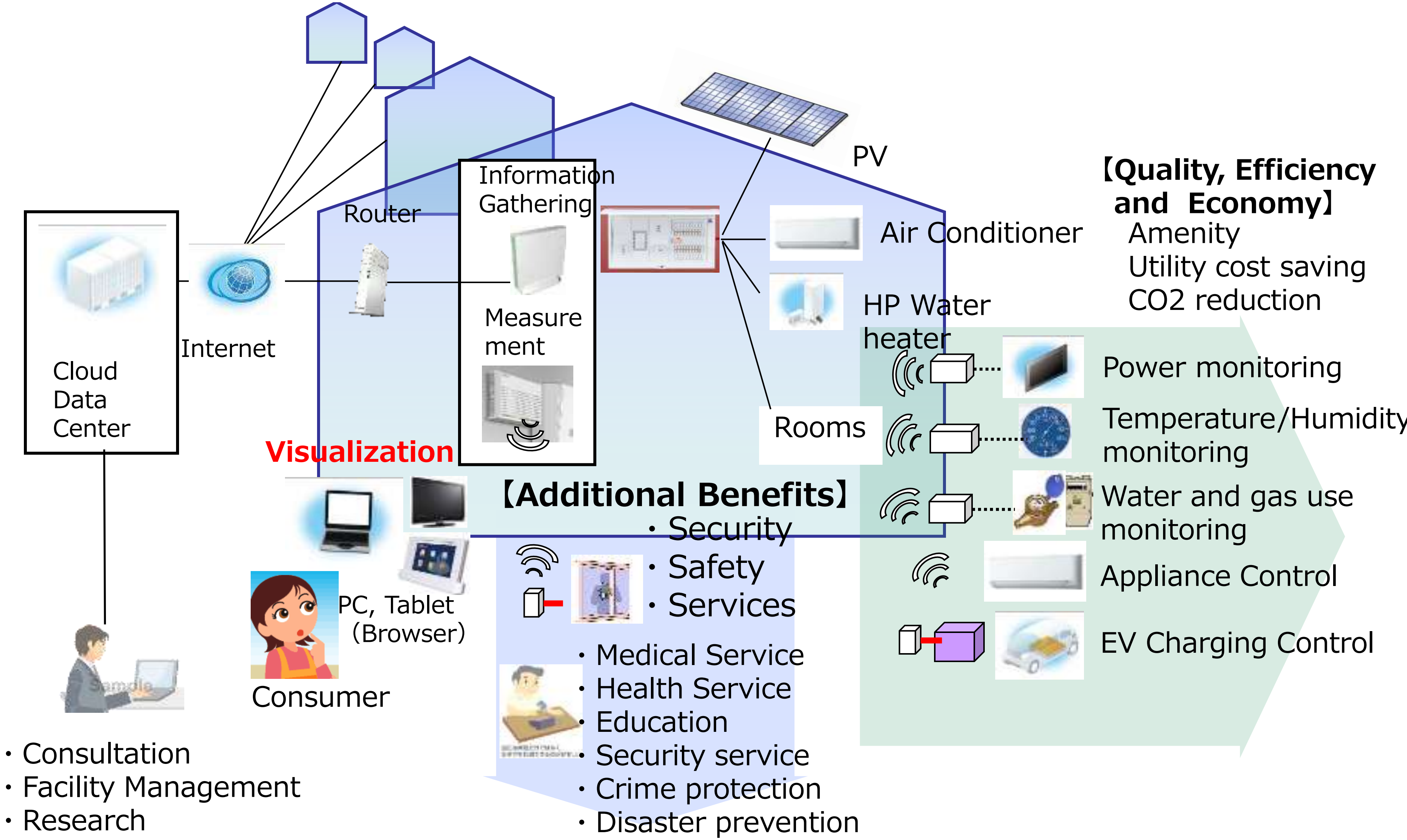




"Yuichi Ikeda,Takashi Ikegami,Kazuto Kataoka,Kazuhiko Ogimoto: An Economic Dispatch Model of Power System with Demand Response for the Integration of Renewable Energies, JSER Annual Conference, , (2012)"

Beyond Energy: the Future of HEMS

- The HEMS/BEMS will realize more values in fields other than energy.



Necessity/applicability of batteries

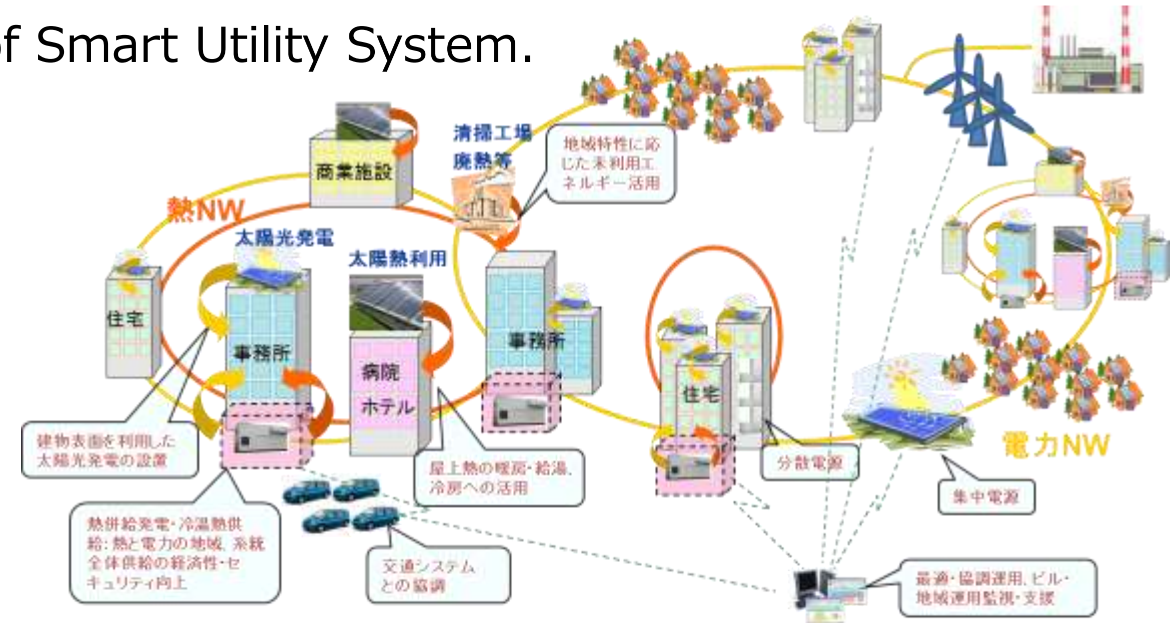
- Commercialization of storage batteries has progressed from those with small capacity to those with greater economic value
  - Mobile phones
  - Notebook PCs
  - Electric vehicles (including PHEV)
- Power storage capacity will be an essential function in the future as a measure to handle variation of renewable generation.
- When will power storage become "necessary" in large quantities to adjust supply/demand? When will it become "possible" to use batteries?
  - Economy of batteries for stationary use
  - Potential use of EV batteries for stationary use
- Charging demand for EVs in Japan is 100TWh・・・・・・10% demand increase in Japan
  What about the EV charging market?
  (Charging volume for mobile phones is not ¥23/kWh)

Possibility of Community Energy System

- Optimization of energy sector and maximization of service level, economy and security through maximum rational utilization of renewable/unused energy and rational energy use.
- In urban area, energy and utility system will be established and operated by building and area management system in optimized and harmonized manner.
- Networks of various energies and utilities and will be managed through monitoring, controlling, and optimizing.

↓

Establishment of Smart Utility System.



Contents

Energy System Integration

- Energy is essential for all the human activities. The constraints of energy directly affect our economy and quality of life.
- For the sustainable society, energy system should sustainable according to multiple criteria such as economy, stability and environment, and stability. And uncertainties such as fuel price, environmental constraints, technology development and socio-economic conditions should be considered.
- For the sustainable energy system, it is important to integrate all the options of technology, institution, and change of life style for maximum optimization.
- For the evolution of energy system, broad and long-term perspective is important including R&D and deployment of technology and human development.
- There being variety of conditions and constraints in the real world, the path of the energy system evolution is diversified and uncertain.

Government's Cost Verification Committee : Generation cost

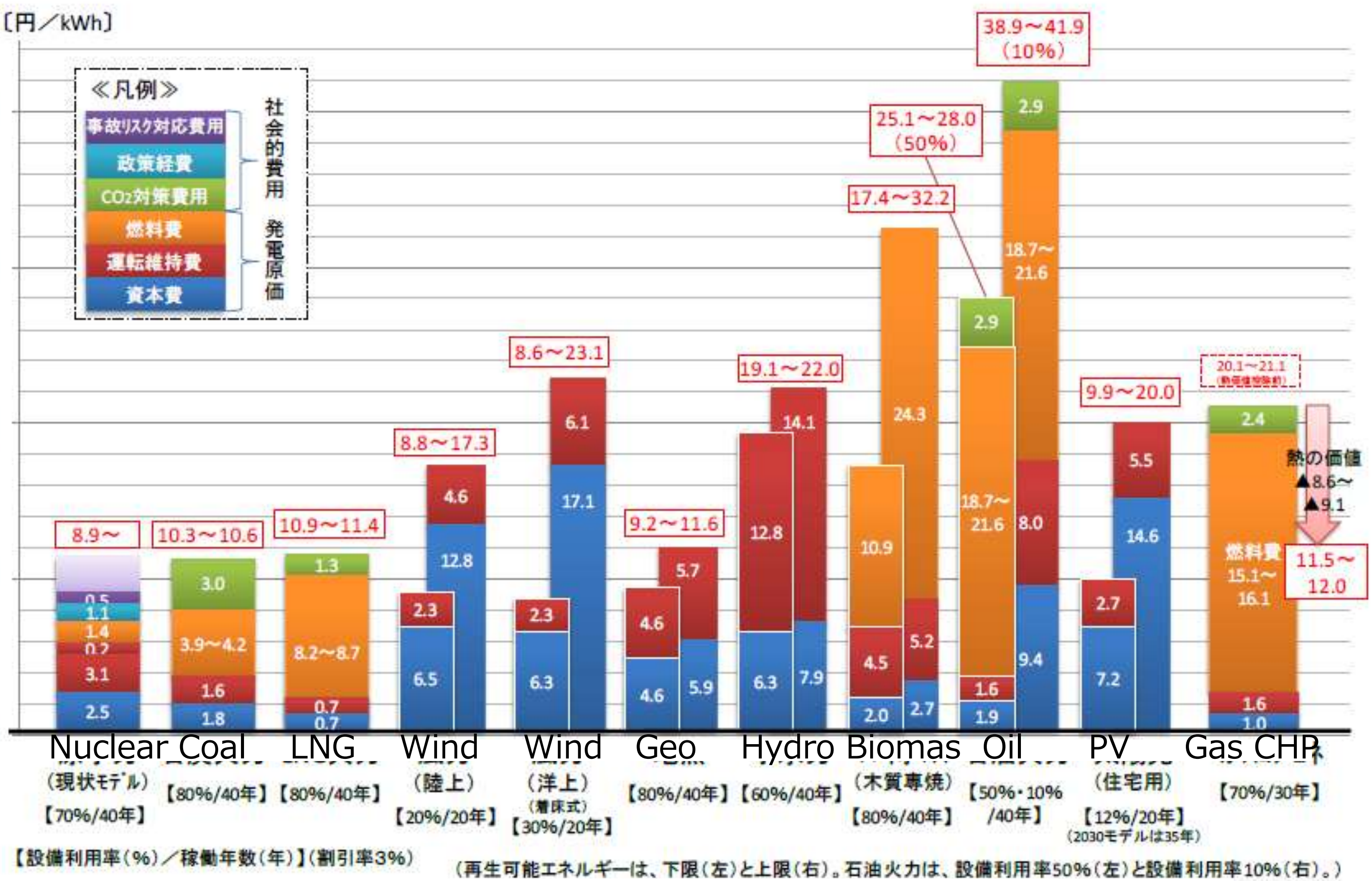


Fig. 37 Generation Cost of Major Generation Type

Report of the Cost Verification Committee (2011)

Government's Cost Verification Committee : Physical Potential and economic resources of RES

		既設	Physical resources		Economic Deployment	
PV	RS	263万kW	戸建住宅・集合住宅の屋根・屋上 6500万kW	戸建住宅・集合住宅の屋根・屋上・側壁 9100万kW	自家消費が中心で、発電事業の観点からの普及の過程にあることから、実績を積み重ねた段階での試算が望ましい。	
PV	Non	260万kW	公共系建物・業務分野・産業分野の屋根・屋上 2030万kW	公共系建物・業務分野・産業分野 最終処分場・交通・運輸分野・耕作放棄地等にできる限り設置（壁面を含む。） 1億5000万kW	FITの導入を前提とした試算例 （48円/kWh×20年。事業収益率8%） 0kW 発電事業としての検討・実績事例が少ないことから、個別の検討等が進んだ段階でのさらなる試算が望ましい。	
Wind	On shore	244万kW	2億8000万kW / 2億9000万kW （自然公園2・3種地域・普通地域・国有林も開発不可とした場合 1億5000万kW）		20円/kWh×15年 事業収益率8% と仮定した場合 1億kW / 1億kW	左記仮定の下での試算に、自治体の導入意欲係数（52%）と社会的受容性係数（75%）を乗じた場合 3900万kW （さらに、自然公園2・3種地域・普通地域・国有林も開発不可とした場合 2300万kW）
Wind	Off shore		15億kW / 16億kW （共同漁業権区域のみ設置可とした場合 4億kW）		20円/kWh×15年 事業収益率8% と仮定した場合 17万kW / 4500万kW 水深50mでは 59万円/kW 水深50mでは 45万円/kW	左記仮定の下での試算に、自治体の導入意欲係数（52%）と社会的受容性係数（75%）を乗じた場合 1300万kW （さらに、共同漁業権区域のみ設置可とした場合 600万kW）
Hydro		960万kW （550億kWh）	1400万kW / 2000万kW 建設単価の高い地点を除外		20円/kWh×20年 事業収益率8% と仮定した場合 0万kW	石油火力の経費以下となる地点 （事業収益率を見込んでいない） 250万kW
Geothermal	熱水資源開発	53万kW	150℃以上 国立・国定公園の特別保護地区・特別地域を除く。 430万kW	53℃以上 左記区域を除きつつ、国立・国定公園等の外縁部から内側1.5kmの地下も対象 1400万kW	NEDO調査を基に資源量密度の高い地域に絞り込んだ試算（2009年当時補助金下での発電原価9.2～21.7円/kWh×15年 事業収益率0%） 95万kW	20円/kWh×15年 事業収益率8% 国立・国定公園等の外縁部から内側1.5kmの地下も対象と仮定した場合 360万kW
Geothermal	温泉	0万kW	72万kW		20円/kWh×15年 事業収益率8%と仮定した場合 68万kW	
Bio		154万kW	林地残材・家畜排せつ物・農産物非食用部・食品廃棄物 73万kW		発電事業としての実績事例が少ないことから、個別の検討等が進んだ段階で、試算が行われることが望ましい。	

※表の数字のうち赤字は環境省調査、青字は経産省調査、緑字は農水省試算より引用。これらの数字は、前提の異なる各省の調査結果の一部を引用したものであり、単純に比較することはできないが、分かりやすさの観点から、各省横断的視点で再整理したもの。

Report of the Cost Verification Committee (2011)

Maximum Optimization and Constraints

- By considering the total structure of energy system, we can expand our optimization scope: from a house, a community, a grid, a nation, to the world, from supply side to supply and demand sides including network, from electric power, all the kind of energies such as power, gas, oil, to all the utilities.
- However, there are various constraints:
  1) Technological: distribution/transmission system, interconnections
  2) Institutional: Tariff, codes, operation condition, balancing
  3) Conditions for reliability and security: Robustness to natural disasters, failures, and malicious attacks
- Demand activation in a house, a community, which is realized by distributed energy management, is the key to the future energy system.

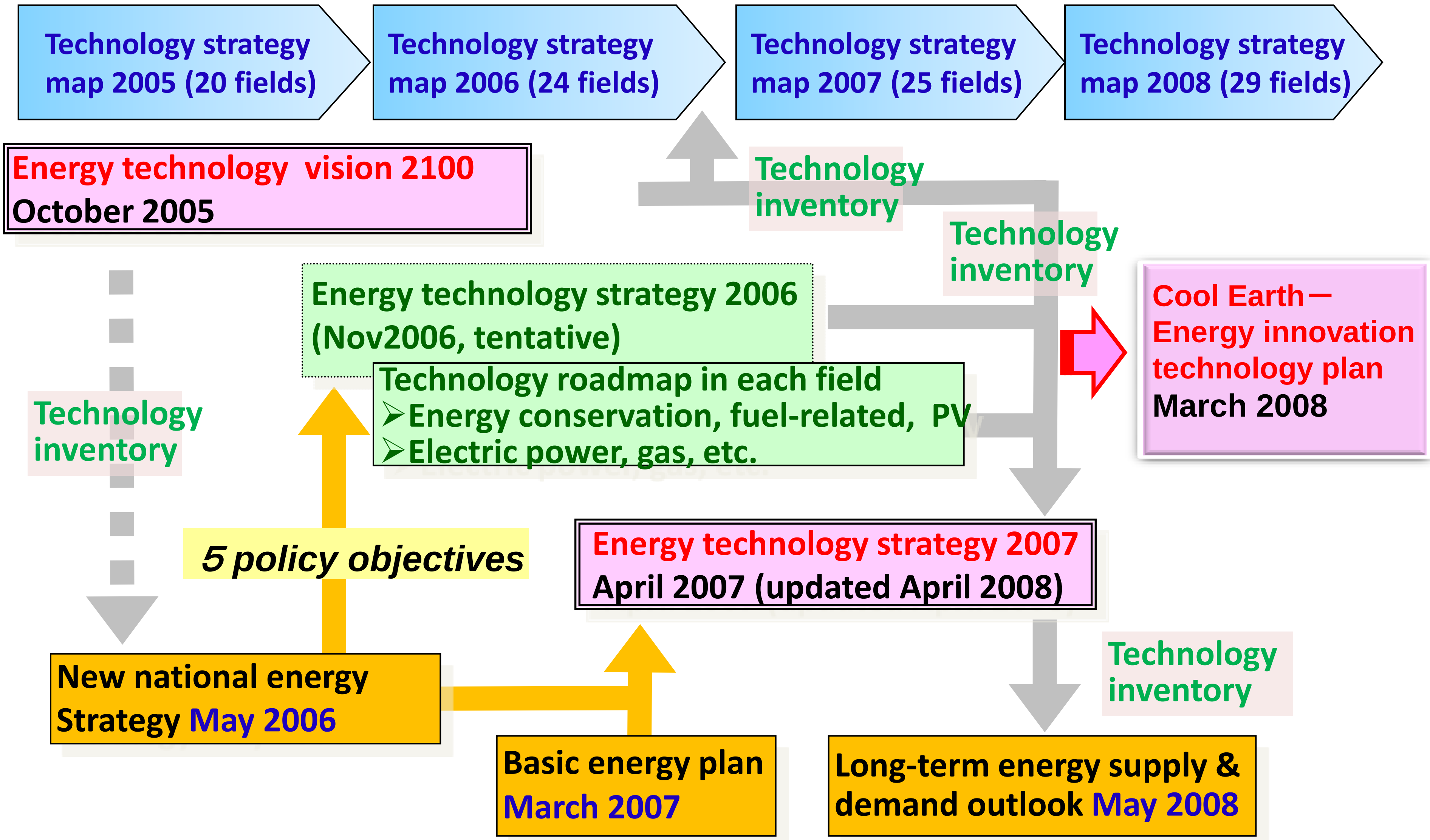
It is important to include lessons learned from the quake.

- Furthermore, it is important to recognize that what we need is not energy itself, but services such as well-conditioned space.

Contents

1. Impact of Scenario Selection
2. Issues of Future Energy System
3. Demand Activation
4. Energy System Integration
5. Energy Technology Strategy
6. Demonstration tests

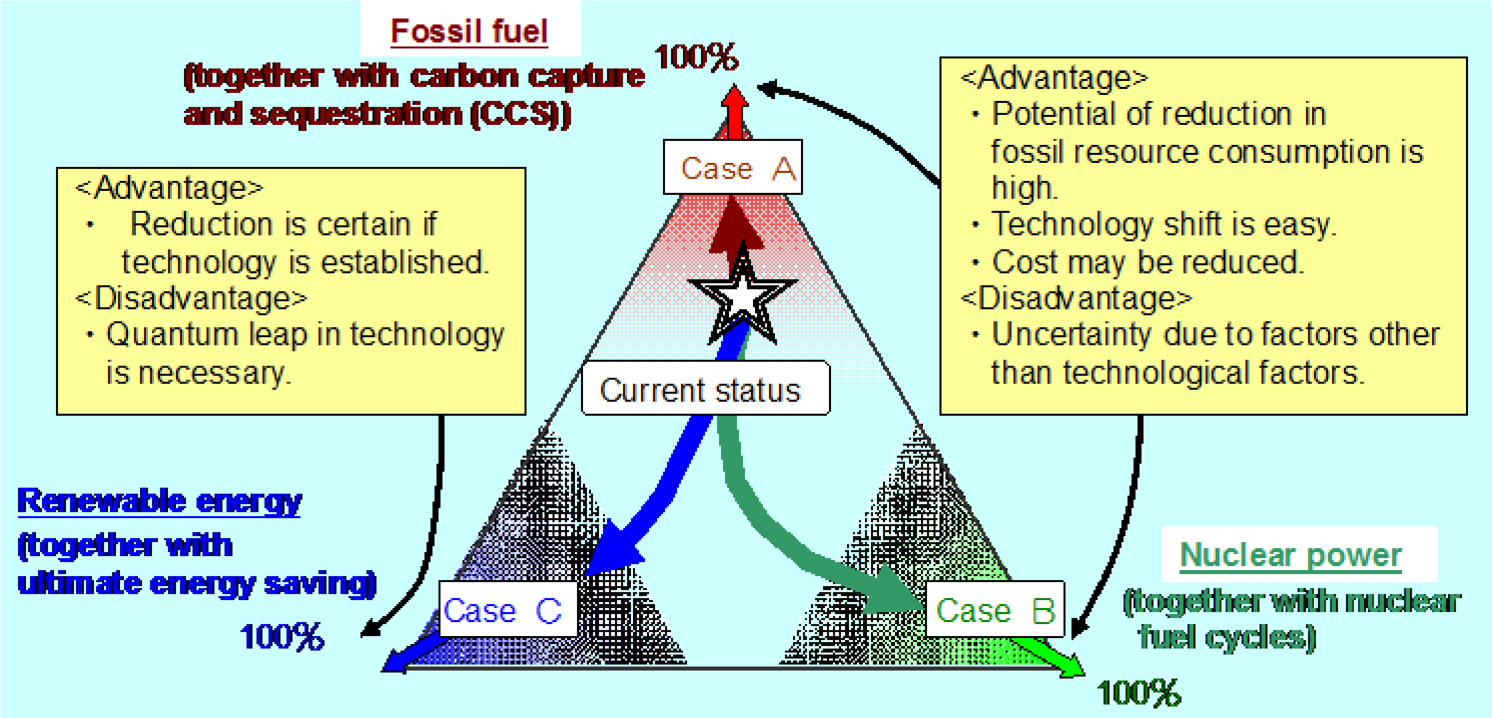
Practices of Energy Technology Strategy (2004-)



Energy Technology Vision 2100
Extreme cases and possible pathways

In 2005, METI formulated the "Energy Technology Vision 2100" as a navigating tool for strategic planning and implementation of energy technology.

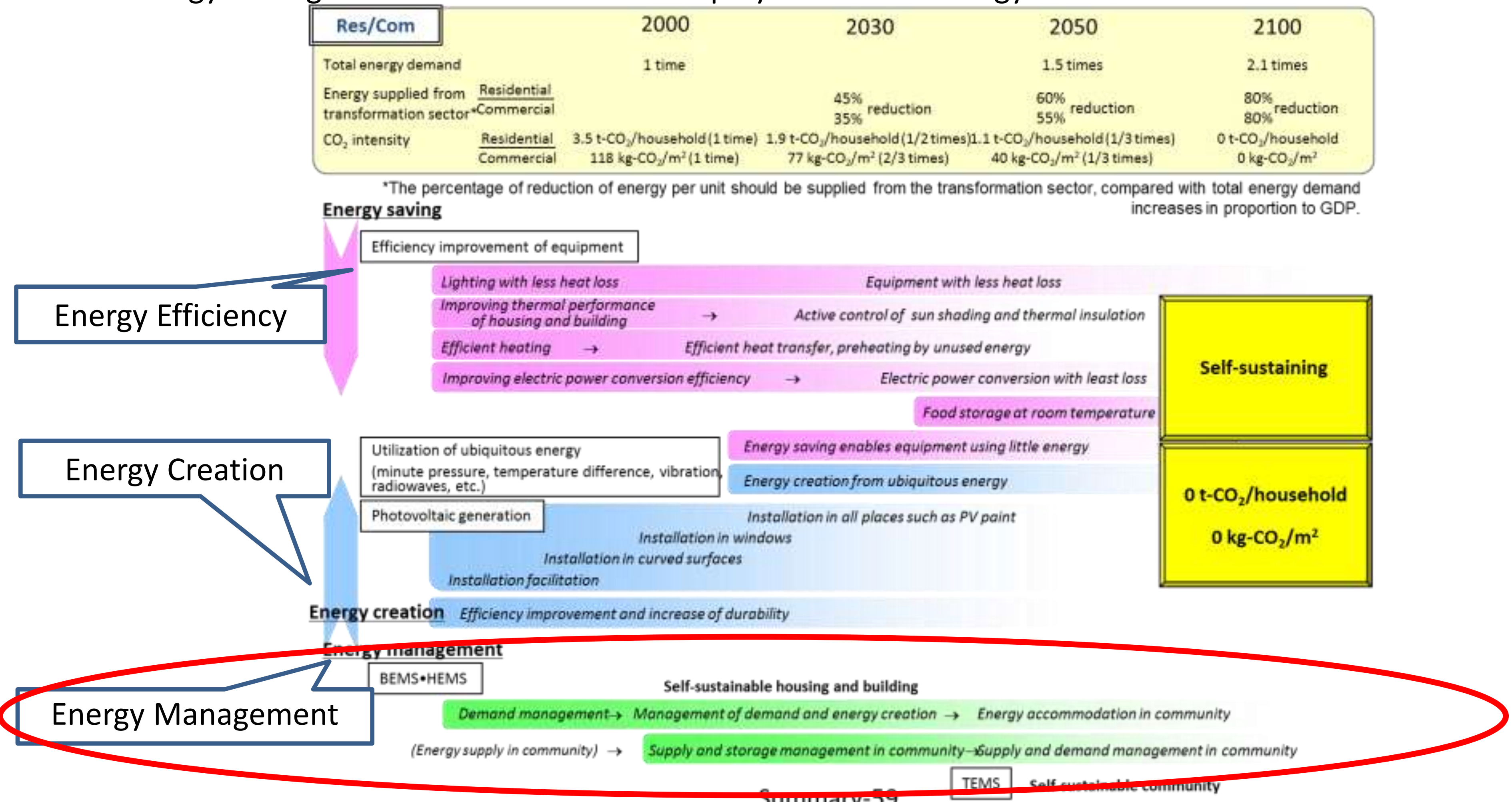
The vision, being developed by back-casting the technology portfolio from the year 2100, consists of roadmaps of Residential/Commercial, Transportation, Industry, Transformation sectors.



Source: Energy Technology Vision 2100, Institute of Applied Energy and METI (2005)

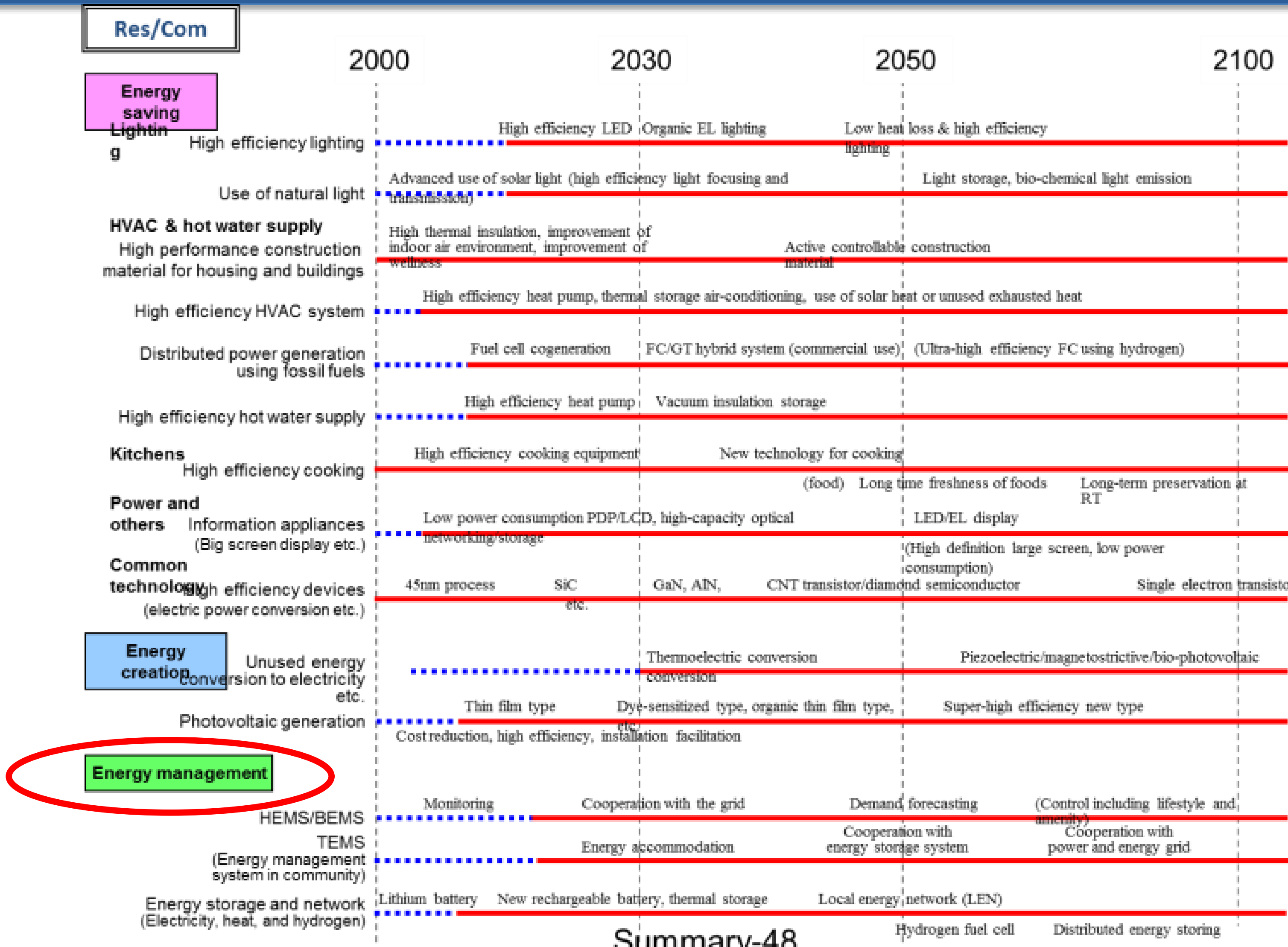
Energy Technology Vision 2100 Residential/Commercial Sector

The three domains of strategy are energy efficiency, energy creation and energy management.
The energy management is also effective to deploy renewable energy.



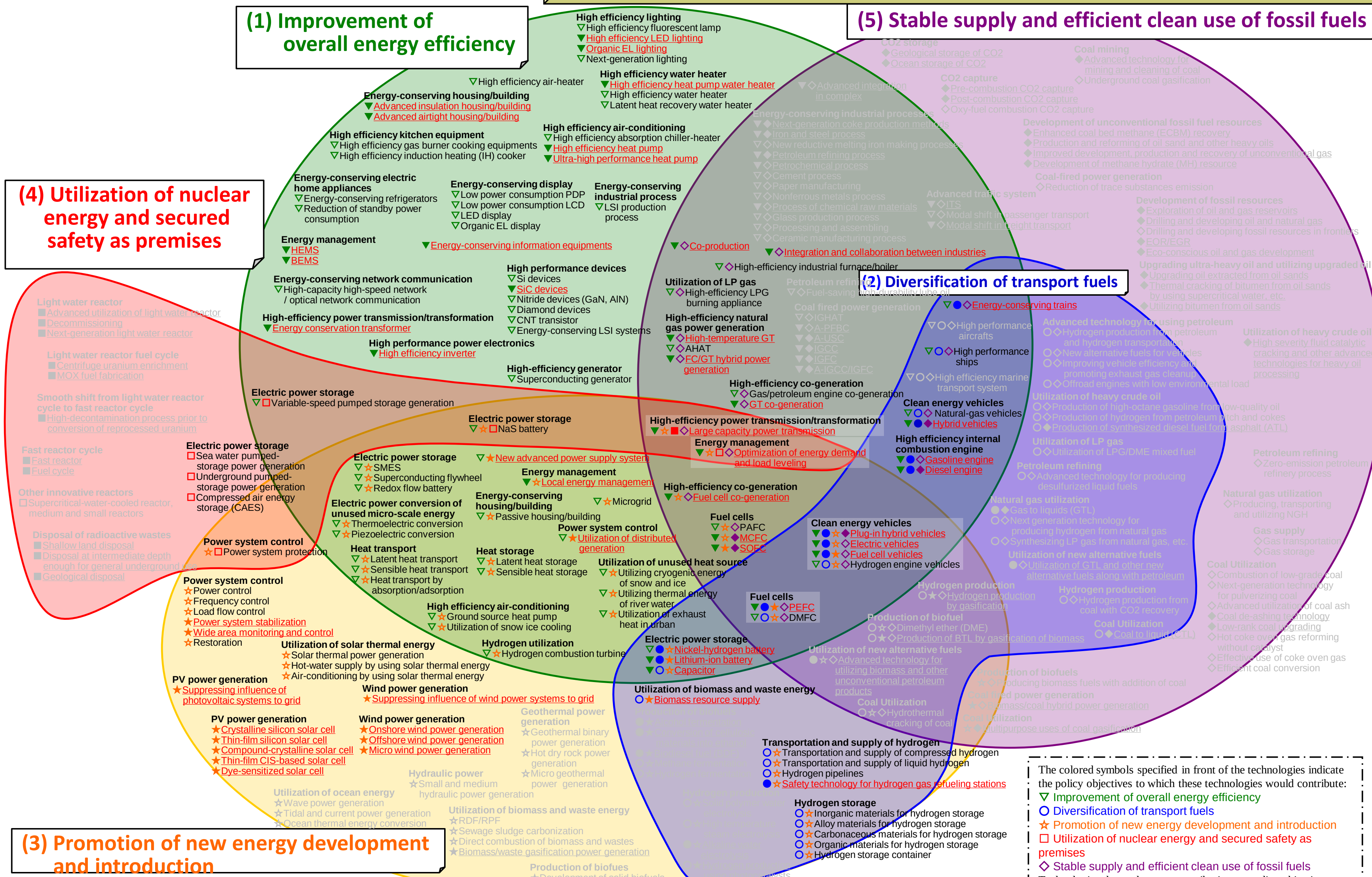
Source： Energy Technology Vision 2100, Institute of Applied Energy and METI (2005)

Energy Technology Vision 2100 Residential/Commercial Sector



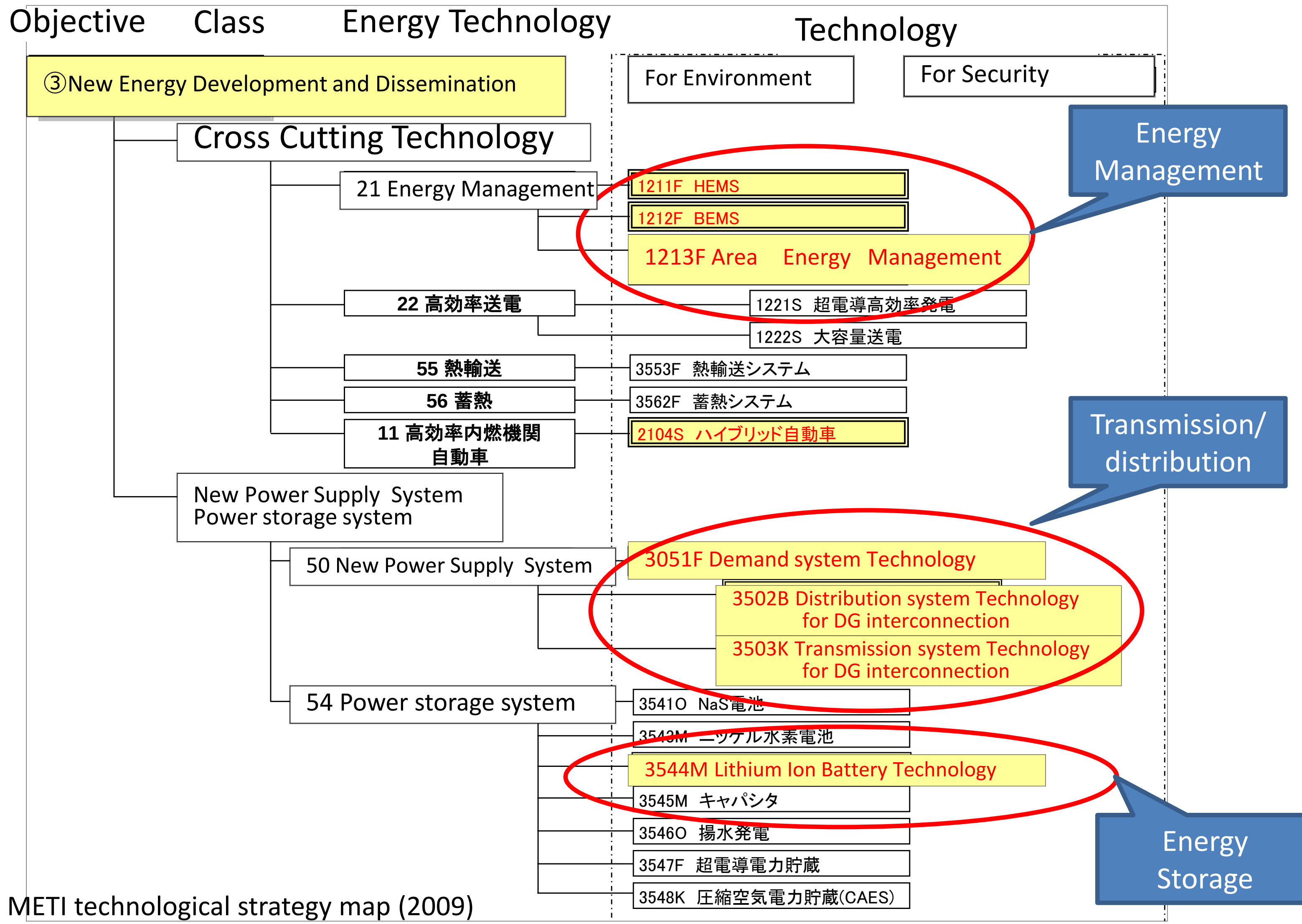
Source : Energy Technology Vision 2100, Institute of Applied Energy and METI (2005)

"Energy Technology Strategy Map 2007"



Source： Energy Technology Strategy Map by Institute of Applied Energy and METI (2007)

Energy Technology Map for RES and Distributed System

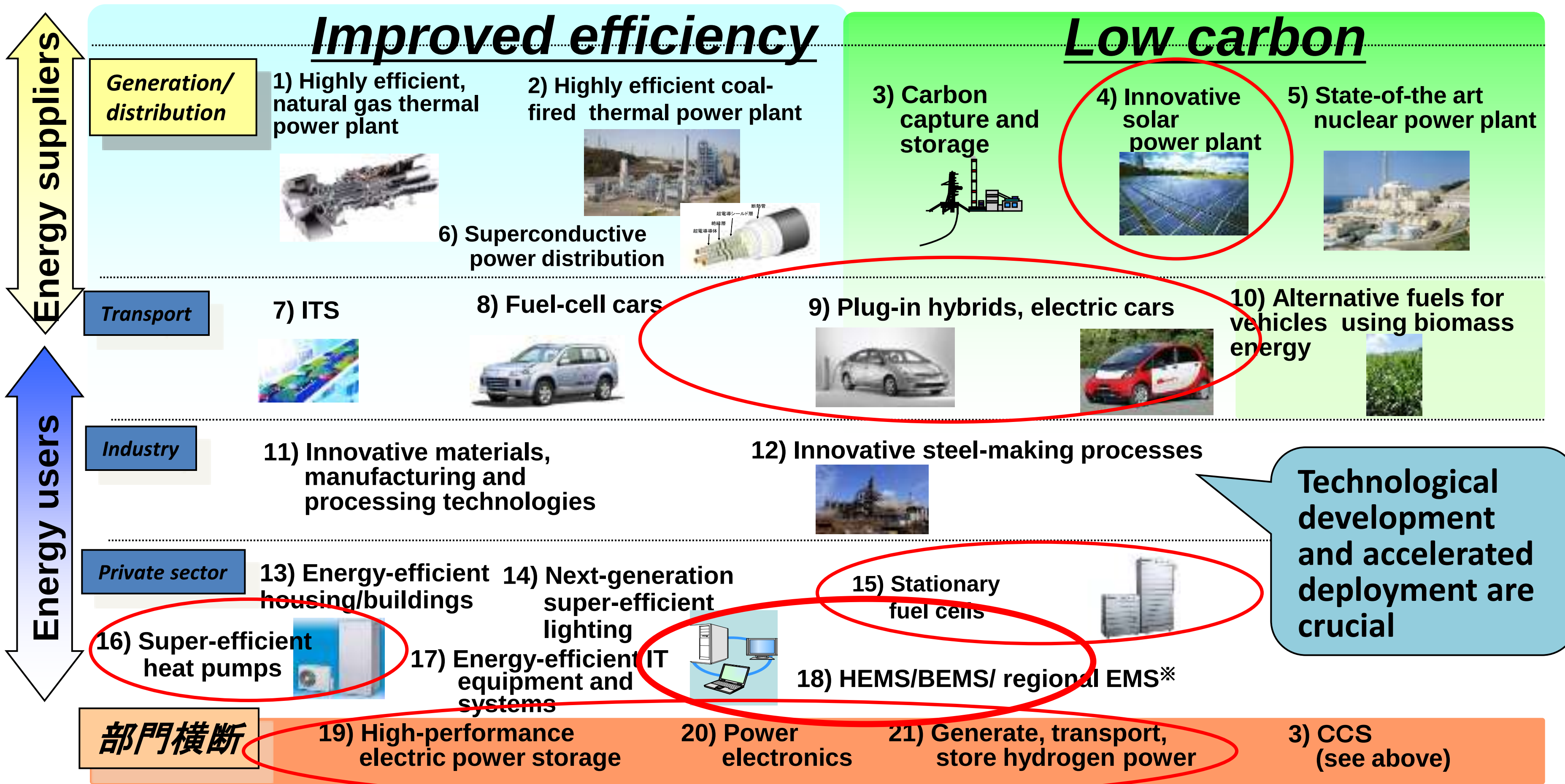


Source: METI technological strategy map (2009)

http://www.meti.go.jp/policy/economy/gijutsu_kakushin/kenkyu_kaihatu/str2009.html

Cool Earth energy technology innovation plan (2008)

Based on the series of studies of energy technology strategy, Cool Earth energy technology innovation plan was established to 21 energy technologies.



※EMS：Energy Management System, HEMS：House Energy Management System, BEMS：Building Energy Management System

Source: METI Cool Earth energy technology innovation plan report

Thank you for your attention.

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the University of Tokyo
http://www.ogimotolab.iis.u-tokyo.ac.jp/

In nippon.com related contents are available in English and Japanese.
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日経BP社「ECO JAPAN」で「低炭素型エネルギーシステムの将来像」を連載しました。最終回の「第12回　持続可能な世界を目指すこれからのエネルギー計画」までを公開中です。
http://eco.nikkeibp.co.jp/article/column/20110328/106234/

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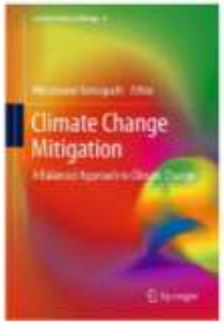
A Balanced Approach to Climate Change

Part of Springer's Lecture Notes in Energy series

Scheduled publication date: July 2012
ISBN: 978-1-4471-4227-0



The description of "1. Impact of Scenario Selection" is available in this book which is just published July, 2012.