e 3rd IAEE Asian Conference
rowing Energy Demand, Energy Security and the Environment in Asia
Challenges under Enormous Uncertainty --

Outlook of Energy Resources in Japanese Power Sector and Application Technologies after Earthquake of 11th March

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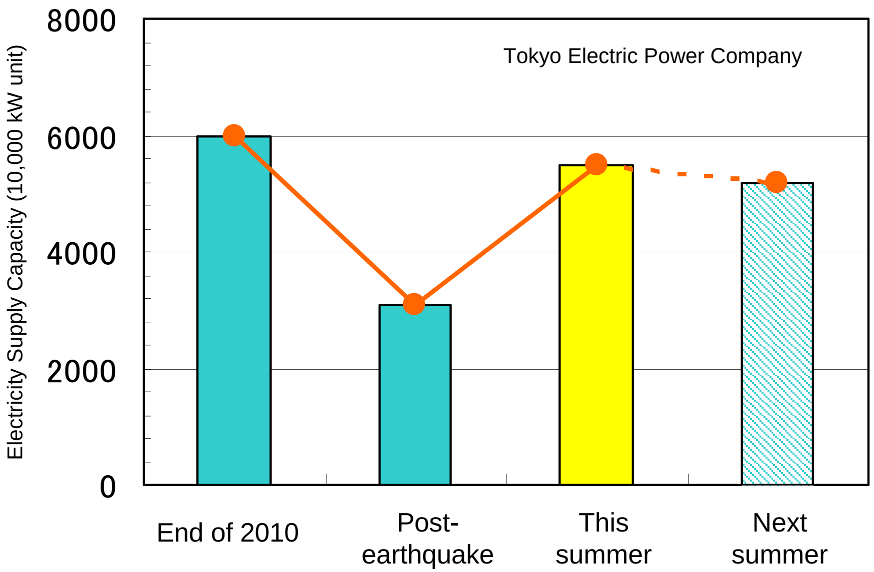
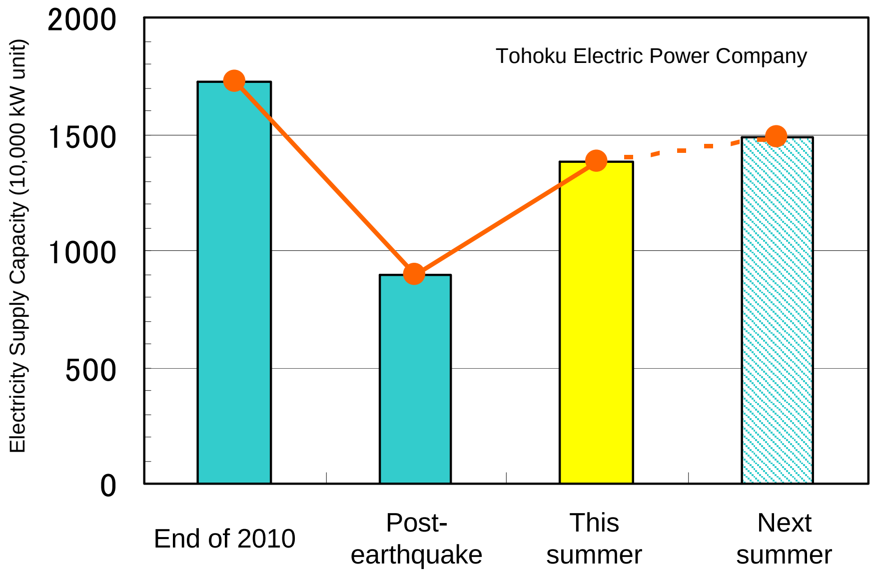
   - Wind Power Generation
   - Solar Energy Power Generation
   - Lithium-ion Secondary Battery

Impact of the Great East Japan Earthquake (1): Retrieval Status of Damaged Power Plants

- Power supply dropped approximately to 50 percent of capacity immediately after the earthquake due to plant shutdowns
- Back to over 80 percent of capacity in the summer

Pre- and Post-Earthquake Power Supply Capacities of Tokyo and Tohoku Electric Power Companies

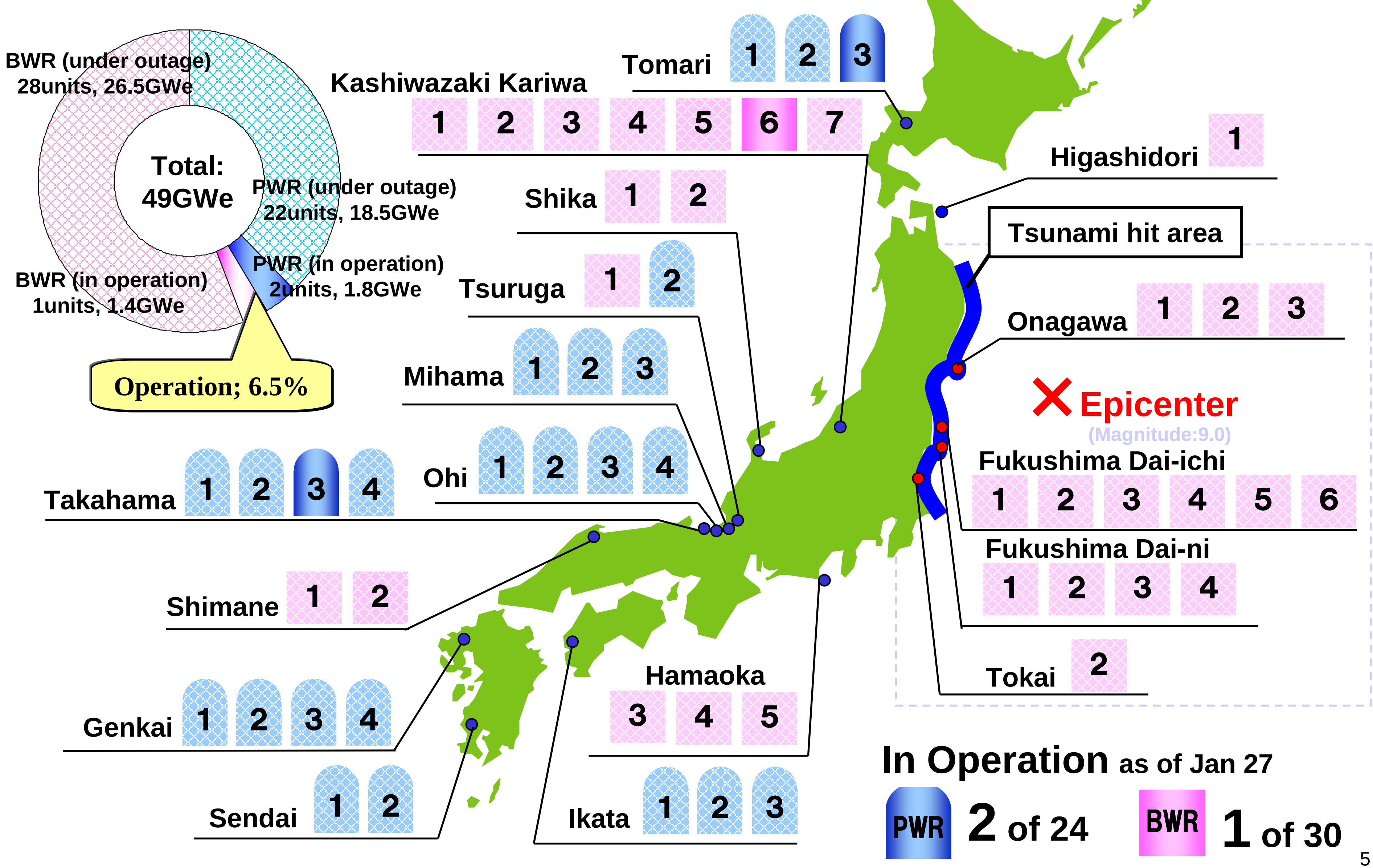




Source: Data prepared for Energy and Environment Strategy Meeting (July 29)
Forecasts for next summer are based on assumptions that nuclear power plants remain closed due to inspection, etc.

Impact of the Great East Japan Earthquake (2): Operation Status of Nuclear Power Plants

- Many plants under outage ready for restart but waiting for governmental judge upon stress test results



MHI's Support Activities to the Earthquake

1. Support Thermal Power Plants

- Dispatched 20,000 man-days (*1) of technical adviser for thermal power plants recovery in north-east Japan
- Increased production of gas turbine and other power generating equipment

*1: Number of technical advisors (TA) up to mid-September.
Thereafter, many more workers were dispatched for the repair work.

2. Support Existing PWR Nuclear Power Plants (emergency safety measures)

- Reinforce emergency power source (power supply vehicles, gas turbine generators, etc.)
- Enhance cooling function (additional systems, etc.)

3. Support TEPCO Fukushima Dai-ichi

- "Mega-Float" to store contaminated water
- Special heavy-duty forklifts with radiation shielded cabin, etc.
- Sludge waste storage facilities
- Dispatch of doctors

4. Other Support

- Relief Aid
  US$ 6.25M by company
  US$ 1.25M by employees
- Establish a scholarship for orphans
- To support sales promotion of products from the disaster areas, a "Tohoku Product Fair" was held.
- Corporate jet and helicopters delivered engineers, doctors, medicines, etc.

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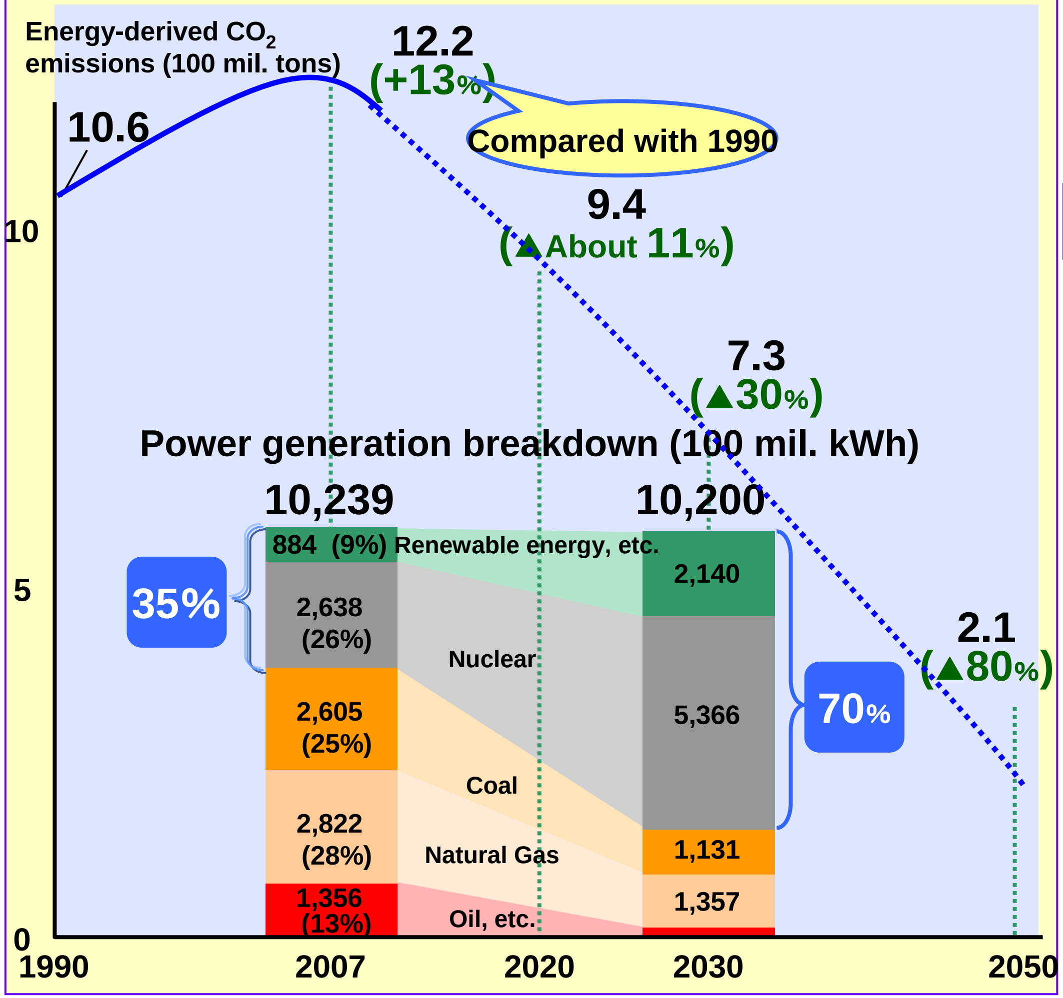
Energy Master Plan and it's Revision after Earthquake

Goals for 2030 in Energy Master Plan established in last year (before earthquake)

- Increase the ratio of nuclear power and renewable energy sources to about 70% (currently 35%) to achieve **30%** reduction of CO2 emission in 2030.



Moves toward revision of Energy Master Plan (after earthquake)

- The Energy Master Plan established last year needs to be revised due to negative mood of new nuclear power installation by the serious damage of radioactive contamination from the Fukushima Nuclear Power Plant.

Challenges ahead of revision

Public Consensus is required;

- To determine cause of the nuclear power plant accidents and revise safety standards for re-start of nuclear units
- National reassessment of nuclear power
- Public-private responsibility sharing
- Further encouragement of energy conservation and renewable energy use
- Mid- to long-term promotion of the realization of the best mix of energy

Agency for Natural Resources and Energy, METI's view

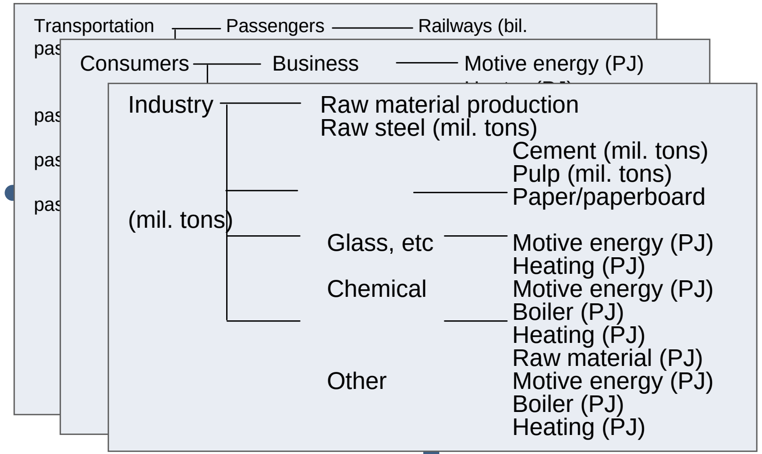
- Focusing on fossil fuels, nuclear power, renewable energy and energy conservation, the agency proposes energy system reform, energy technology renovation and international strategy.
- Putting the great concern on the growth of renewable energy and conservation of energy, the safe use of nuclear power is required.

Simulation Outline for Medium-to-Long Term Energy Supply and Demand

The purpose of simulation is to show the realistic provision of energy resource diversification with minimum energy cost against CO2 reduction requirement.

Simulation scheme:

Assumed demand



[Input]
Energy demand per usage in each sector and each industry
Key point: Appropriate prediction of demand

Assumed energy utilization technologies

[Input]
Characteristics of energy system / technology

Key points:
1. Appropriate technological innovation scenario
2. Appropriate technology selection rules based on potential societal changes

CO_2 reduction target, incentive, etc.

[Input] Restrictions of emissions

Simulation program (*)

Objective function
Minimization of energy cost

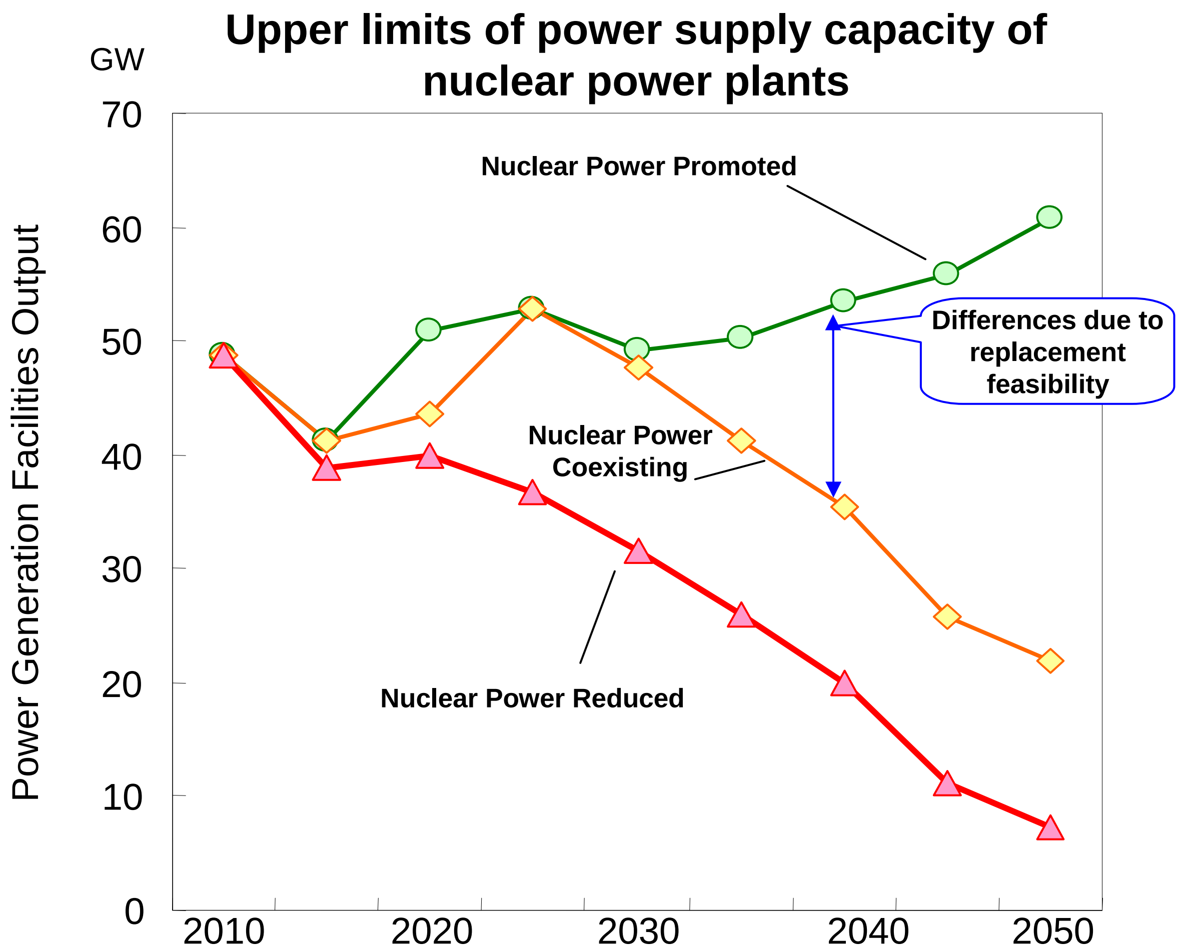
[Output]
Various kind of vision for optimized energy system

- **Best mix of technologies**
  - •EV in transportation sector
  - •High efficiency technology , etc.
- **Best mix of imported energy resources**
- **CO_2 emissions**
- **Energy cost**

* This program is a modification of MARKAL (MARKet ALlocation) developed by IEA to handle various energy demand and supply situations and measures against global warming

Condition Setting: Future Nuclear Power Supply Capacity

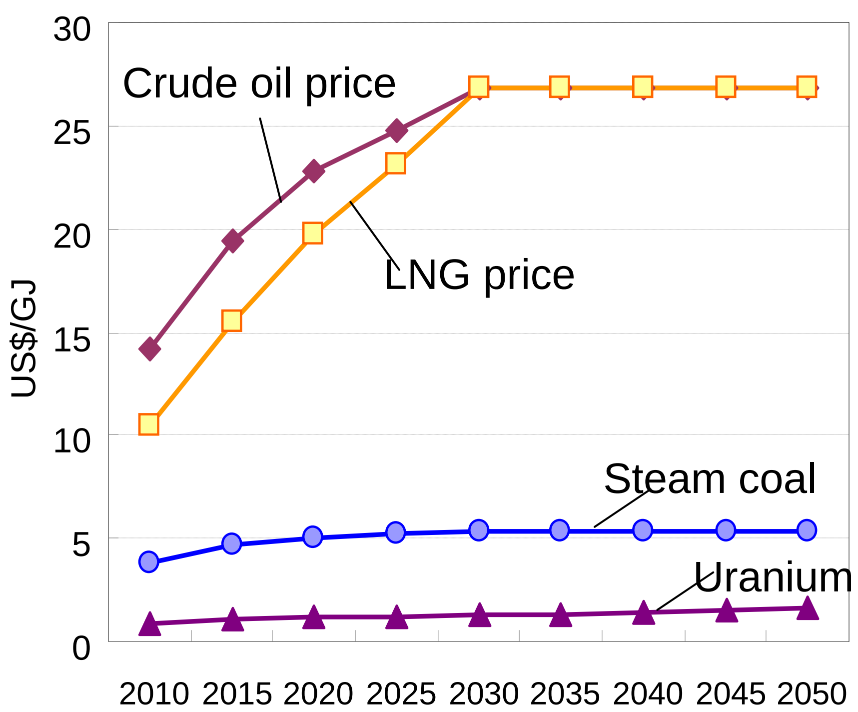
- Future nuclear power supply capacities are examined for three levels of groups, the handling of new construction plans and replacement feasibility.
  The estimated operation life of nuclear power plants is set at 50 years after construction.
- Conservative estimates of 100,000 yen/kW for decommissioning reactors were used.



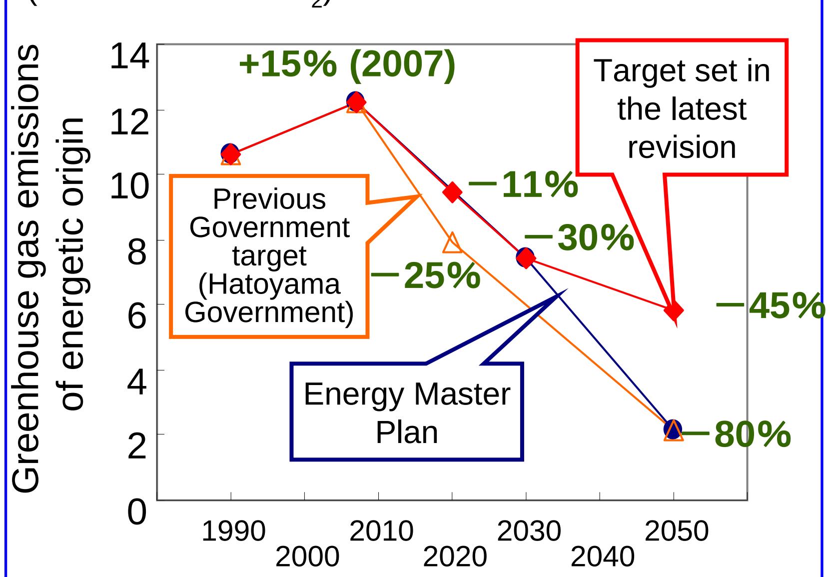
Condition Setting: Fuel Price and CO_2 emissions Caps

- Fuel price: The price of crude oil in 2030 is projected to rise to US$150/barrel.
  (The standard scenario of US$130/barrel in World Energy Outlook 2010 by IEA is used as a reference with an expected price rise due to the earthquake disaster added.)
  The price of LNG is projected to remain at the same level as the crude oil price in terms of calories, while the price of coal is projected to be 20% in terms of calories.
- The CO_2 emissions reduction target is set based on reduction standards stipulated in the existing Energy Master Plan, except for 2050, for which -45% over 1990 is assigned as the maximum feasible reduction even in the case of nuclear power reduction.

Projections of imported fuel prices (LHV base)



CO_2 Caps
(Reduction curves for CO_2 emissions)



Values in % are comparisons with 1990 values

Simulation Results: Primary Energy Structure

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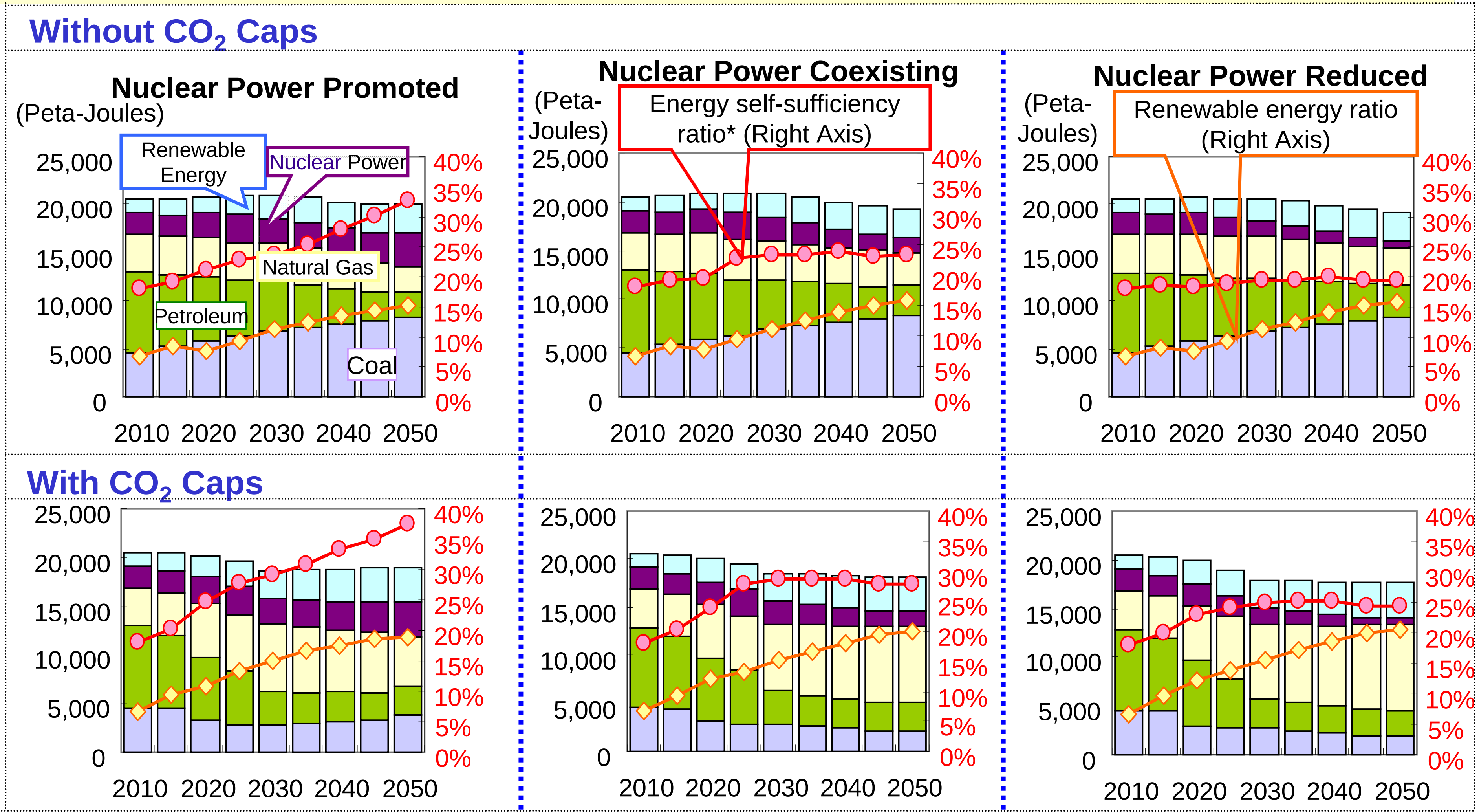
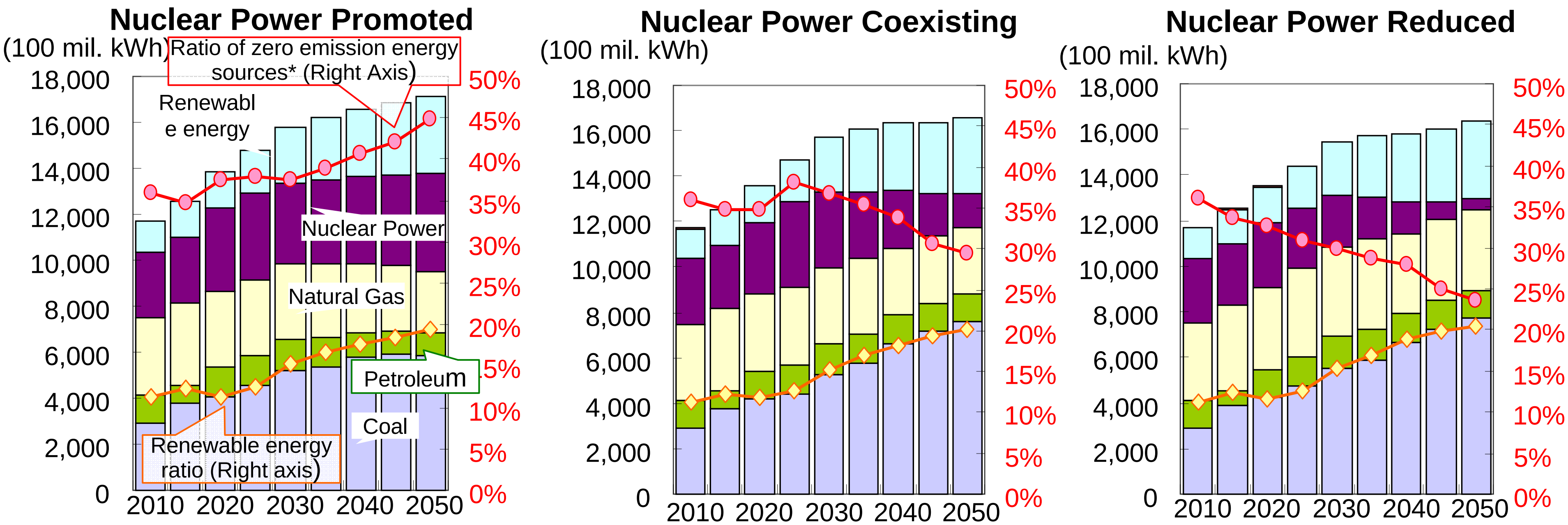
- Primary energy demand will be decreased due to enhancement of energy conservation.
- Coal will be the primary alternative energy in place of nuclear power in the case of “Without CO_2 Caps,” while natural gas will be the primary alternative energy in the case of “With CO_2 Caps.” In either case, petroleum will decline.
- Reduction of nuclear power supply capacity will also result in reducing the energy self-sufficiency rate.



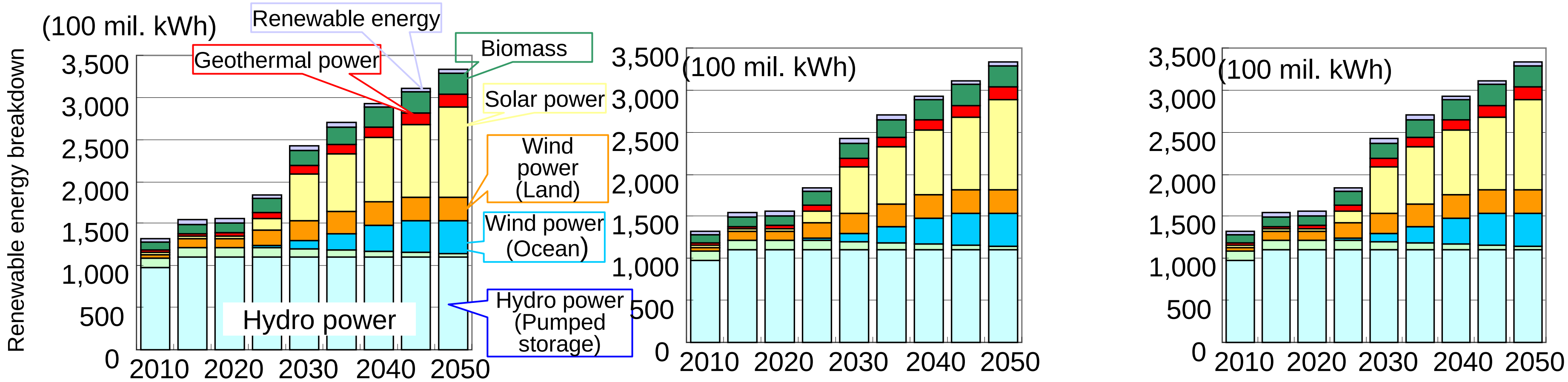
* Graph indicates ratios of renewable energy and nuclear power counted as quasi-domestic energy among the total primary energy supply

Simulation Results [Without CO_2 Caps]: Structure of Power Supply Sources

- Electrical demand will be increased.
- In the case of "Without CO_2 Caps," the amount of the reduced nuclear power will be compensated mainly by coal-fired thermal power. Solar power will exceed 30 GW energy generation in 2030 due to cost reduction.



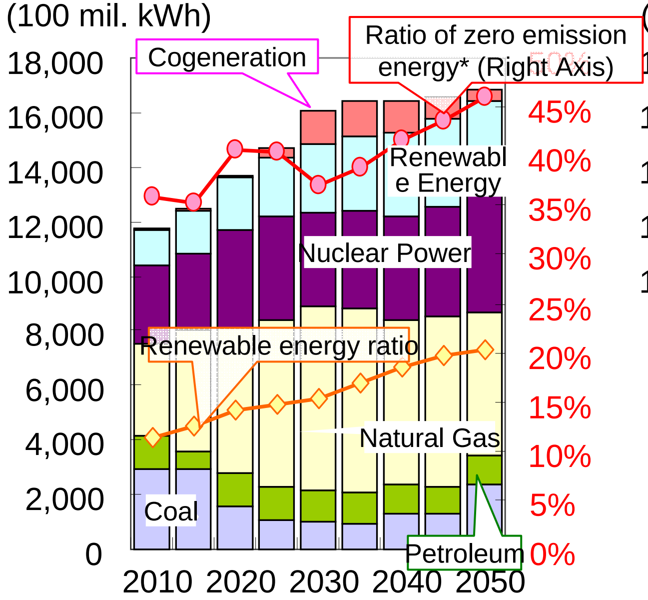
* Ratio of renewable energy and nuclear power in power generation



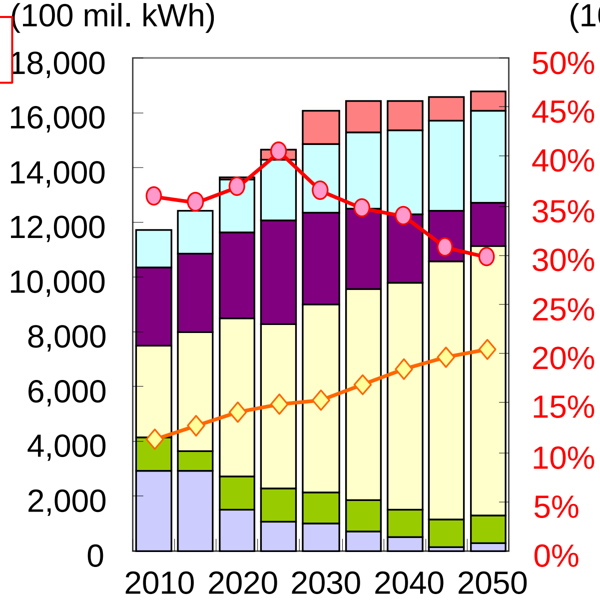
Simulation Results [With CO_2 Caps]: Composition of Power Supply Sources

- In the case of "With CO_2 Caps," nuclear power will be compensated for mainly by Natural Gas thermal power. Solar power will be introduced at an earlier stage compared with the case of "Without CO_2 Caps" because of strict CO_2 restrictions.

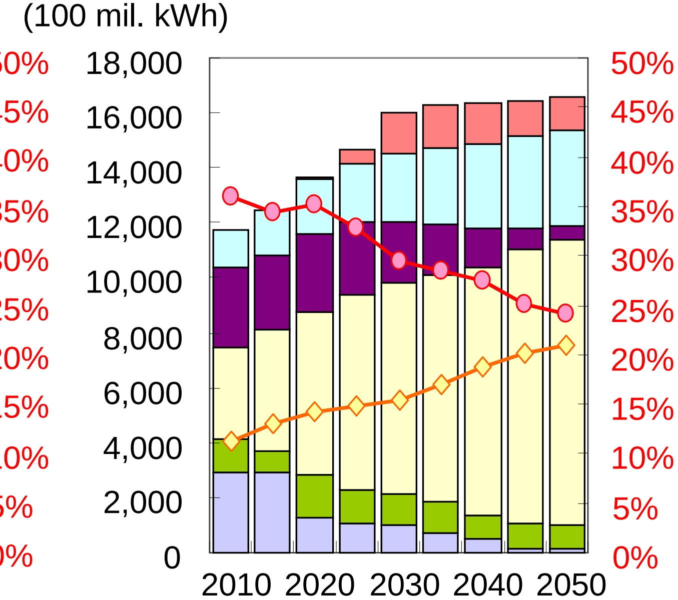
Nuclear Power Promoted

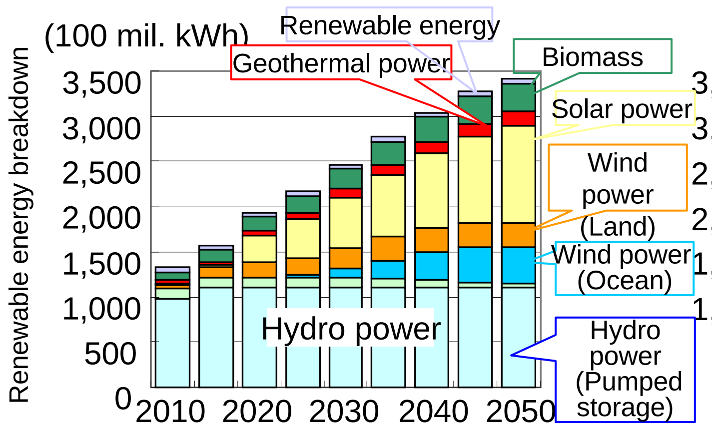


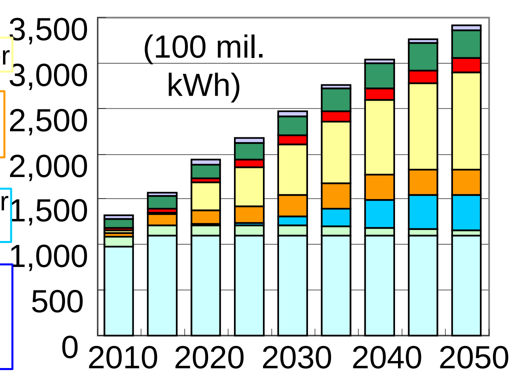
Nuclear Power Coexisting

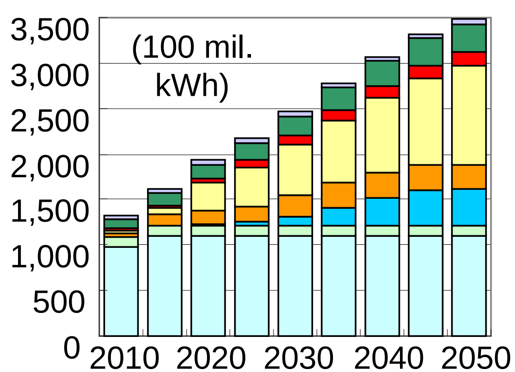


Nuclear Power Reduced





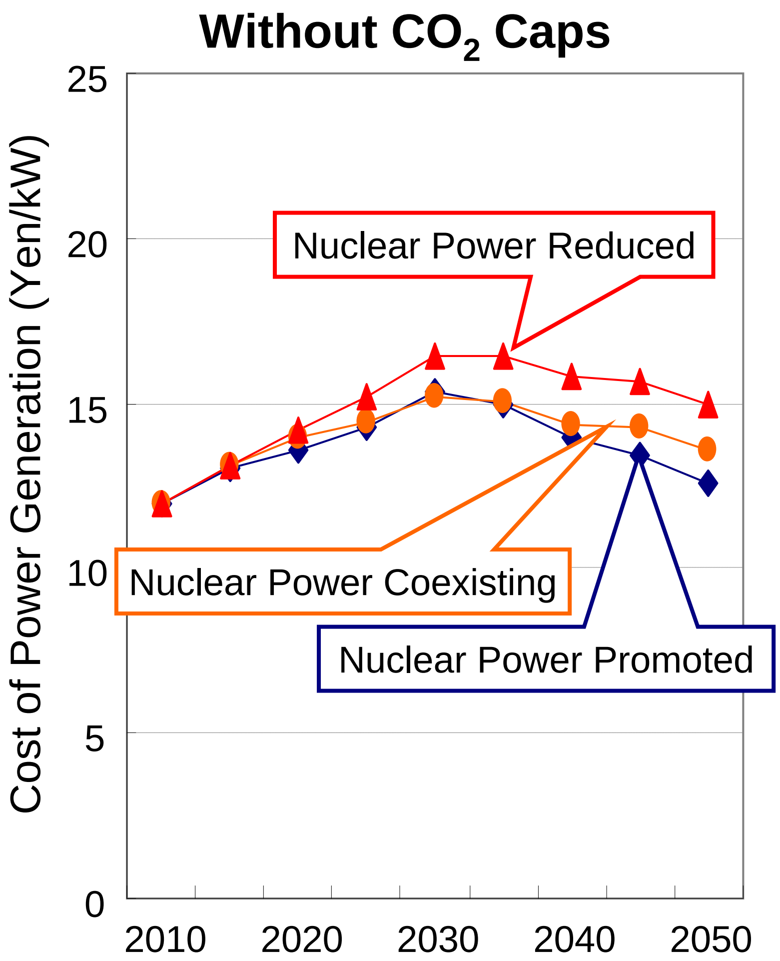


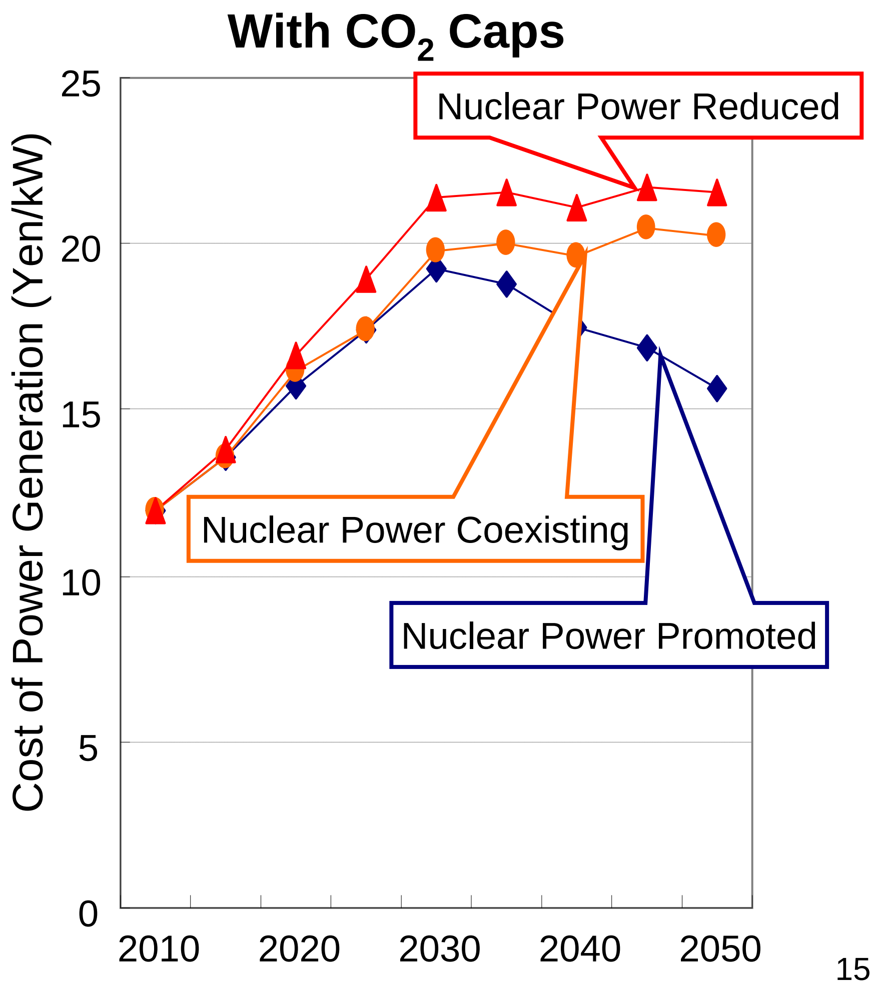


Simulation Results: Cost of Power Generation

- The price of electricity significantly rises for "With CO_2 Caps" operation compared to "Without CO_2 Caps" operation, for which the main factor is an increase in the amount of expensive natural gas imports.
- The price difference between the Nuclear Power Promoted case and Nuclear Power Reduced case is significant

Note: Recent projections do not take into account rising prices of fossil fuels after 2030. However, if the possibility of a price rise is taken into account, electricity prices will rise further along with the reduction of nuclear power generation.





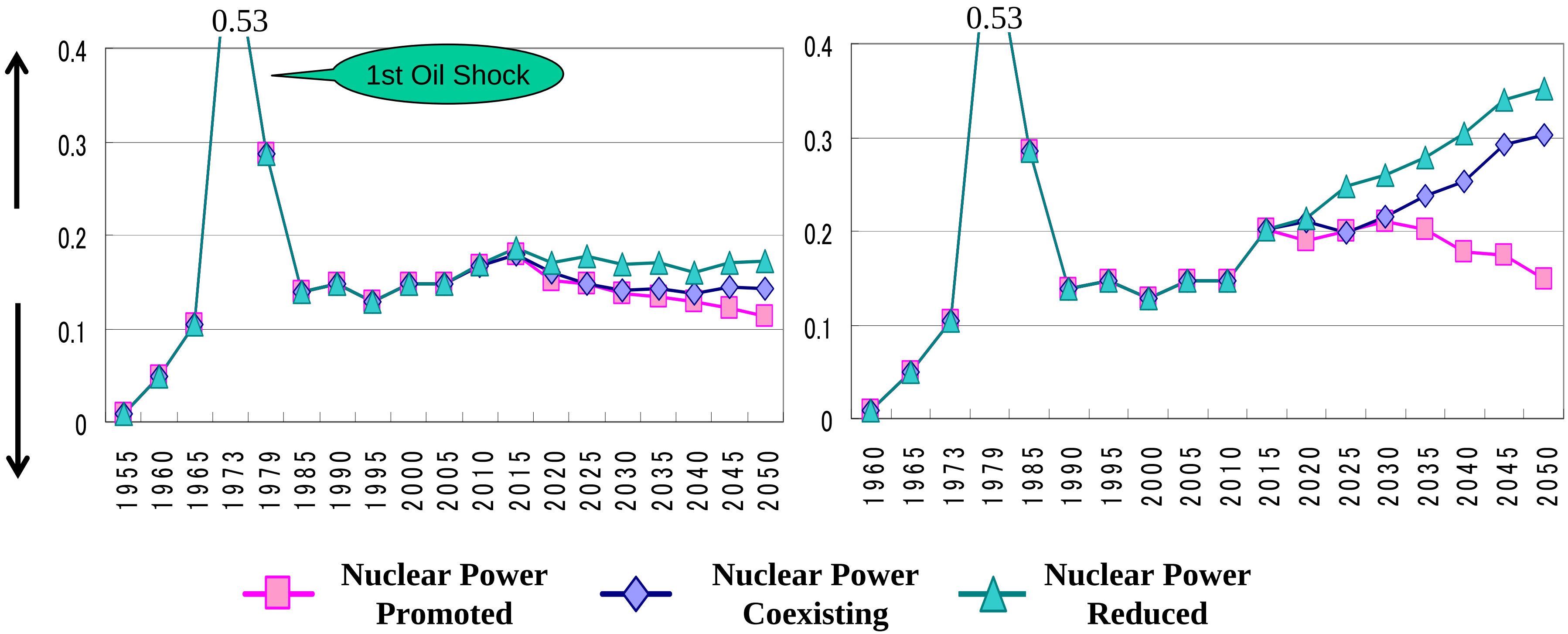
Simulation results:
Energy Security Index of Power Generation Source Structure

○Energy Security Index: Evaluation based on Security related to resource procurement (imports) and security of domestic supply/conversion facilities and the domestic network

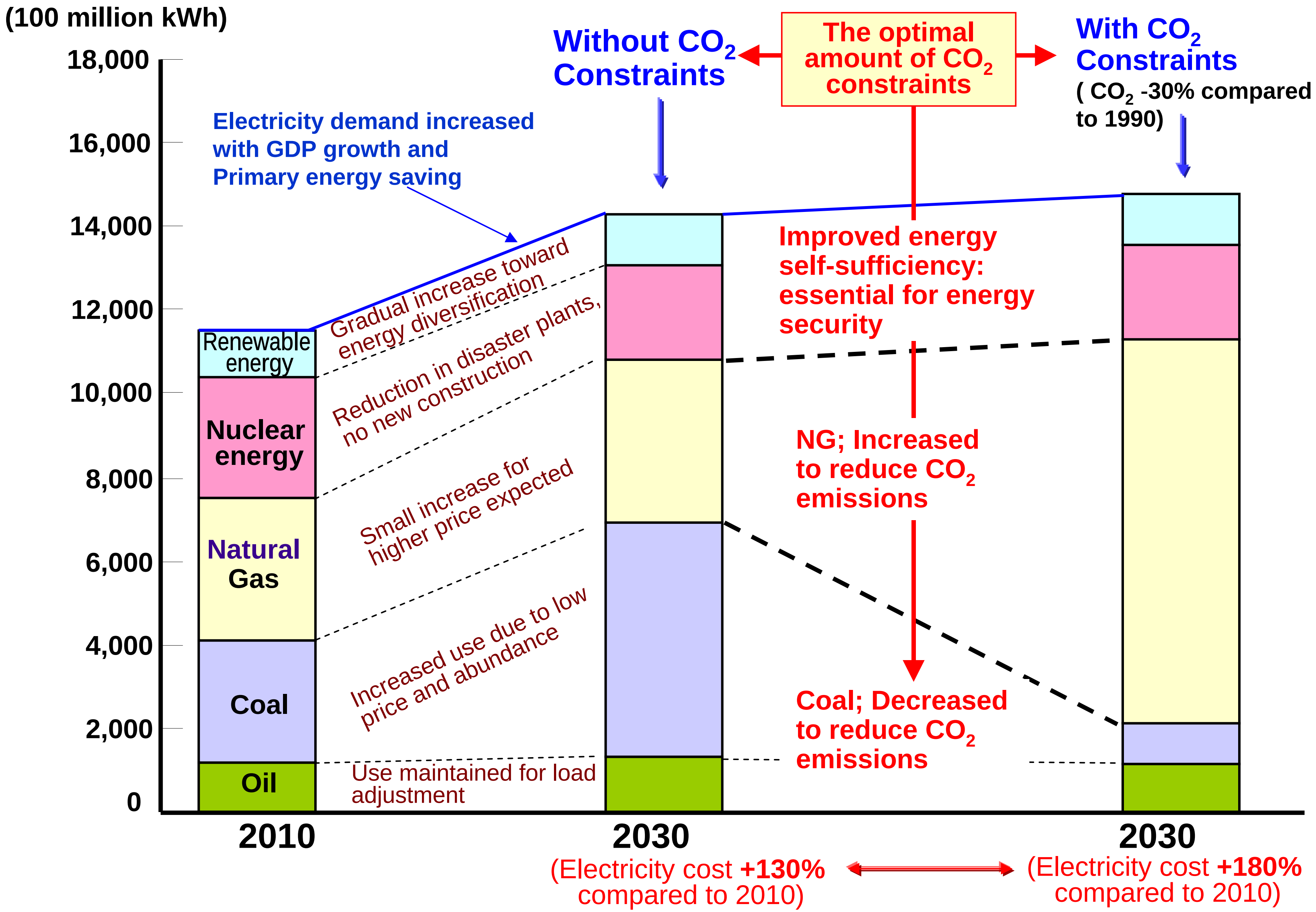
- Due to nuclear supply reduction, the self-sufficiency rate will notably decrease (as low as 20% in 2050)
- Owing to the large tilt in the energy mix toward natural gas (and away from coal, with its high supply security), the energy security index - which had been reduced and held low via reduction in oil reliance - will once again worsen.

Without CO_2 Caps | **With CO_2 Caps**

Higher security index = higher risk



Simulation Results: Japan's Power Generation Source Structure



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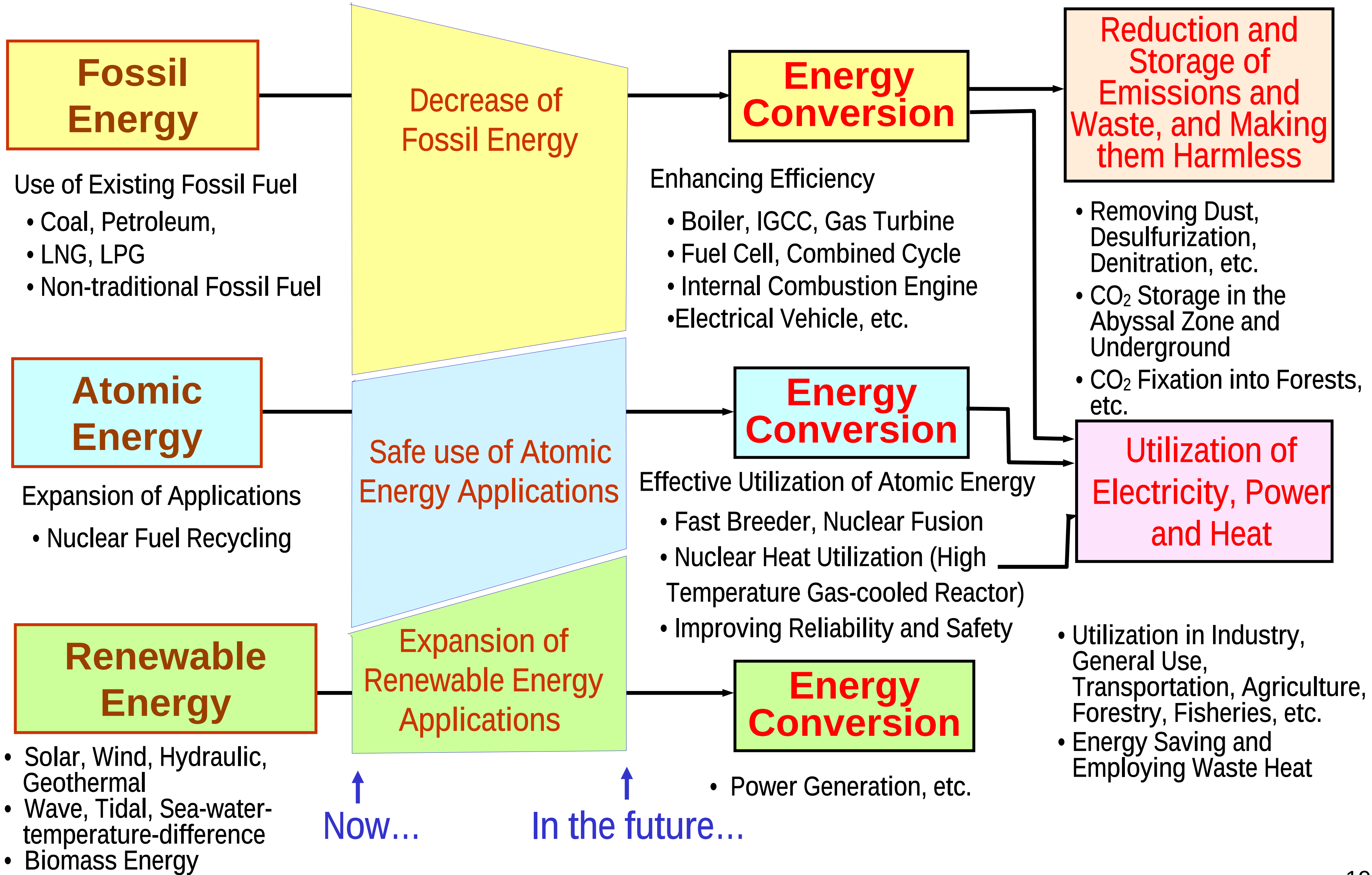
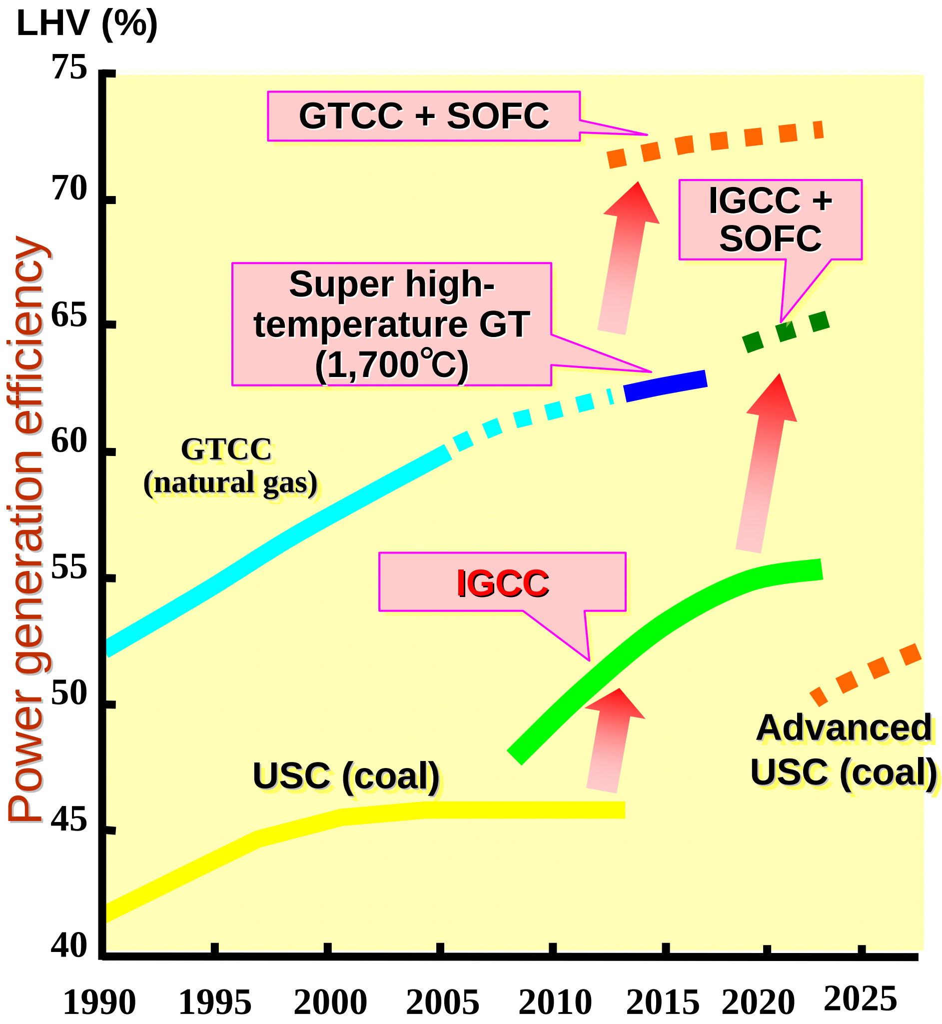
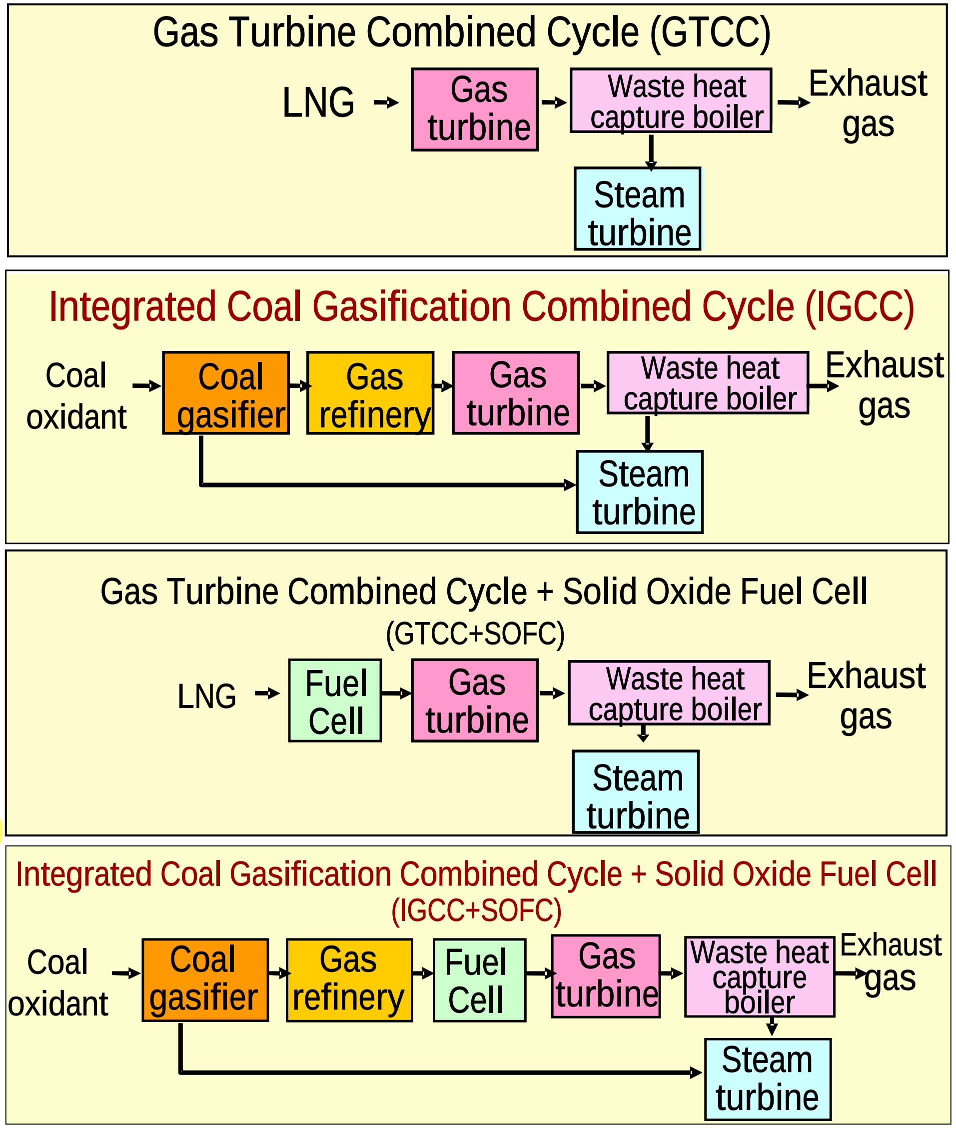
Integrated Promotion for Diversification of Energy Sources and Global Environmental Measures



Enhancement of Thermal Power Generation Efficiency





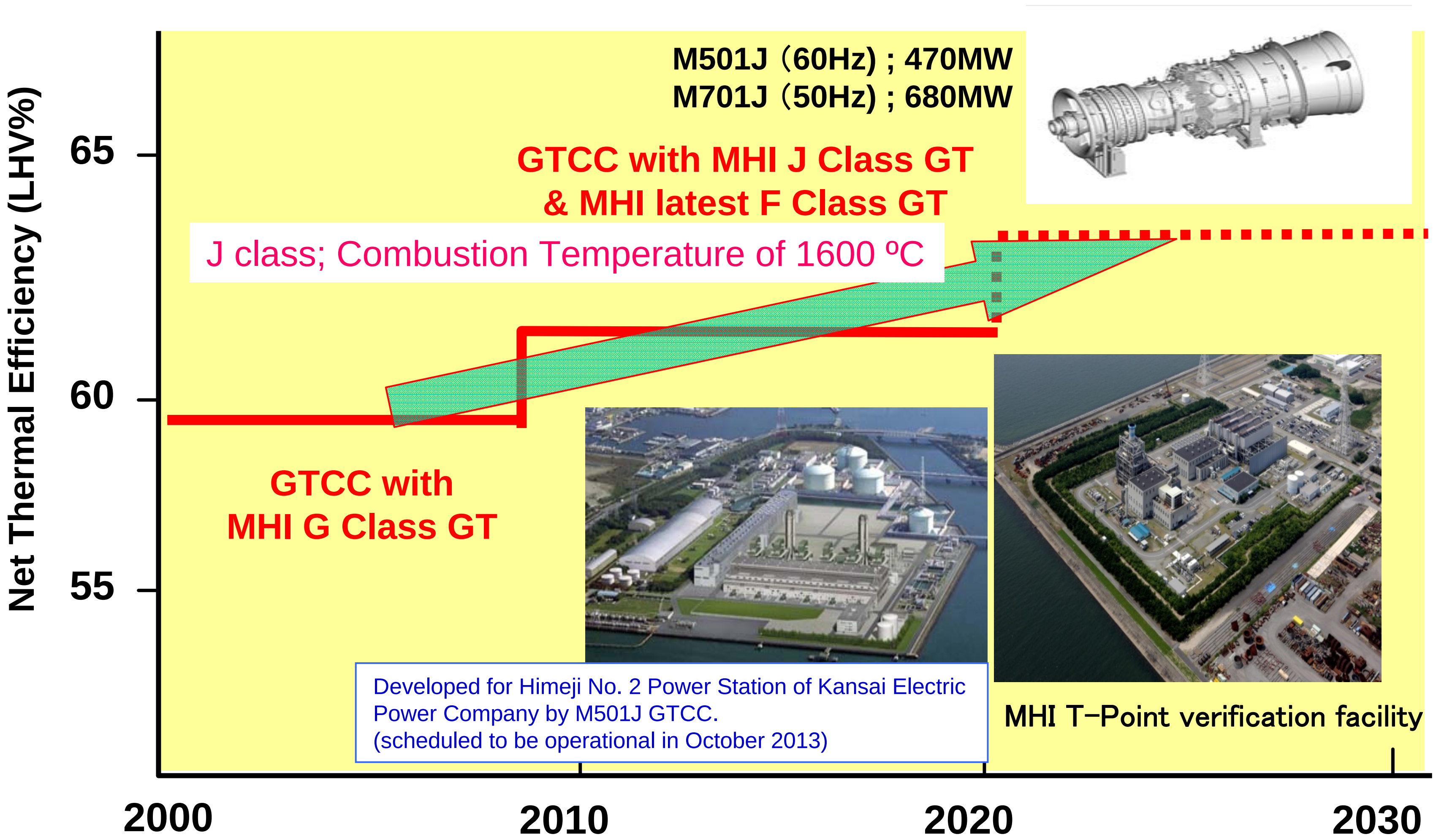
IGCC: Integrated coal Gasification Combined Cycle
SOFC: Solid Oxide Fuel Cell

GTCC: Gas Turbine Combined Cycle
USC: Ultra Super Critical pressure Coal-fired plant

Combined-Cycle Gas Power Generation

- High efficiency combined-cycle with the latest gas turbine technologies substantially reduces CO_2 emissions

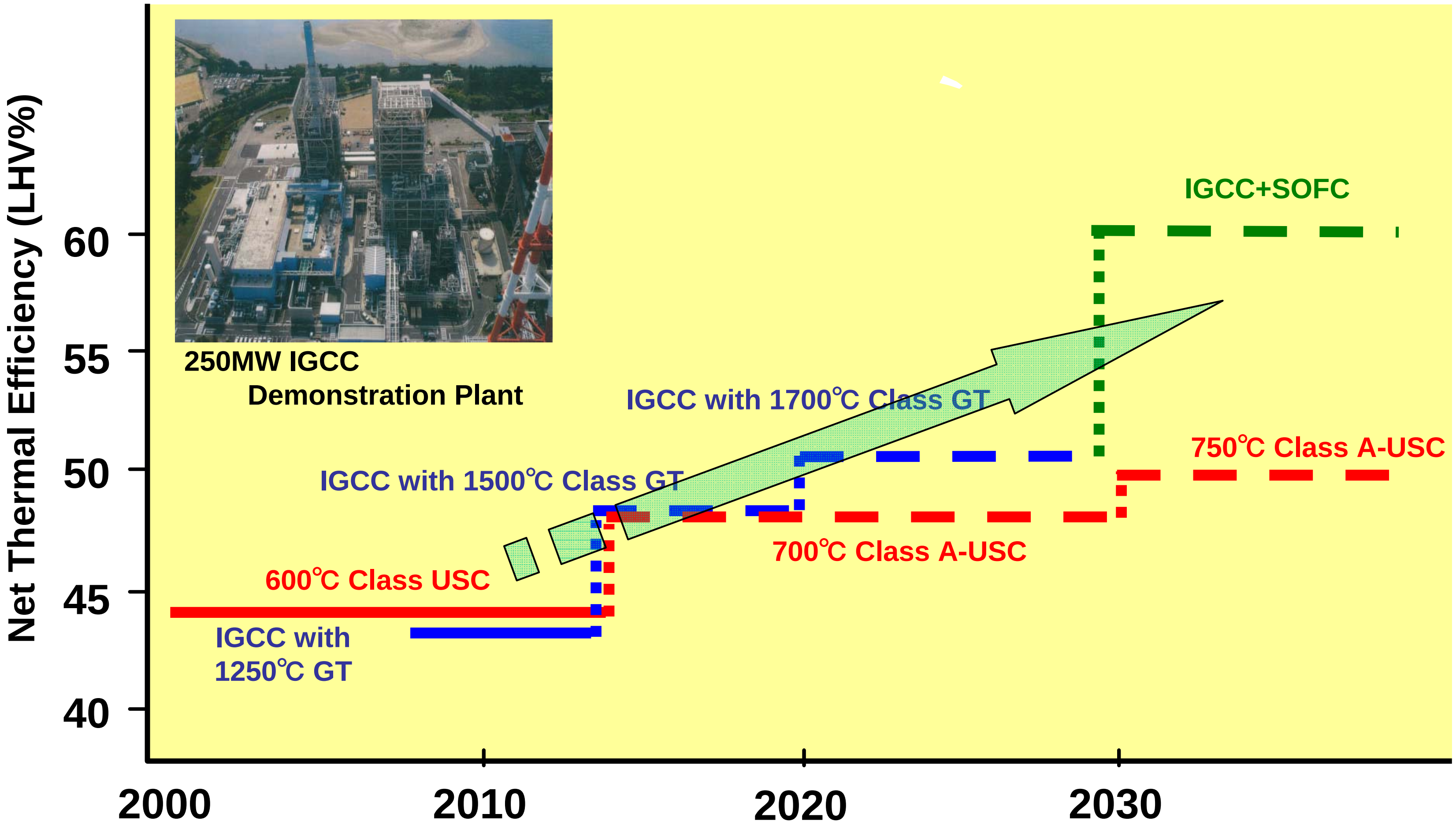
Gas Power Generation: Forecasted Efficiency Improvement



High-Efficiency Coal Power Generation

- Abundant coal reserves and low price.
- IGCC is a realistic solution technology to improve coal use efficiency.
- A-USC will follow IGCC.

Coal Power Generation: Forecasted Efficiency Improvement



CO_2 Capture and Storage（CCS）

Fossil fuel → CO_2 emissions source (thermal power plant) → CO_2 separation and capture facility → CO_2 transportation (pipeline, etc.) → CO_2 storage — Ocean and underground

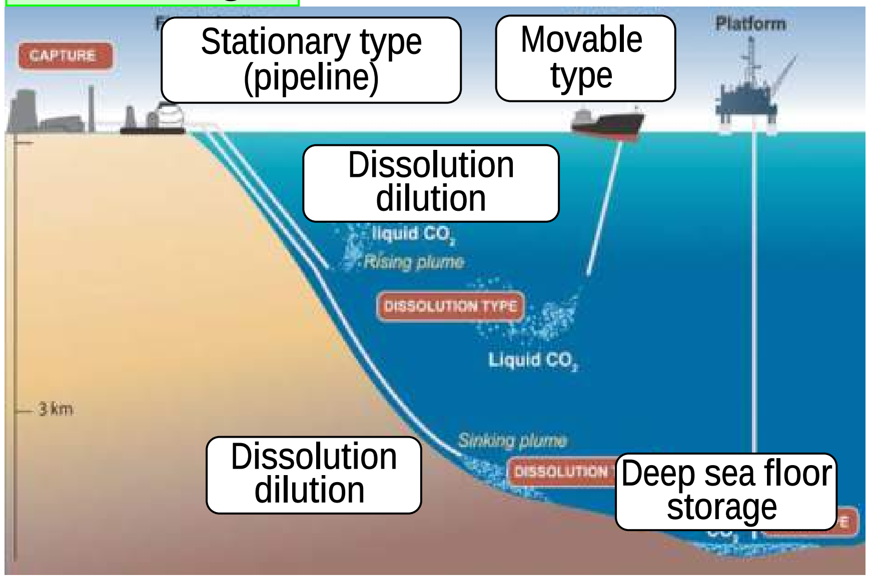
High efficiency IGCC plant

CO_2 capture plant

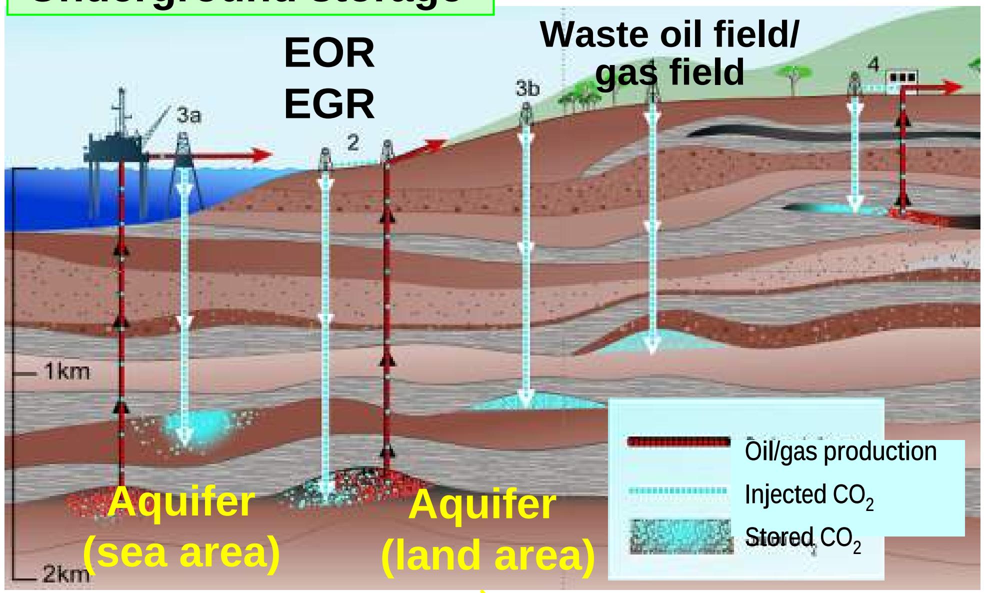
High pressure CO_2 compressor delivered to CCS plant in Algeria

CO_2 Storage Method

Sea storage

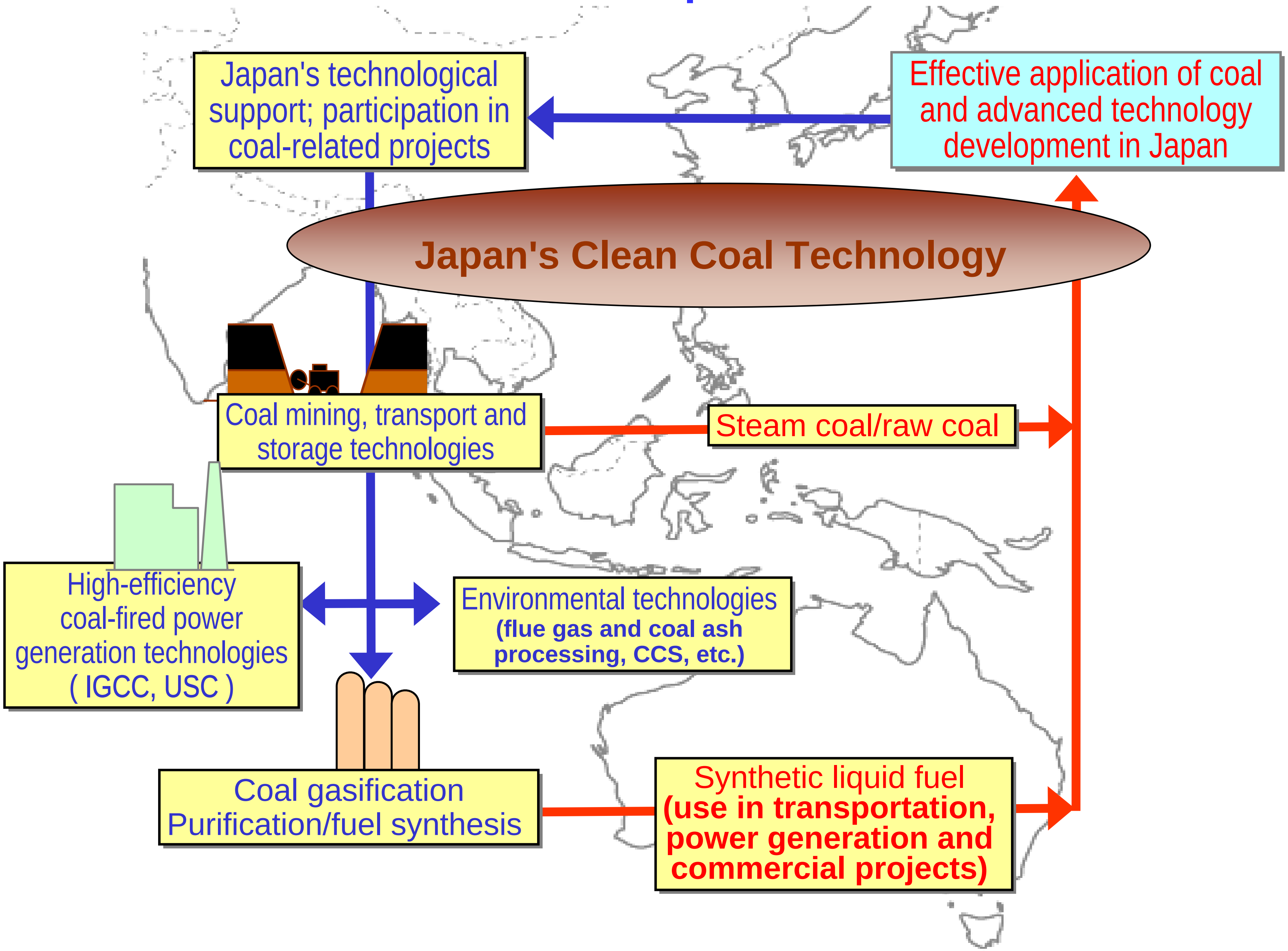


Underground storage

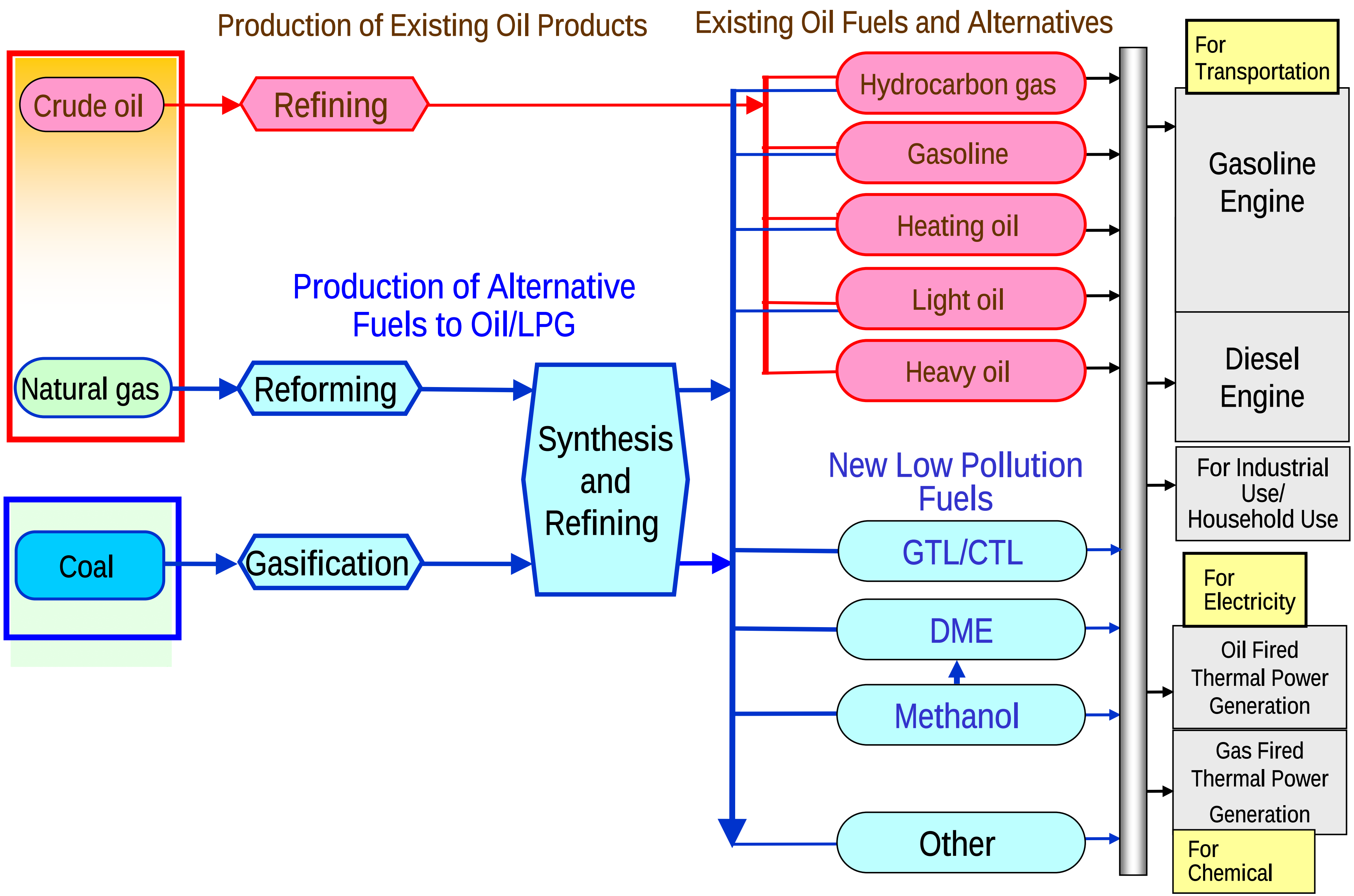


Source: Carbon dioxide Capture and Storage, IPCC Special Report 2005.09

Coal utilization in Partnership with Australia/Asia



Production of Alternative Fuels to Oil



Mitsubishi Coal Gasification Technology

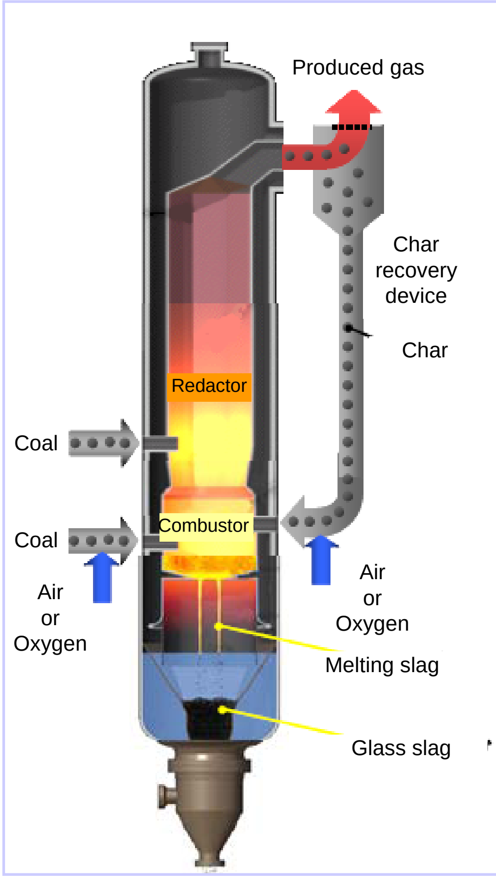
Applicable technology for both power generation and chemical plants
(e.g., fuel production, chemical raw materials)

Power Generation*1

- Air-Blown Integrated Coal Gasification Combined Cycle
  - ★ High power generating efficiency
  - ★ Low power generating cost

Chemical Plants*2

- Gas/Liquid Fuel Production Plant (e.g., SNG, CTL, DME)
  Chemical Raw Material Production Plant
  (e.g., ammonia, urea)
  - ★ High-efficiency gasification
  - ★ Low utility consumption
    (e.g., low volume of oxygen required)



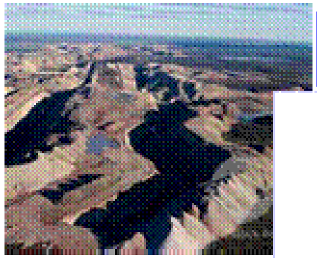
*1: Used for air-blown gasifier
*2: Used for oxygen-blown gasifier

Supply Flow of DME/SNG Produced From Low-Quality Coal

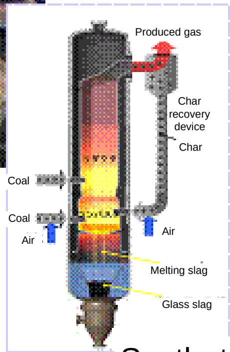
DME: dimethyl ether (CH_3OCH_3) SNG: synthetic natural gas

Low-quality coal for export (e.g., lignite)

Australia/Indonesia

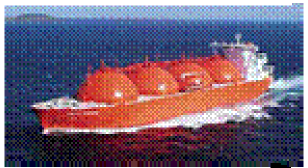


Lignite mining site



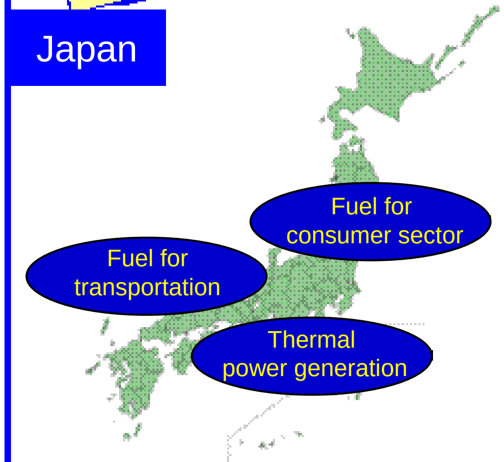
Synthetic fuel production plant

Ocean transportation (DME/SNG)



Securing of clean alternative energy (liquid/gas fuel)

Japan



Synthetic fuel production using lignite

Fuel transportation

Synthetic fuel applications

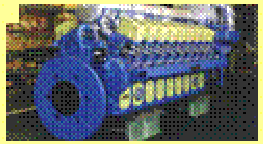
Synthetic fuel production process with coal gasification using lignite

Coal → Coal gasification → Gas refinement → Synthesization/refinement → Synthetic fuel

- ○ Fuel synthesization system can be developed based on existing expertise such as large-scale methanol production processes
- ○ CO_2 recovery plant can be added as CCS measure

Synthetic fuel applications

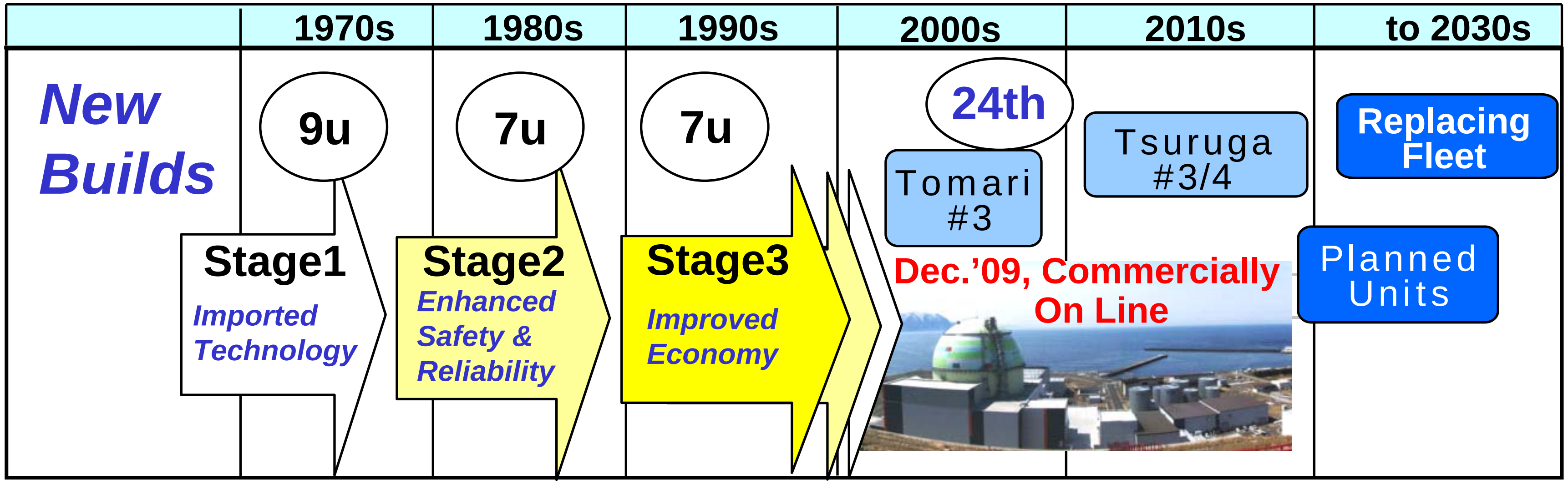
Diesel engine

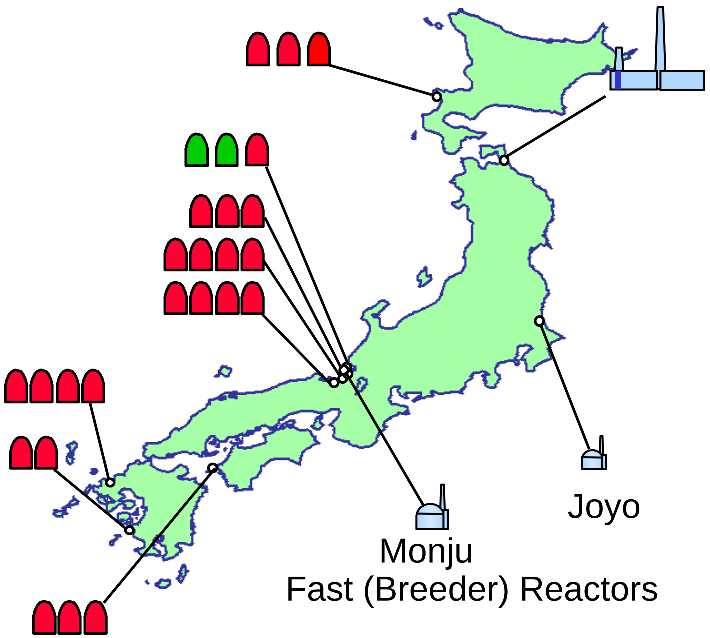


Boiler

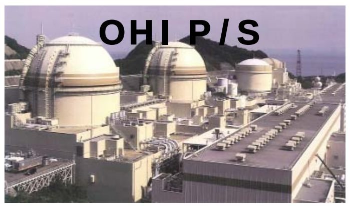
Gas turbine

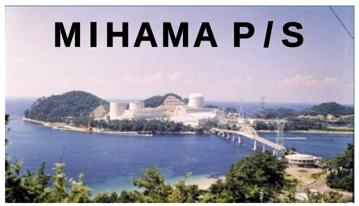
Nuclear Power ; MHI's Extensive Experiences of New Builds





24 PWRs in operation
Tsuruga -3/4 APWRs under Licensing





MHI's Renewable Energy Technologies

・Developed and applied for energy source diversification, reduction of CO_2 emissions and industry revitalization

Wind

Biomass

Photovoltaic

Hydraulic

Geothermal

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Geothermal Power Generation

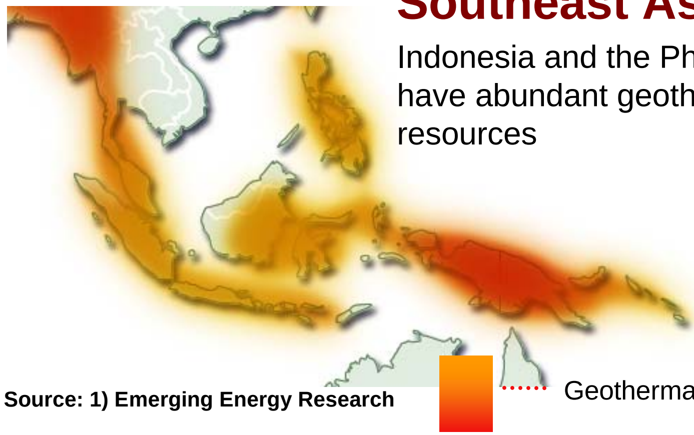
Characteristics of geothermal power generation

1. Low CO_2 emissions
2. Virtually inexhaustible energy source
3. High availability regardless of the weather
   = Stable energy source

MHI's Geothermal ; 25% share and 3.0 GW in the world

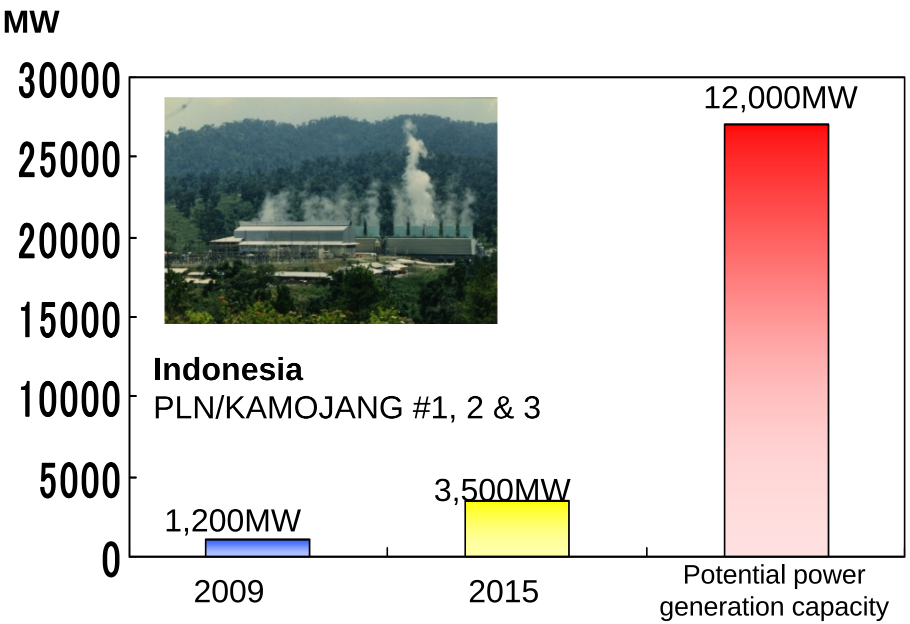
Geothermal resources in Southeast Asia

Indonesia and the Philippines have abundant geothermal resources



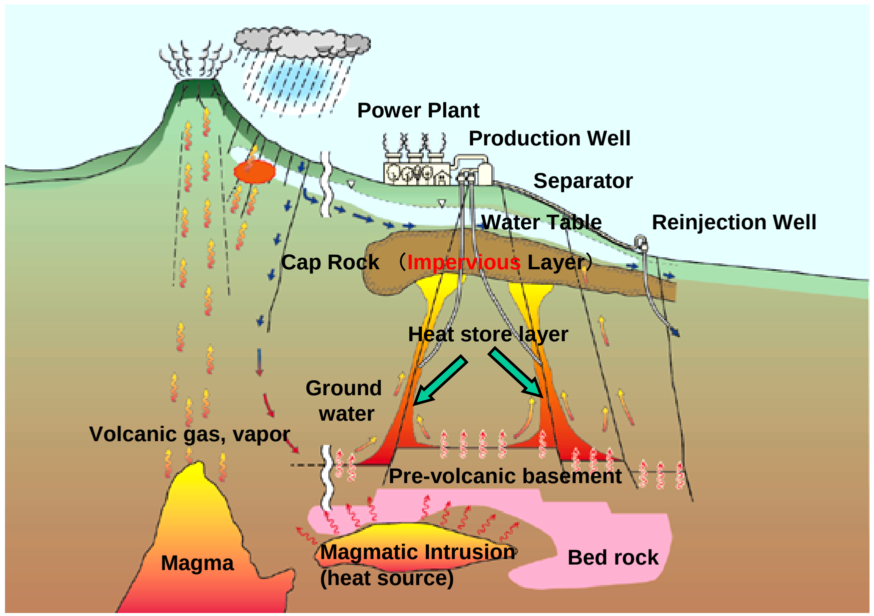
Source: 1) Emerging Energy Research

Example of geothermal energy potential in Indonesia



In 2009, Indonesia's rate of utilization was only 4.4% of its potential power generation capacity

Principles of volcanic geothermal power generation

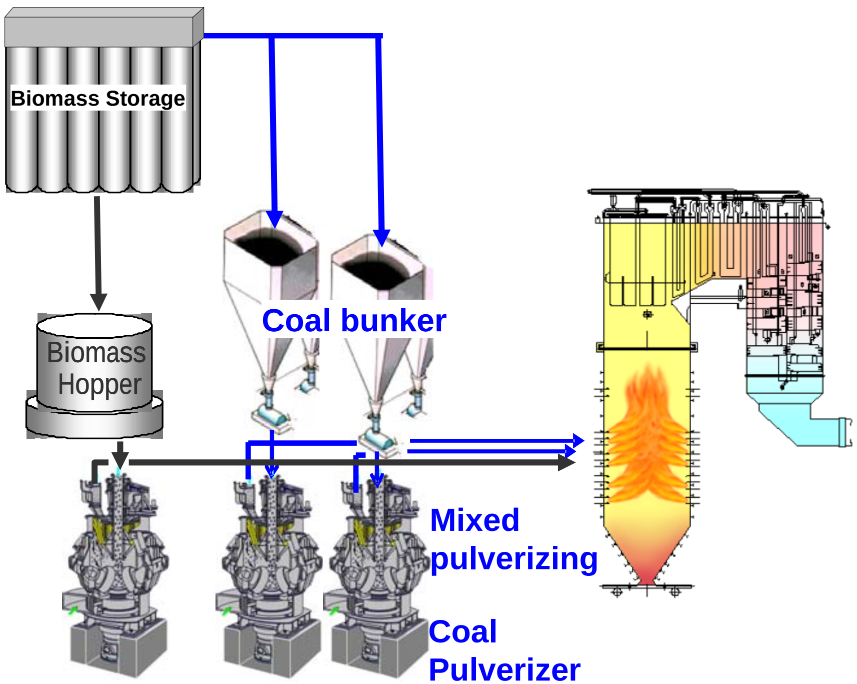


(Source: Geothermal Energy Serial No. 87, July 1999)

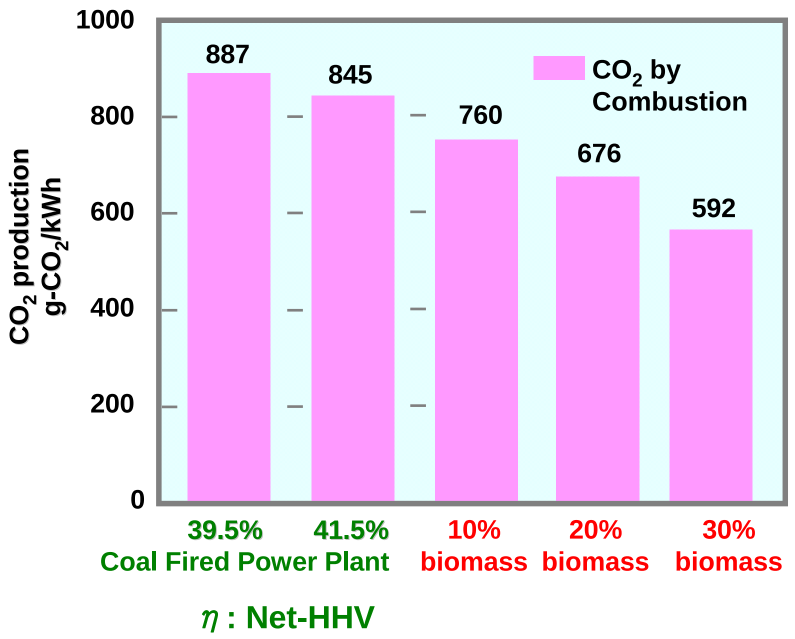
Biomass: Dual Fuel Power Generation with Coal

・Reduction in CO_2 emissions and effective use of lumber materials achieved by co-firing of wood pellets and coal in boiler.

Coal/biomass co-firing power generation system



Reduction Effect of CO_2 by Biomass co-firing

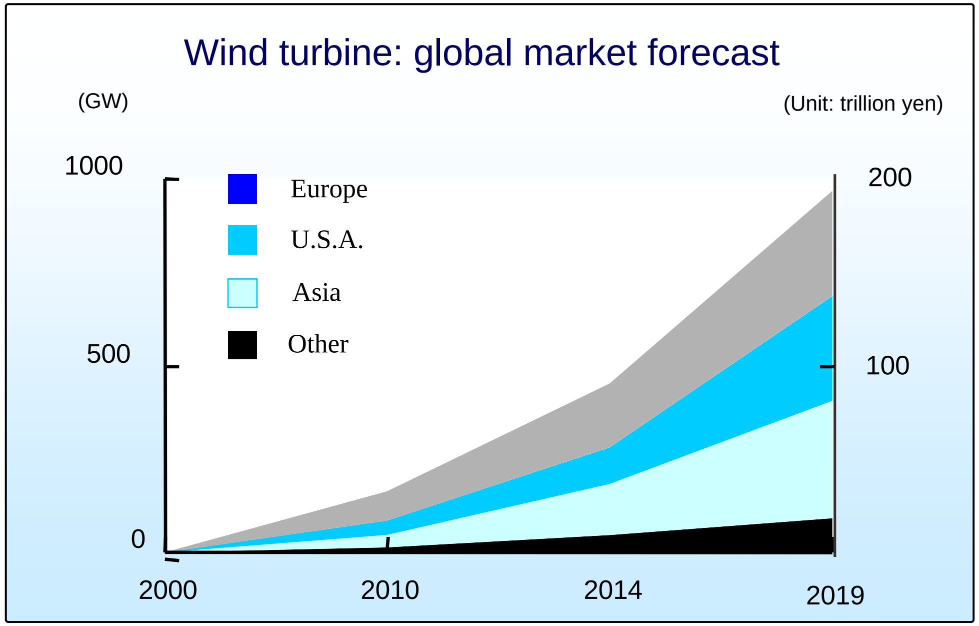


Ref: CRIEPI review No. 44

Wind Power Generation

- Wind power generation: most widely-used renewable energy
- Conventional onshore wind turbines and development of offshore facilities for greater power generating capacity

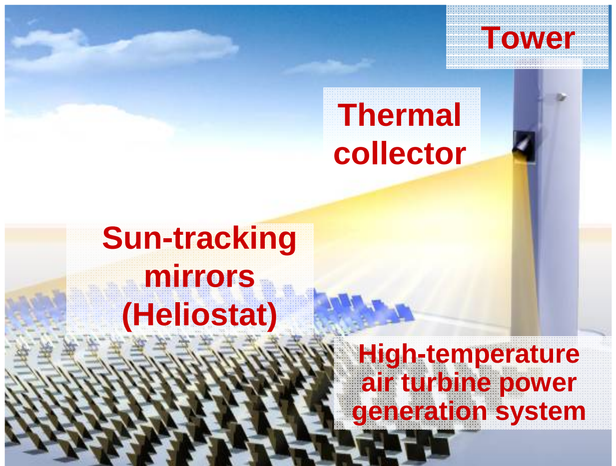
MHI's Wind turbine ; 3,919units and 3.8GW



7MW - 11MW Class Wind Turbine

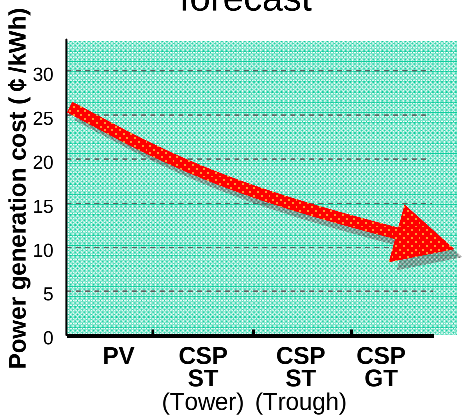
Solar Energy Power Generation

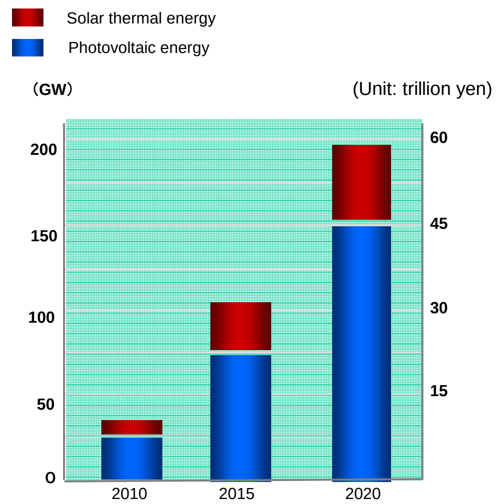
- Photovoltaic modules in growing demand due to preferential policies
- Power generation using concentrated solar thermal energy already put to practical application; development of large-capacity, high-temperature solar air thermal power generation system with high efficiency



High-temperature solar air thermal power generation

Power generation cost forecast

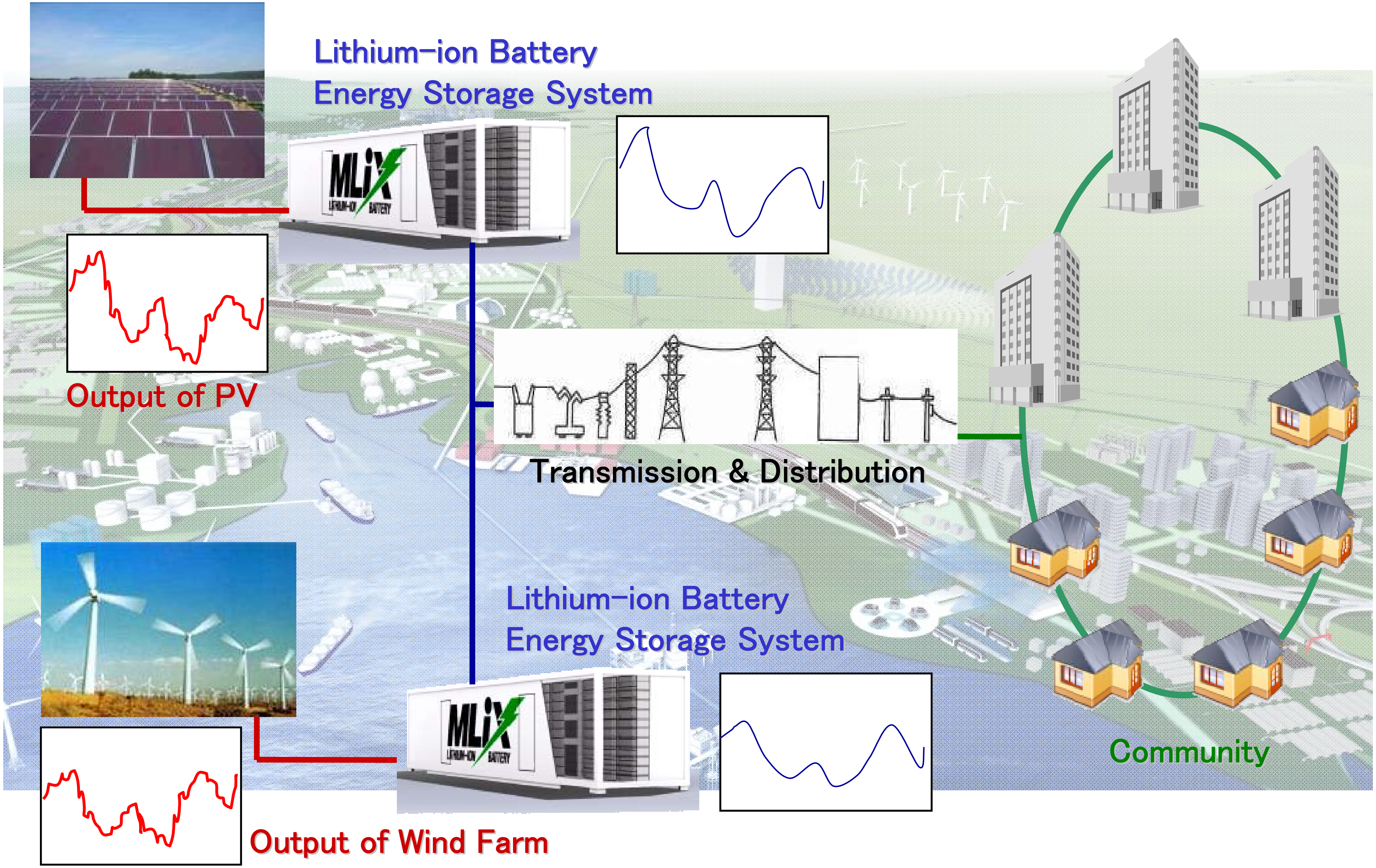




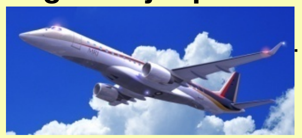
Solar steam thermal power generation

Photovoltaic power generation

Lithium-ion Secondary Battery
Energy Decentralization & Stabilization System



Low-Carbon Emissions in Final Energy Consumption

Area	Technology option	Key aspect	Mitsubishi's Product
Transportation	Improved fuel efficiency	Lightweight vehicles, high-efficiency engines and hybrid vehicles	Electric vehicle  Hybrid forklifts 
	Alternative fuels	Oil-alternative fuels (gas, coal, bio, etc.) and electric vehicles	Lithium-ion batteries 
	Modal shift	Public passenger transport service, marine bullet train system and freight railway transport	Urban transportation (LRT) 
	IT	Advanced traffic control system and efficient truck transport	Traffic control system 
Consumer	Heating/cooling system	High-efficiency heat pump, high-performance insulation and natural energy utilization	Energy-efficient carrier  Next-generation regional jet plane 
	Lighting	High-efficiency light transfer and solar power utilization	
	Appliances	Advanced use of electricity and late-night power usage (increased nuclear power demand)	Organic ELs 
	Regional heating/cooling system	Use of low-temperature heat from river water, manufacturing plants and incineration facilities; thermal energy transport/storage/utilization	
Industry	Waste heat capture/utilization	Industrial heat pump and power generation using low-temperature waste heat	Waste heat capture hot water heat pump  Turbo refrigerator 
	Low-carbon manufacturing	Energy-efficient industrial machinery; shift toward use of low-carbon fuels	

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