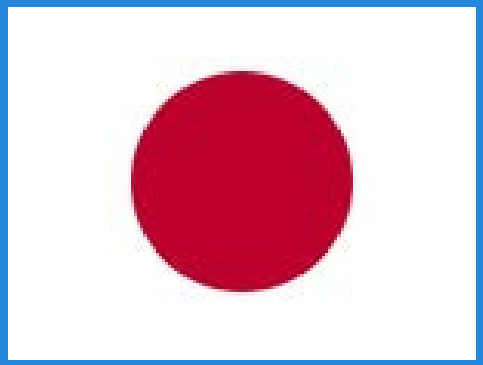
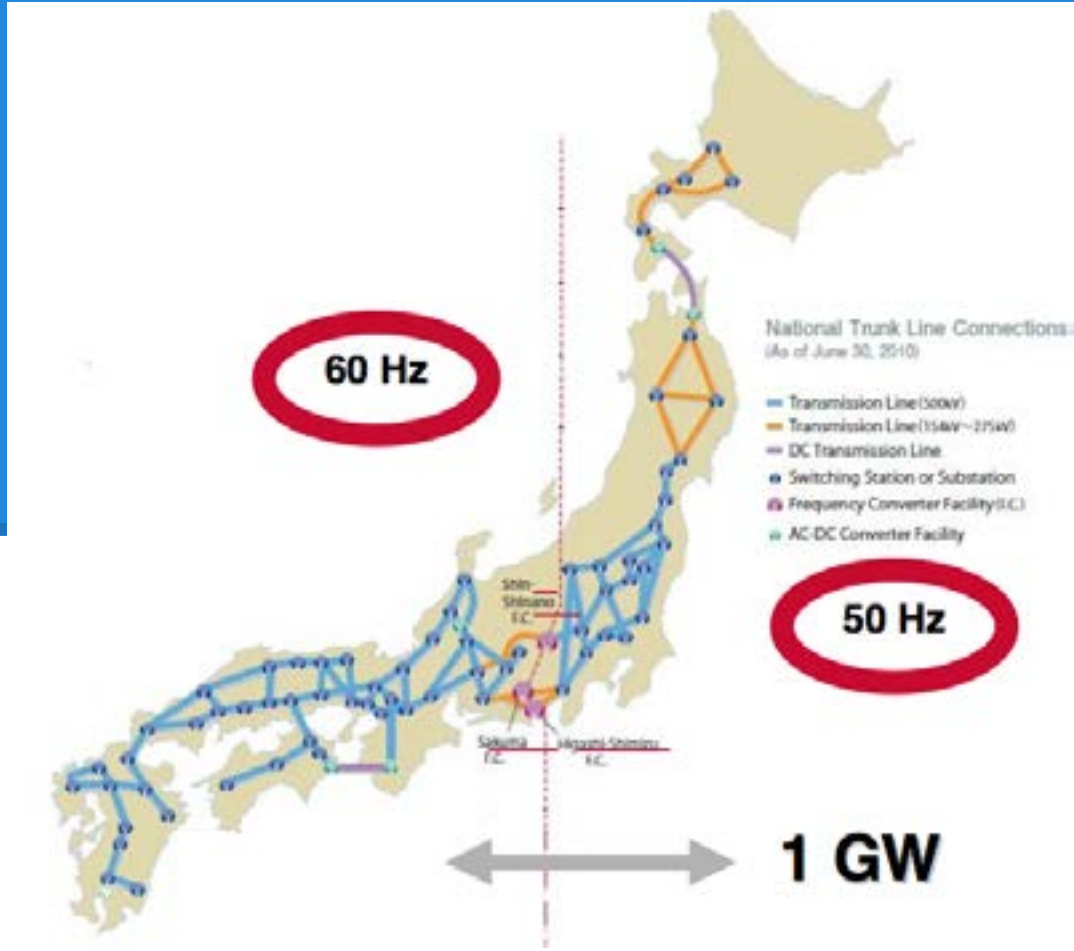
Japan's Energy Future

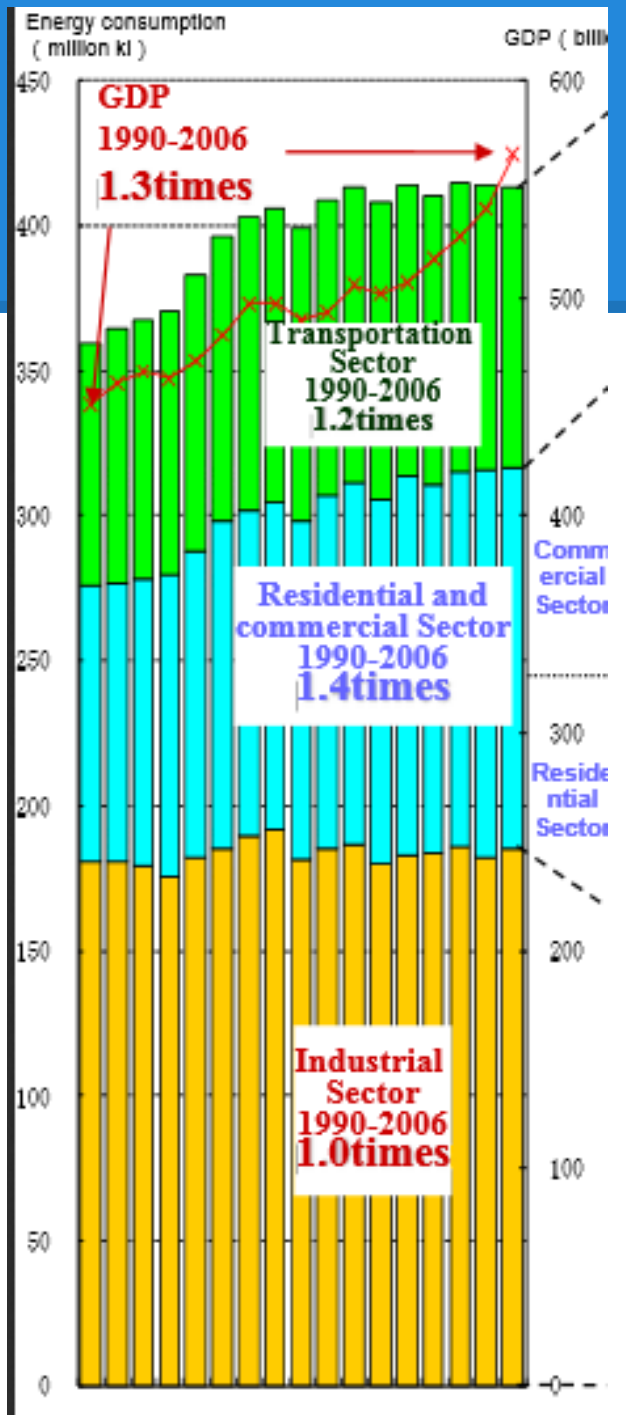


Andu Nguyen
Miguel Carrasco
Joel Logan



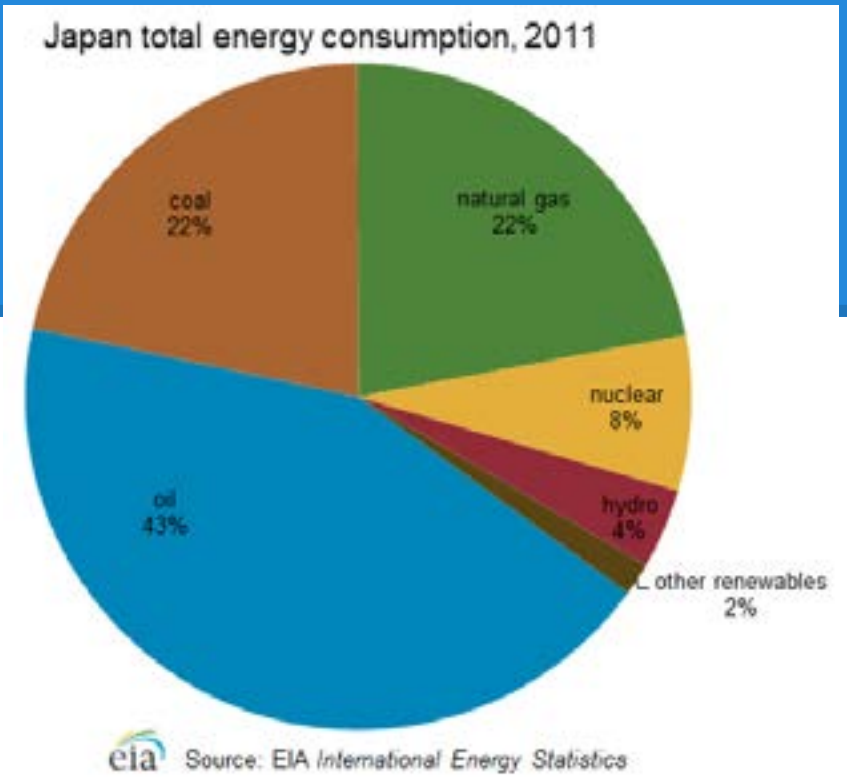
About Japan

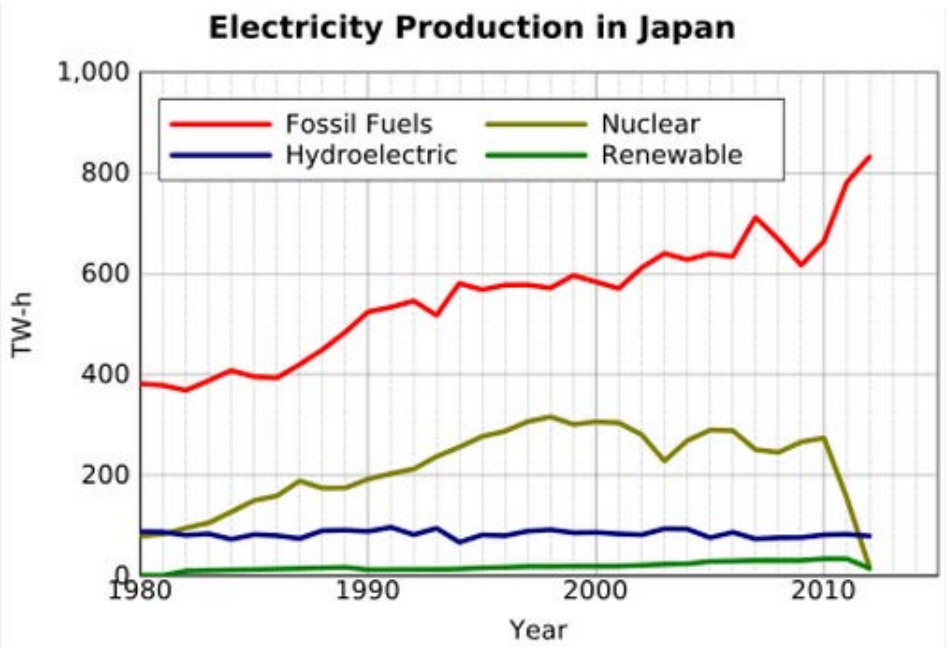
- Highly developed nation, with very limited natural resources, scarcity of space and water, declining population, low economic growth
- Fukushima nuclear disaster, and subsequent shut-down of all nuclear generation
- Extensive, and well operated high speed train system
- Two separate grid systems with different frequencies and only 1 GW of transfer capacity



I.1 Overview of Japan current energy mix

- Population: 126 mil (2012)
- 18th in energy usage per capita (2004). Total usage: 6TWh/ year (4th, 2012)
- 85% energy is from import (250$ billion for fuel import in 2012)
- 1st liquefied natural gas importer, 2nd largest coal importer, & 3rd largest net oil importer (2013)
- 3rd in the world by electricity production, after the US and China (2008)
- 3rd largest nuclear production before 2011
- Highly efficient transportation sector due to short distances traveled, and high use of trains
- Nuclear Regulatory Authority, formed in 2012, must approve reopening based on compliance with new safety guidelines





Future planning

- Japan will turn to oil, gas and coal to make up most of the nuclear shortfall. In May 2013 the government won American approval for imports of cheap shale gas from the US. (Economist, 9/2013)

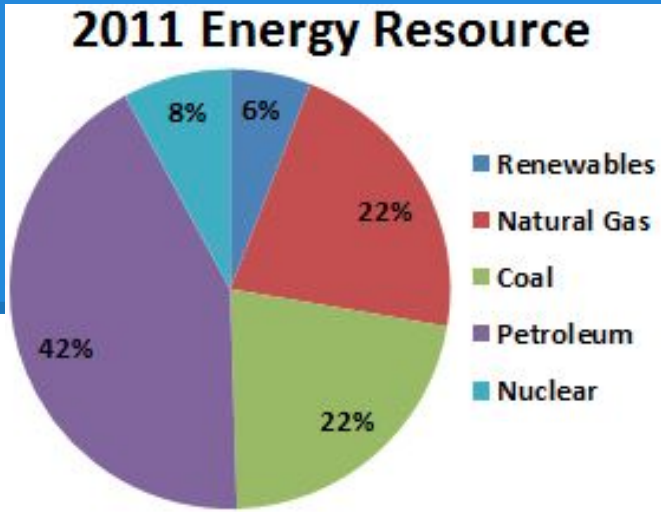
- Scarcity of water, and space. Crowded, mountainous country. A square metre (10.8 square feet) of land devoted to wind power generates just two watts of power. For solar power, the equivalent area generates 20W. Nuclear power generates about 1,000W a square metre. (The Economist, 9/2013)

- A weak grid: division in two frequency areas (german/american equipment). Exchanging capacities between both regions is limited to 1GW, compared to the 118GW capacity in the West grid and 88GW in the East grid (Japan 2050).

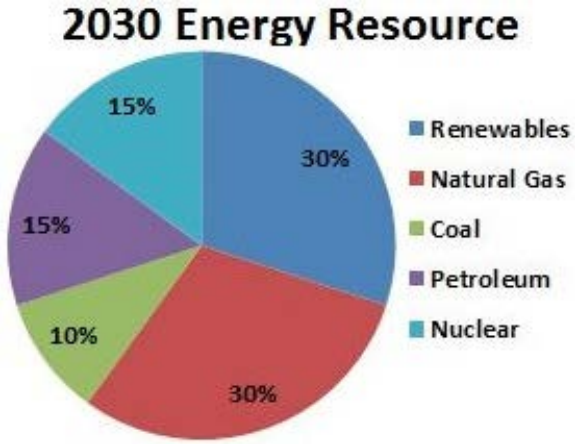
- Vertically integrated utilities operating balancing areas without exchanging power between them.

Future Mix

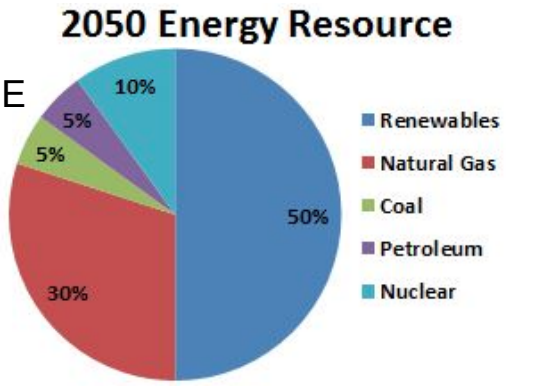
- Before 3/2011 (Fukushima nuclear disaster), 26% from nuclear
- 9/2013: 0% nuclear
- Want to start nuclear again due to high energy import cost.
- Prime minister Abe supports at least 15% nuclear generation.
- 11.2 GW of nuclear has applied to reopen



20% Energy Efficiency (EE)



30% EE

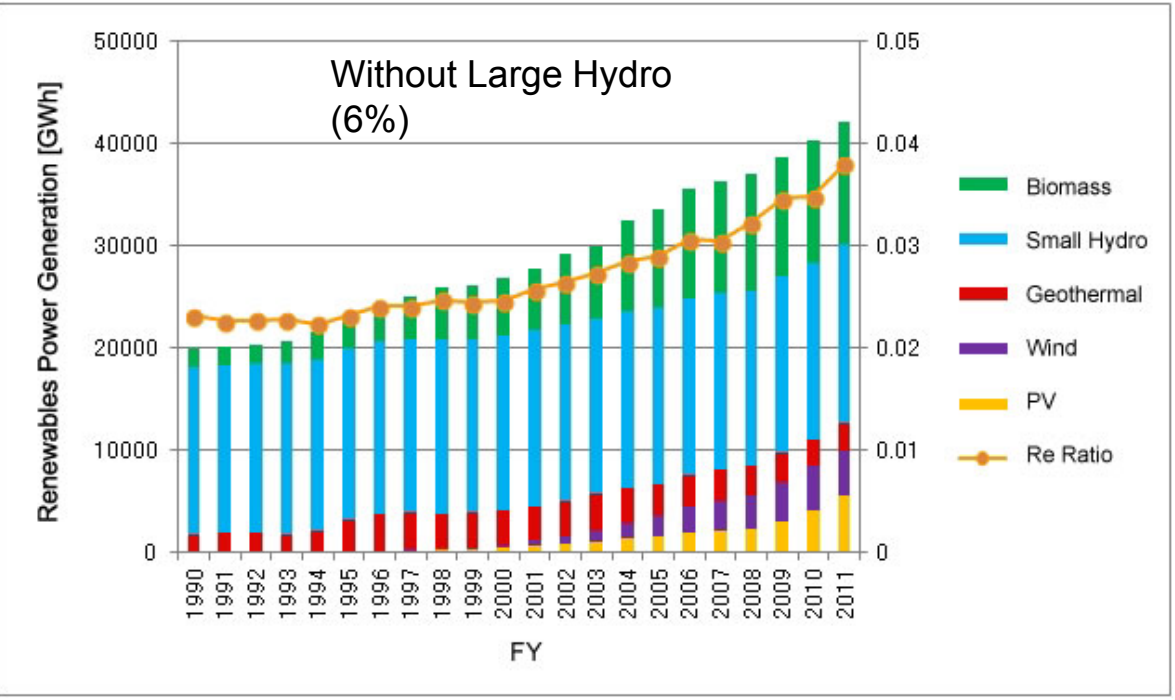


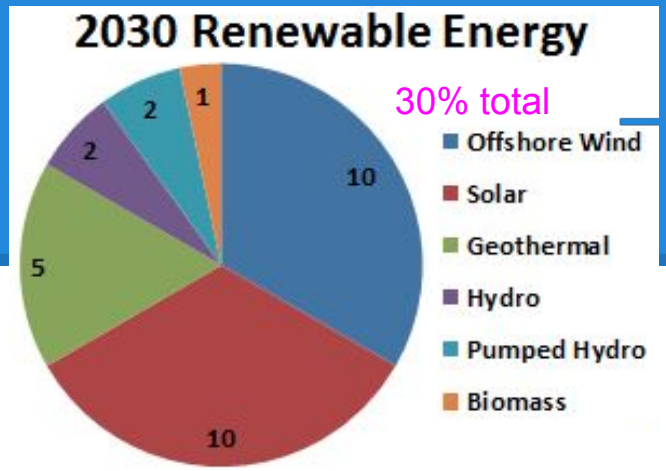
Four options under discussion (Advisory Committee for Natural Resources and Energy, as of June 7):

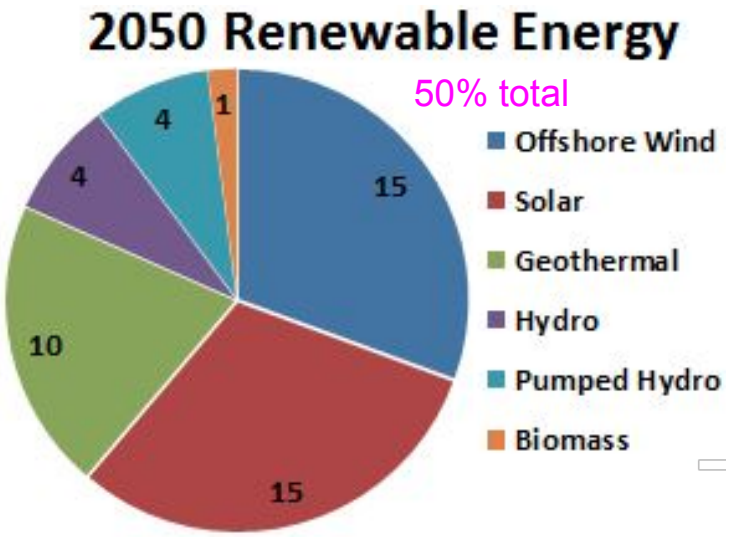
	Nuclear power	Renewable energy	Fossil-fired generation	Cogeneration	Energy conservation (power conservation)	CO_2 emissions (change from the 1990 level)
Option (1)	0%	35%	50%	15%	-20% (-10%)	-16%
Option (2)	15%	30%	40%	15%	-20% (-10%)	-20%
Option (3)	20-25%	25-30%	35%	15%	-20% (-10%)	-23%
(Addition)	35%	25%	25%	15%	-20% (-10%)	-28%

Option (4) Achieving the most desirable generation mix for society by the choice of power consumers in the market after setting up a framework for sharing the social cost (of generation) by utilities (and power consumers)

Current and Future Renewable Mixes



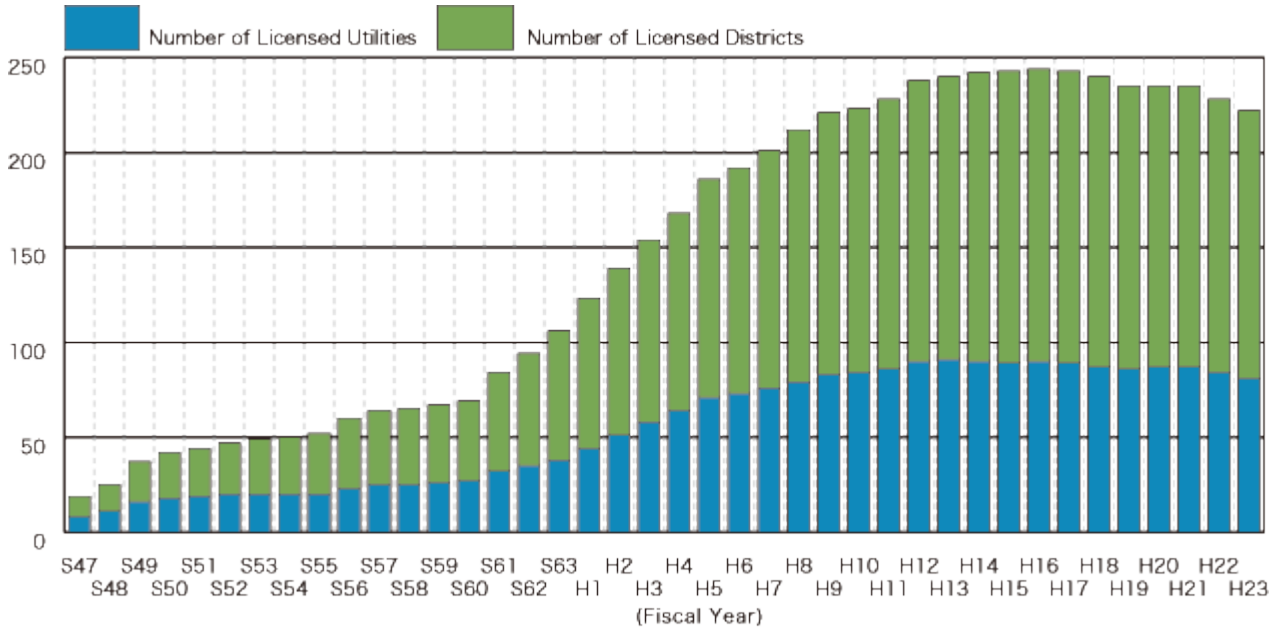




- **Off-shore wind parks**: plenty of space off-shore. No need for water. BUT: Need of a strong grid to integrate them. Wind energy potential is located in the Tohoku and Hokkaido northern areas, while the biggest consumption areas are located in Central Japan (Japan 2050).
- **Rooftop PV**: efficient use of space. Liberalization of residencial energy market and feed-in tariff will help. No need of water. Integration directly into the distribution system. Government approvals for smaller-sized projects of less than 1 megawatt have outnumbered larger projects every month since May 2013 (Bloomberg).

CHP and District Energy Systems

- District heat/cooling providers are public utilities
- New incentives for expansion
- Half of natural gas for CHP and district energy

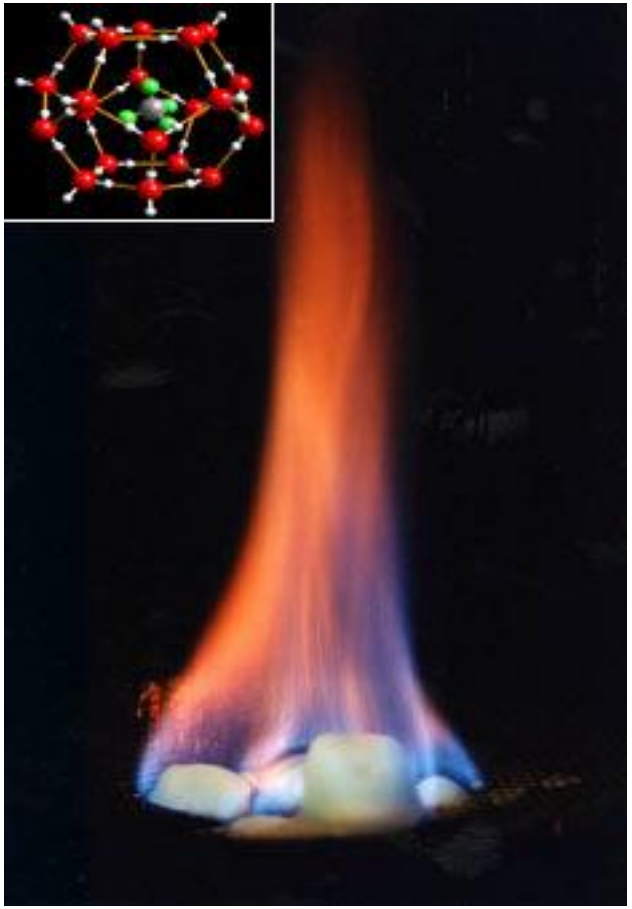


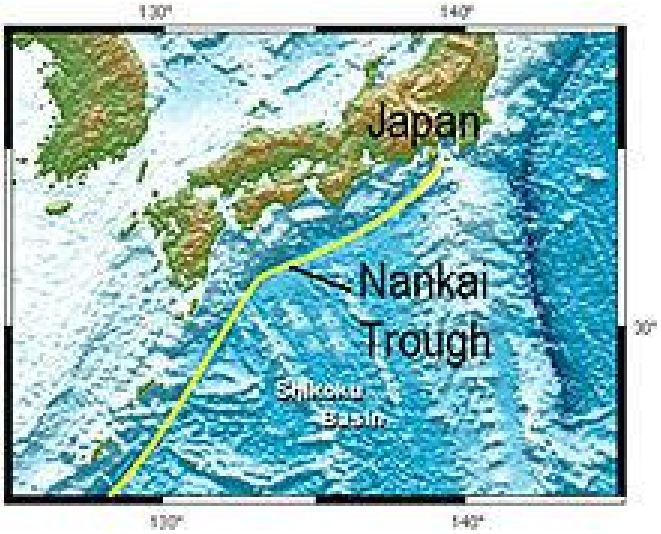
II. How “integrated” will the energy system be?

- Cultural barriers will make integrating systems a challenge
- Electric grid will be more integrated to accommodate renewables
  - Expand HVDC interconnection between
- Transportation will become significantly electrified
  - Light transport vehicles typically travel short distances
  - As renewable electrical production increases, transportation will rely on foreign resources
  - Use charging systems for grid balancing
- Cogeneration expands significantly through district energy systems

Natural Gas in the Sea Bed

- Methane Hydrate-methane trapped in crystalline water
- Initiated 16-year R&D effort in 2001; Goal to start commercial extraction in 2018
- Potential for significant domestic fuel





III. Benefits of the desired future mix

1. **Economically**: optimal use of scarce resources like space and water. Reduced imports of fossil fuels by increasing the share of renewables.
2. Increase **reliability and security of supply** through new HVDC ties.
3. **Environmental**: reduced emissions thanks to a high penetration of pv, and off shore wind.

IV. Technical and regulatory innovations

Technical innovations:

- Electrical interconnection with South Korea, possibly Russia and China.
- New HVDC ties between the 50Hz and 60Hz grids.
- Advanced algorithms to dispatch the electric grid integrated with a high number of small-scale generators.

Regulatory innovations:

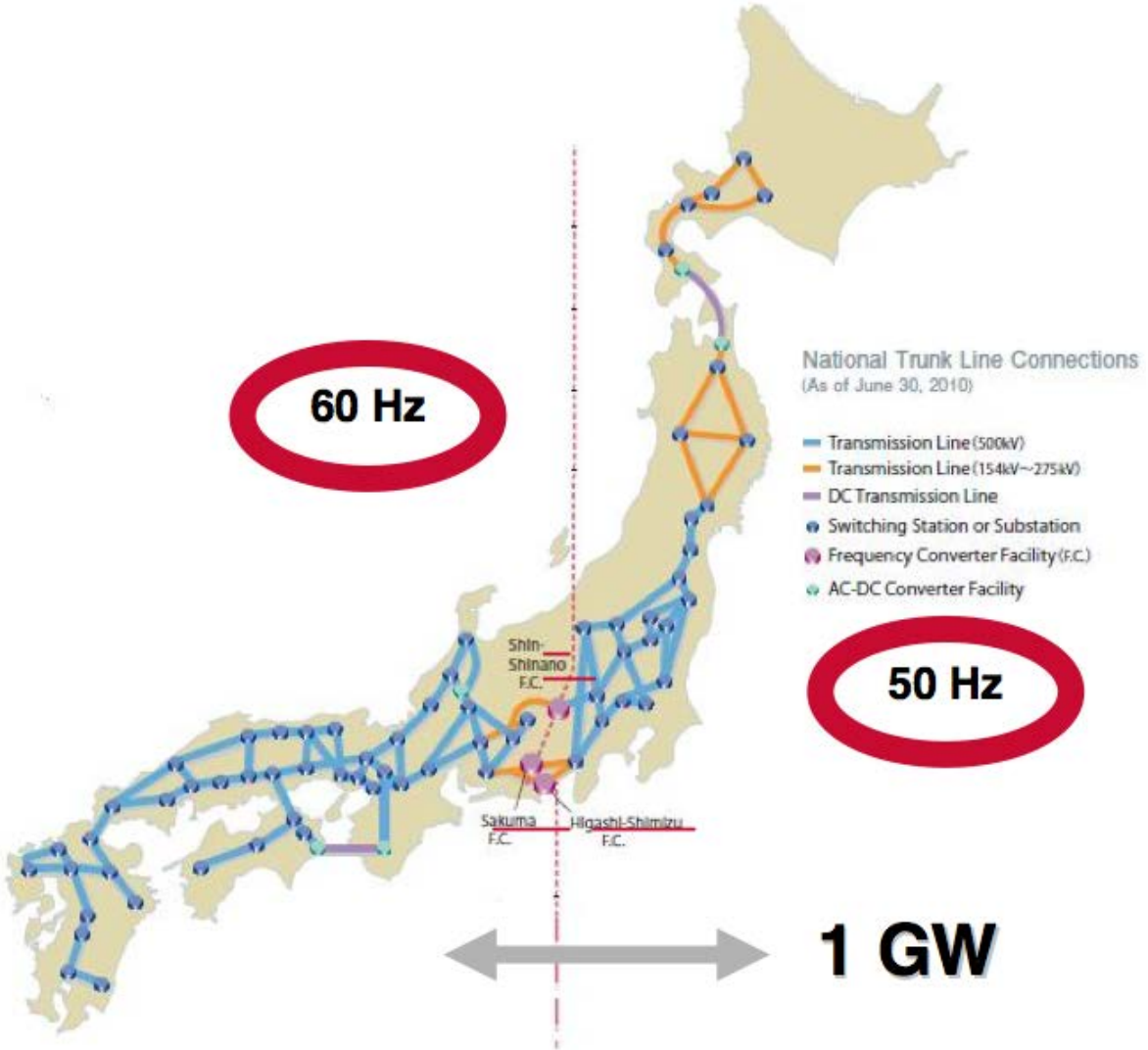
- New regulation to promote the penetration of small-scale solar.
- New regulation to enforce utilities to exchange a greater amount of power between balancing areas.

Currently, government's plan is to split generation and transmission with the residential electricity market open to new competition: the public would have a say over energy choices. (The Economist, September 2013). Furthermore, a relatively high feed-in tariff (38 cents per kilowatt-hour) is since 2011 in place with a ten-year term for small rooftops and twenty years for larger installations.

V. What tools/ techniques will be required to accomplish this

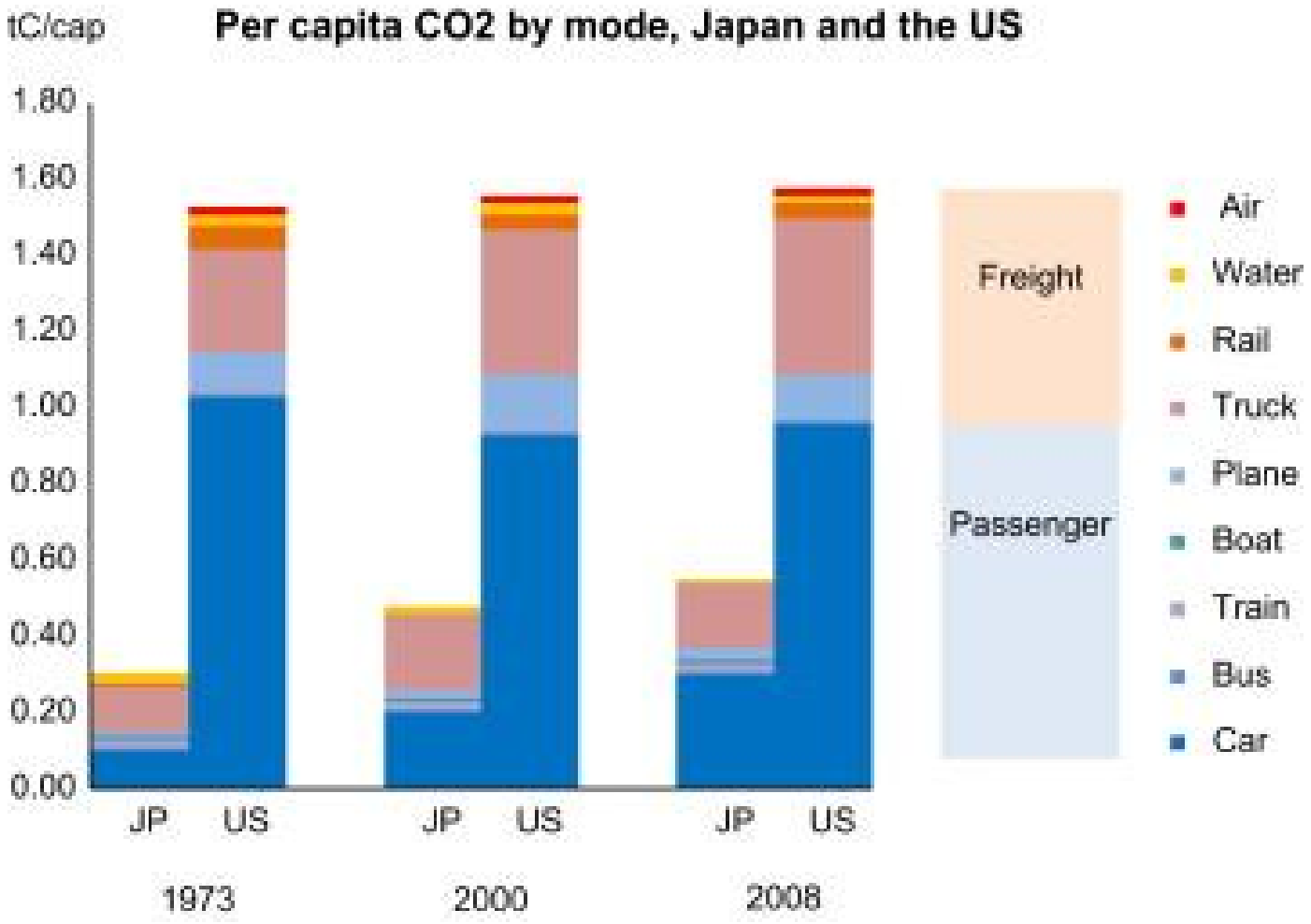
- Expanded energy efficiency codes & efforts
- New tools to evaluate the impact of small-scale PV.
- Significant funding for methane hydrate R&D and development
- Continued support for feed-in tariff

Thank you! Any questions?



Back up slides

Transportation



http://www.sciencedirect.com/science/article/pii/S0301421512010981

Possible Future Regulation

Policy

- A new,strengthened nuclear agency, the Nuclear Regulation Authority (NRA), must declare any plant safe before it starts. (The Economist, September 2013)
- Governmental party contains increasingly more critics of nuclear energy. (The Economist, September 2013)

Outline

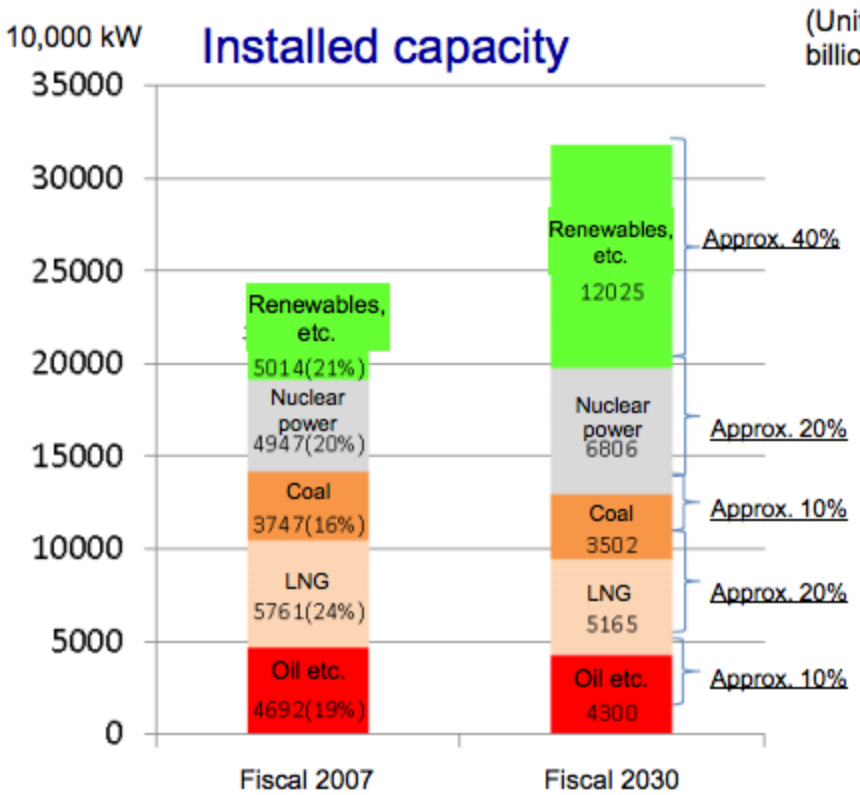
I. What will be the energy mix be in 2030 & 2050?
II. How “integrated” will the energy system be both across domains and scales?
III. Give examples of the above and justify them on the basis of their benefits (economically, reliability, security of supply, environmental) e.g. thermal capacity in buildings for grid services.
IV. Technical and regulatory innovations required to get to the desired future energy system.
V. What tools/ techniques will be required to accomplish this?

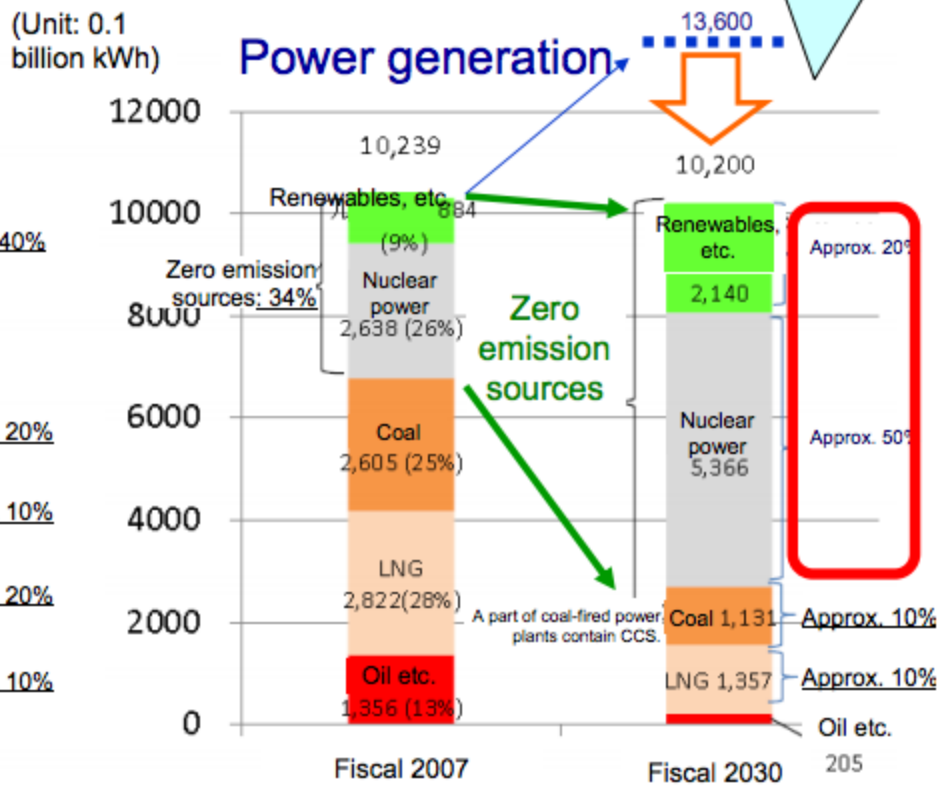
2010 Energy Plan

2) A basic energy plan to address 3E was determined in 2010② : Generation Mix

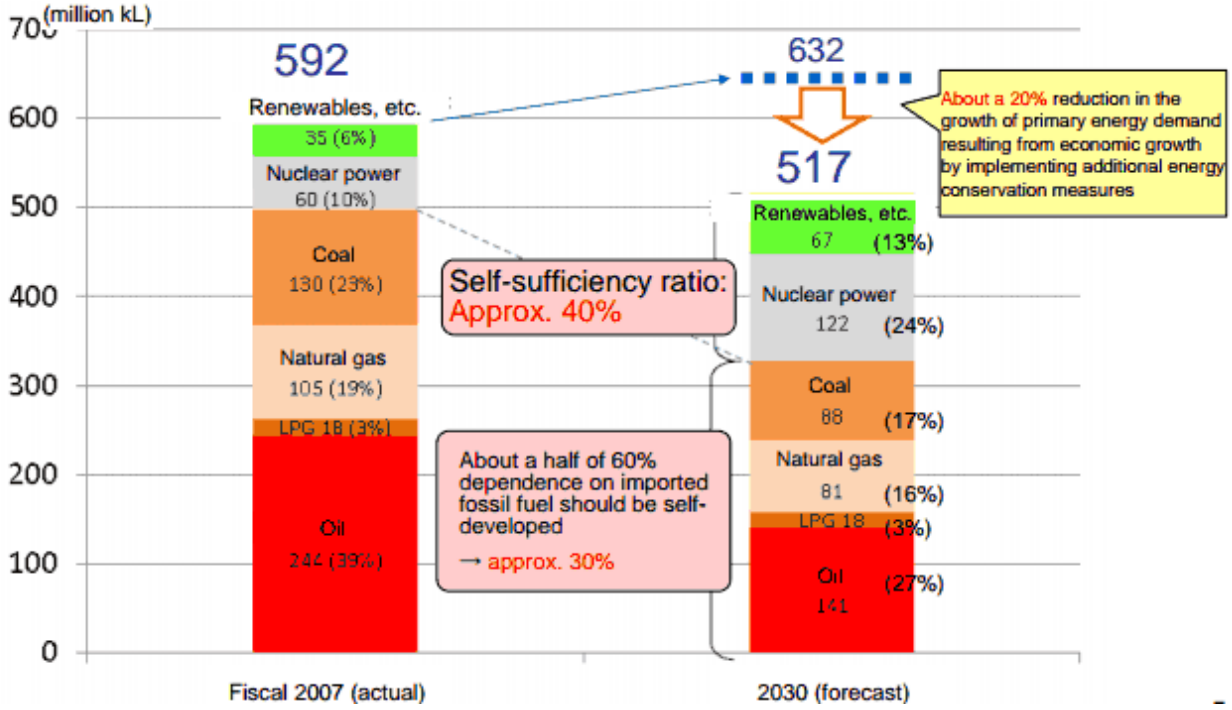
- Building 14 reactors at new and existing sites and improving the operating ratio from 60% to 90%
- Increasing the introduction of renewable energy by 2.4 times (by 15 times, excluding hydropower)
- Increasing the proportion of zero-emission power sources from 34% to ~70%

About a 30% reduction in the growth of electricity demand resulting from economic growth by implementing additional energy conservation measures





Energy Efficiency



- By 2015 incandescent and fluorescent lights will be nearly a thing of the past being replaced by LED technology. (The Economist, September 2013)

- Top Runner program implements energy efficiency standards

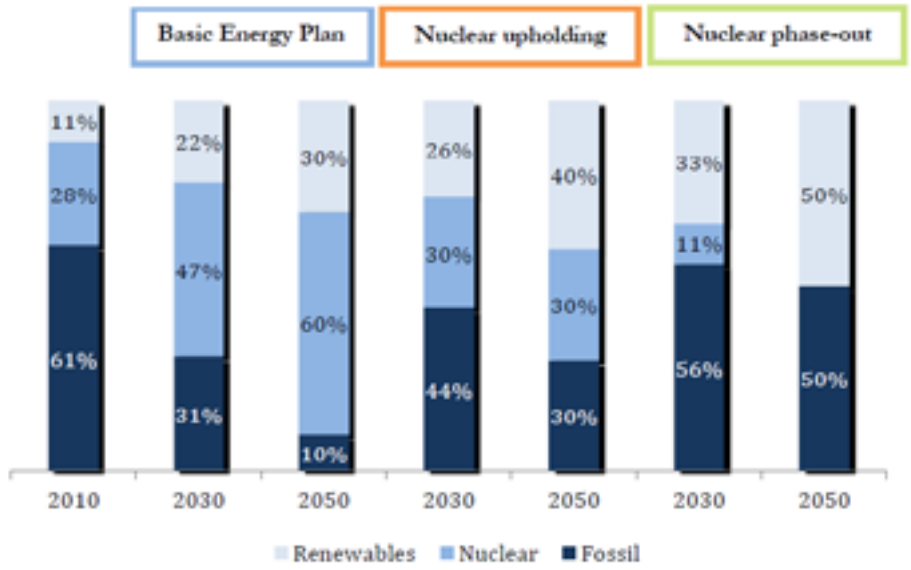


Figure 25: Electricity mix in 2030 and 2050, under the three studied scenarios

Climate Change Goal: In 2013 announced goal of 3.8% reduction from 2005 levels by 2020. Results in 3% increase from 1990 levels. Previous goal 25% decrease from 1990 levels (Reuters, 2013)

Forecasted Mix

“Options for the Japanese electricity mix by 2050”

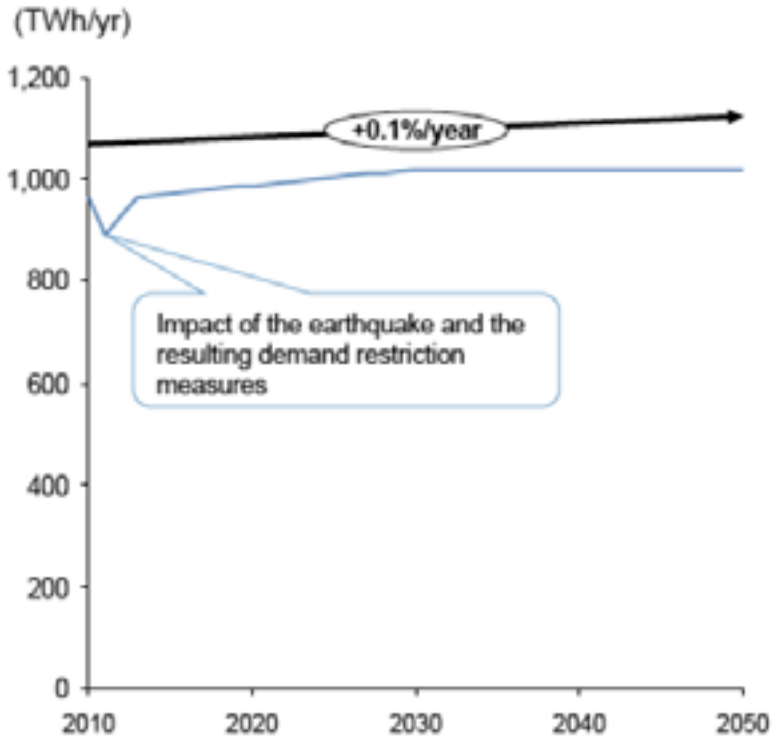


Figure 24: “Strategic Energy Plan” electricity demand reference scenario ([3])

Renewable Future Mix