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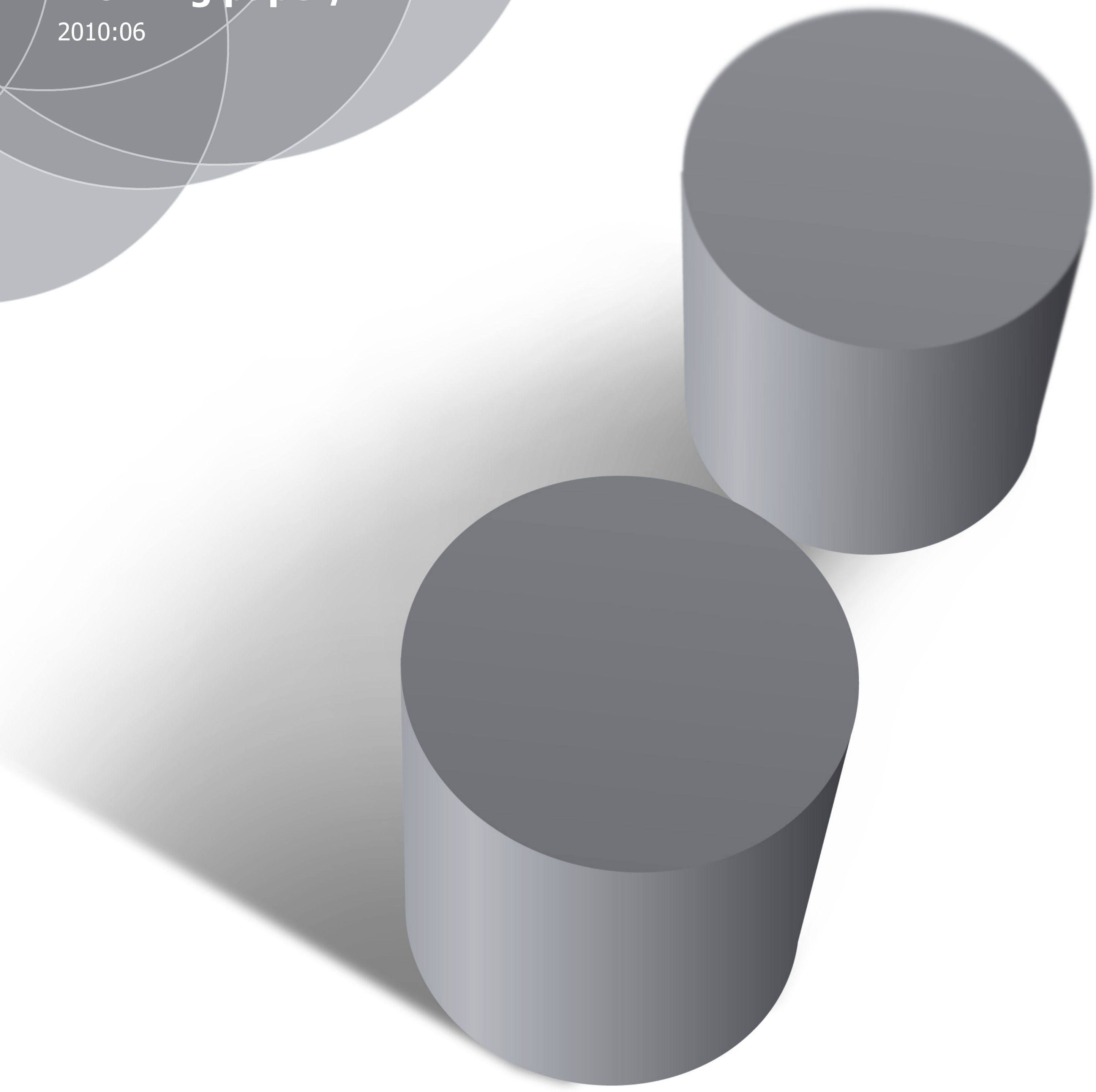

Japan's Energy Situation

Trends in Policies and Technologies

Japan is one of the world's largest energy markets. With few domestic natural resources, Japan is heavily dependent on imports of primary fossil fuels for its energy supply. Japan also has world-leading technologies in areas such as photovoltaics, hybrid- and electric vehicles and nuclear power generation. Other areas, such as biomass are less prominent.

growth analysis

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Swedish Agency for growth policy analysis
Studentplan 3, S-831 40 Östersund
Phone +46 10 447 44 00
e-mail: info@growthanalysis.se
www.growthanalysis.se
For more information contact
Anders Karlsson, Tokyo
Phone +81-3-5562 5030
e-mail anders.karlsson@growthanalysis.se

Förord

Global hållbar utveckling är till stor del en fråga om en stabil och hållbar energiförsörjning. Den tekniska utvecklingen kring förnybara, såväl som icke-förnybara energikällor har därför accelererat på många håll i världen.

Rapporten är framtagen för att öka kunskapen hos svenska beslutsfattare inom departement, myndigheter och näringsliv kring utvecklingen i Japan som både är en av världens största energimarknader och har världsledande teknik inom vissa specifika energiområden.

Japan har väsentligen inga egna naturresurser och är i hög grad beroende av importerade fossila bränslen. För att minska det fossila beroendet har Japan satsat mycket på att utveckla världsledande energiteknisk forskning och innovation. I områden som kärnkraft, solcellsteknik, energieffektivisering, hybrid- och elfordon, har Japan världsledande företag och har initierat en rad nya forskningsprogram och offentliga åtgärder för att främja utvecklingen mot kommersialisering av hållbar energiteknik.

Japansk energiteknik är även klimatpolitiskt av stor betydelse med en växande teknikexport av effektiv energi- och miljöteknik till Kina och Indien och andra snabbväxande ekonomier.

Rapporten är beställd av Tillväxtanalys och framtagen under september 2010 av den japanska konsultfirman E-Square Inc. Företaget har stor erfarenhet av miljö- och energianalyser i Japan och har breda nätverk vid japanska myndigheter och företag.

Projektet har letts av Izumi Tanaka, analytiker vid Tillväxtanalys Tokyo. Kontaktperson i Sverige har varit Martin Flack, temaansvarig analytiker för området hållbar utveckling. Izumi Tanaka och Anders Karlsson, kontorschef och teknisk vetenskaplig attaché har kontinuerligt under projekts gång fört en dialog med E-Square kring rapportens innehåll, granskat texter och bistått med faktaunderlag.

För Tillväxtanalys,

Stockholm, november 2010
Enrico Deiaco
Avdelningschef Innovation och Globala Mötesplatser

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Sammanfattning

Rapporten beskriver Japans energisituation vad avser forskning, teknik och policy, samt diskuterar möjligheterna för svensk export av energiteknik och kunnande. Japan är numera världsledande i ett antal energirelaterade teknikområden och därför av intresse både som marknad, samarbetspartner och för policylärande.

- Beroendet av fossila energikällor har minskat efter de två oljekriserna på 1970-talet, men är fortfarande 84 procent av det totala energibehovet, varav olja står för drygt hälften och kol och naturgas för en fjärdedel var. Resterande 16 procent utgörs till hälften av kärnkraft och till hälften av vattenkraft och olika förnybara energikällor som bioenergi och solenergi. Andelen förnybar energi som andel av primärenergin idag är 3,2 procent 6,4 procent inklusive vattenkraft och geovärme) . Solceller (Photovoltaics-PV) ses som det viktigaste området för tillväxt både nationellt och för export.
- Efterfrågan på energi har ökat i Japan liksom i övriga industriländer i takt med att inkomster och produktion har stigit. I industrin har dock förbrukningen varit ungefär densamma sedan 1970-talet – energieffektiviteten här har därmed ökat markant. I övriga sektorer har däremot energikonsumtionen ökat kraftigt under samma period.
- Energieffektivisering av konsumentprodukter - vitvaror och personfordon - främjas genom offentliga åtgärder i exempelvis "Top Runner"-programmet och "ECO-punktscheman".

Energiteknik i Japan

- På utbudssidan är utveckling och spridning av PV en stark drivkraft, tillsammans med ökad forskning och utveckling av biobränslen. Kärnkraft och effektiv kraftproduktion via fossila bränslen (naturgas och kol) är också viktiga områden för fortsatt forskning och utveckling.
- På efterfrågesidan har EV / PHVs och energisnåla byggnader stimulerat en avsevärd snabb och betydande teknikutveckling.
- Behovet att förbättra elnätets prestanda för att rymma storskalig introduktion av förnybara energikällor har medfört att storskaliga satsningar planeras inom "Smart Grids" och "Smart Communities".

Exempel på möjligheter för svenskt näringsliv i Japan (slutsatser från E-square summerade i de första två punkterna, därefter kompletterade av Tillväxtanalys)

- Produktion av termisk energi från biomassa är ett område för framtida tillväxt. Exportmöjligheter finns för svenska företag för att tillhandahålla teknik såsom torkning av virke för biomassa och pelletstillverkning. Värdekedjan kring hur termisk energi från biomassa kan tas tillvara är också ett område där svenska företag kan bidra med bl a ledarskap och systemkunskap för att stödja framtida japanska projekt.
- Effektiv hantering av lokala förnybara energikällor, i synnerhet kring termisk energi (fjärrvärme), har möjligheter till stora förbättringar i Japan. Användning av spillvärme från fabriker och avfall är ett område där svenska företag kan erbjuda teknik- och konsulttjänster.
- Stora möjligheter finns för samarbete kring *smart grids* och *smart communities*. Systemlösningar som tas fram inom Symbiocity och projekt såsom Norra Djurgårdsstaden, kan liksom tidigare Hammarby sjöstad förväntas möta stort intresse från japansk sida.
- Japansk elbilsteknik och systemlösningar kombinerade med svenska systemlösningar kan vara av intresse för ”återexport”.
- Japansk starka kärnkraftssektor har varit av stort intresse från svensk sida via SKB och Studsvik, och kan fortsatt förväntas vara av stort intresse, både för samarbete kring slutförvaring och möjliga framtida svenska investeringar.
- Svensk cleantech och unika lösningar, tex. inom solcells- och nanoteknik är av stor relevans när japanska företag ställer om till grön innovation.
- Japans fortsatta starka satsningar mot grön innovation är intressanta att följa kontinuerligt för policylärning.

Summary

1. Energy Situation in Japan

   - Dependence on oil has been declining after the two oil crises in the 1970s. The major sources of energy are fossil fuels (natural gas and coal) and nuclear power. Nuclear power is being promoted to achieve a low-carbon society.
   - Energy demand has been increasing, although consumption in the industrial sector has remained roughly the same since the 1970s. The commercial/ residential sector and the transport sector are seeing sharp increases.
   - The target for the amount of renewable energy for primary energy supply was earlier in 1966 set to 6 % for 2010 (including hydro- and geothermal power), which now have been met, and for 2020 the projection is 9 %.
   - Energy efficiency in appliances and passenger vehicles are promoted through government subsidies and support measures.

2. Energy Technology in Japan

   - On the supply side, the development and deployment of photovoltaic energy is gaining strong momentum, along with the acceleration in the research and development of biofuels. Nuclear power and high efficiency fossil fuels power generation (natural gas and coal) are also key areas of continuing research and development.
   - On the demand side, electric cars and high-efficiency houses/buildings have made considerable improvements in their technologies.
   - In the cross-cutting areas, the need to improve performance of the electric grid to accommodate large-scale introduction of renewable energies and to enhance communication between diverse power supplies has made the realization of both the “Smart Grid” and the “Smart Community” an opportunity and a challenge.

3. Opportunities to Expand Swedish Business and Technology in Japan

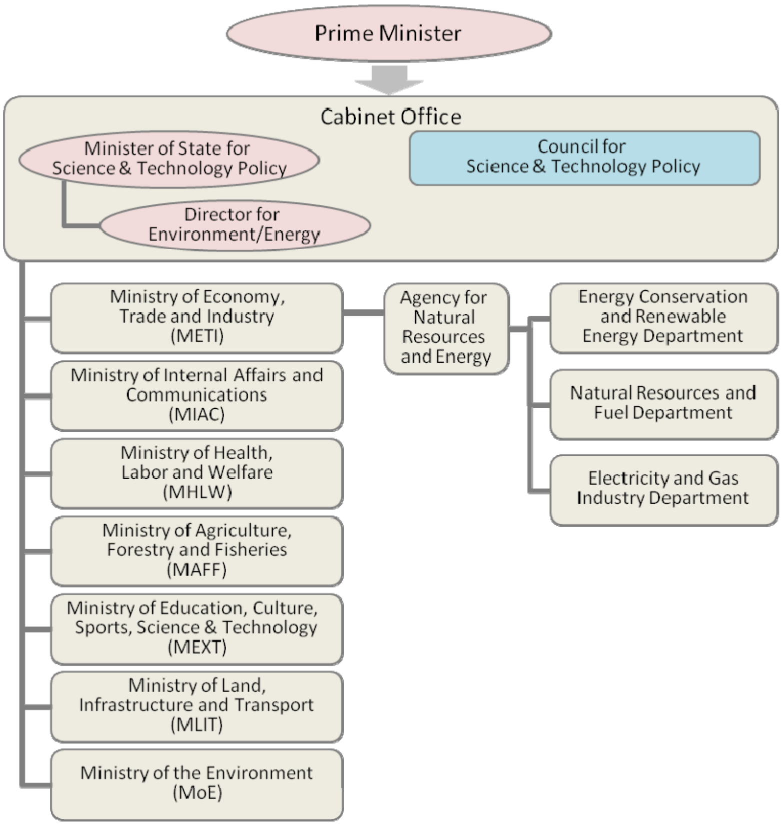
   - Energy policy and strategy in Japan are focused on electric power and its role in the realization of the “Smart Grid” and “Smart Community”, with less emphasis on thermal energy and unused energy.
   - Production of thermal biomass energy using unused wood biomass (including forest residue) is an area of future growth. However, as the problem of cost effectiveness with Japanese technology is difficult to overcome, there are opportunities for Swedish business to provide technologies such as drying of wood for biomass and pellet production. The “value chain creation” concept for thermal biomass energy is also an area where Swedish business can provide thought leadership to support future Japanese projects.
   - Efficient management of local renewable energy, in particular for thermal energy, has opportunities for large improvements in Japan. Acquisition of secondary energy (unused thermal energy) from factories and waste are neglected and is an area where Swedish businesses can provide technology and consulting for Japanese cities and smaller communities.

Notes on Japan's Energy Situation

I. Political Structure for Energy

The Ministry of Economy Trade & Industry (METI) controls the energy policy in Japan. (Figure 1) The Liberal Democratic Party (the previously ruling party) held close ties with the 10 major electric suppliers and strengthened policies and strategies towards achieving a low-carbon society. The Democratic Party of Japan (the ruling party since September 2009) is less focused on a low-carbon society, but positions "green innovation" (including renewable energy) a key area for economic growth.

Figure 1: Political Structure for Energy[1]



*Ministries will be referred to in their acronyms in this report.

II. Role of New Energy and Industrial Technology Development Organization (NEDO)

Originally established as a semi-governmental organization in 1980 and reorganized as an Incorporated Administrative Agency in 2003, NEDO undertakes the development of new

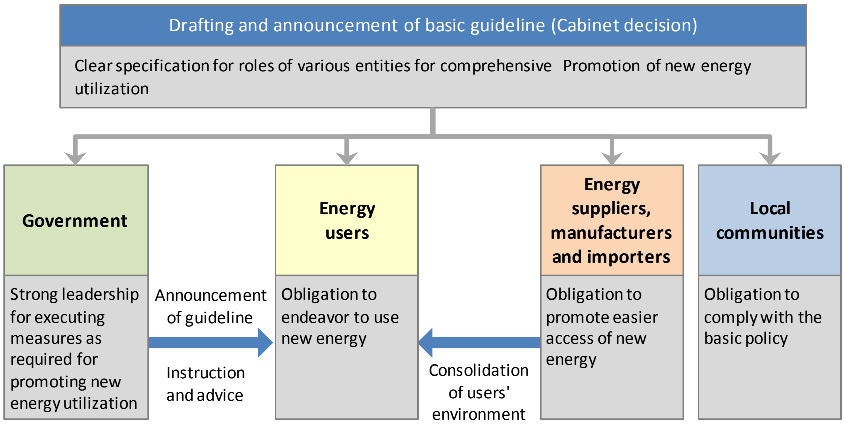
[1] *Created by E-Square Inc. based on information from the Council for Science and Technology Policy Website and Agency for Natural Resources and Energy Website, "Organization": http://www8.cao.go.jp/cstp/english/about/administration.html http://www.enecho.meti.go.jp/english/outline/index.html*

energy and energy-conservation technologies, verification of technical results, and introduction/dissemination of new technologies (e.g. support for introduction) that individual private enterprises alone are incapable of implementing. NEDO currently employs 1,000 personnel (as of April 2010) and operates under a budget of 209.7 billion JPY（17.5 billion SEK） for FY2010.[2]

III. Summary of Players for Renewable/New Energy Policy Making

In June 1997, a law was enacted to facilitate the introduction of new and renewable energy. This Law states that "any person involved in energy has an obligation to strive for the introduction of new and renewable energy," and on that basis the government has been implementing policy measures geared towards accelerating the introduction of new and renewable energy.[3] (Figure 2).

Figure 2: Basic Structure of the “Law on Special Measures for Promotion of New Energy Utilization” [4]



IV. Electricity Market Structure in Japan

In Japan, the electricity market is divided up into 10 regulated electricity suppliers which cover 10 regions separately. They monopolize most of the market and the grid, and as they are the largest companies in each region, they consequently are also one of the most influential political actors both in national and local governments. Since 1995, due to deregulations in the industry, some independent Power Producer and Suppliers (PPSs) have been slowly entering the market.

The standard voltage at power outlets is 100 V, but there are two frequencies in use: 50 Hz in Eastern Japan and 60 Hz in Western Japan

[2] *New Energy and Industrial Technology Development Organization Website, “About NEDO”: http://www.nedo.go.jp/english/introducing/mis_poli.html*

[3] *New Energy Foundation Website, “Implementation of New/Renewable Energy”: http://www.nef.or.jp/english/new/implement.html*

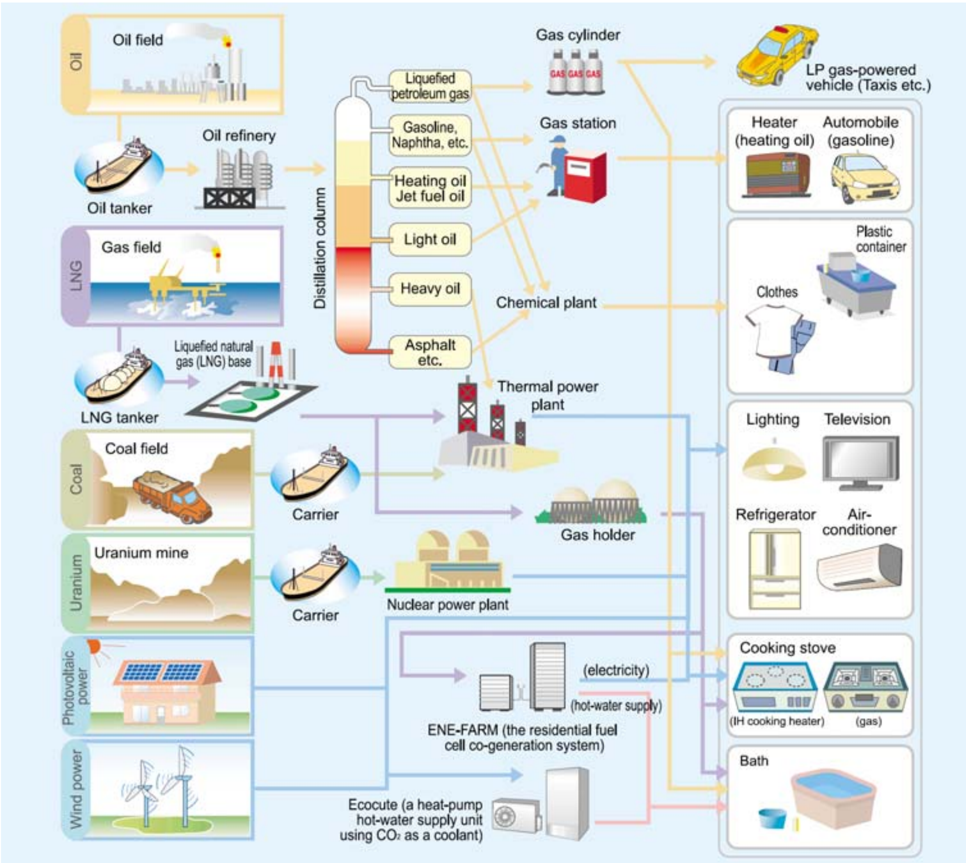
[4] *(same as above)*

1 Energy Situation in Japan

1.1 Energy and Japanese Society

Japan's society and livelihood relies on a large quantity of energy resources for transportation, communication and almost every aspect of modern society, not to mention electricity, gas, and water services which are essential to daily life. (Figure 3)

Figure 3: Process of Energy Supply and Consumption in Japan[5]



1.2 Energy Supply

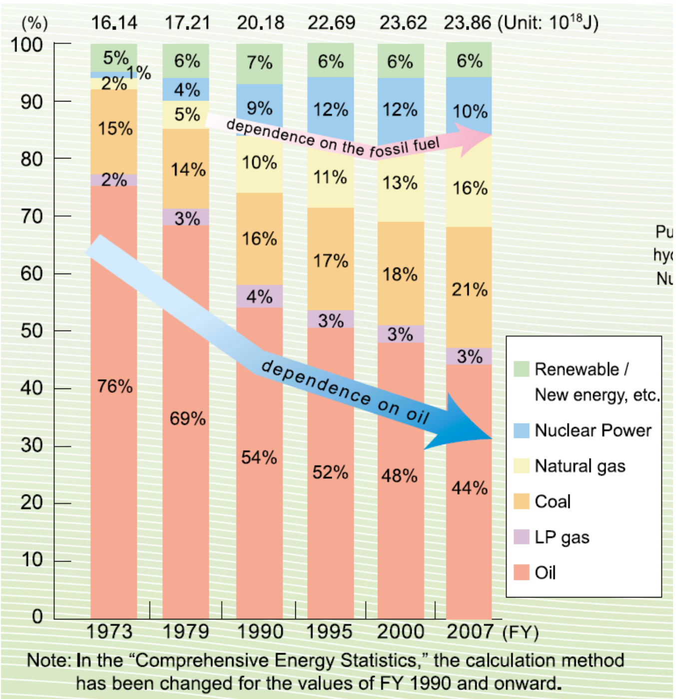
1.2.1 Primary Energy Source

Japan's current primary energy source is oil at 44%, followed by coal (21%), and natural gas (16%). The dependence on oil has decreased considerably and the degree of dependence on natural gas and coal has increased since the first oil crisis in 1973. As a result, the dependence on fossil fuel as a whole is still very high at 84%, and the

[5] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 2)*

dependence on non-fossil fuels including nuclear power (defined as a “non-fossil fuel” by the Japanese government) (10%) and renewable energies (6%) is still comparatively low.[6] (Figure 4) To shed dependence on fossil fuels, Japan has taken measures to expand the utilization of alternatives to oil, and particularly encourages diversification of energy sources for power generation.

Figure 4: Trends in Japan’s Primary Energy Supply (2007 data)[7]



Nearly half of the primary energy sources such as oil and gas are converted into the secondary energy source of electricity. The transition from the use of oil to other major power sources has made significant progress with nuclear power now supplying 24%. In terms of hydro electricity, which is 46% of Sweden’s domestic electricity generation, Japan‘s generation of hydro electricity accounts for only 8% of the domestic electricity generation.[8] (Figure 5)

[6] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 9, original data from the Agency for Natural Resources and Energy “Comprehensive Energy Statistics”)*
[7] *(same as above)*
[8] *Key World Energy Statistics 2010, International Energy Agency, 2010 (p.17,19)*

Figure 5: Producers of Nuclear (left) and Hydro (right) Electricity (2008 data)[9]

Country (top-ten producers)	% of nuclear in total domestic electricity generation
France	77.1
Ukraine	46.7
Sweden	42.6
Korea	34.0
Japan	24.0
Germany	23.5
United States	19.3
Russian Federation	15.7
Canada	14.4
People's Rep. of China	2.0
Rest of the world*	11.9
World	**13.5**

Country (top-ten producers)	% of hydro in total domestic electricity generation
Norway	98.5
Brazil	79.8
Venezuela	72.8
Canada	58.7
Sweden	46.1
People's Rep. of China	16.9
Russian Federation	16.0
India	13.8
Japan	7.7
United States	6.5
Rest of the world**	13.6
World	**16.2**

1.2.2 Self-sufficiency

In 1960, Japan had attained an energy self-sufficiency ratio of about 60% by using domestic natural resources such as coal and hydroelectric power. However, this ratio fell to as low as 4% (or 18% including nuclear power which is a quasi-domestic source) due to the fall in price of oil supplied for high economic growth.[10] The current comprehensive ratio which also includes government and private sector interests overseas stands at 38%. The Japanese government has set a goal to increase this percentage to around 70% by 2030, by raising the average operating rate at nuclear plants from 60% to 85% and foster cross-industrial alliances between power utilities, gas and oil firms, and other relevant entities.[11]

1.3 Energy Demand

1.3.1 Energy Consumption by Sector

Energy consumption in Japan is generally divided into the commercial/residential sector (home and workplace), the transport sector (transportation of people and goods), and the industrial sector (production of goods). The amount of consumption in the industrial sector has remained roughly the same after the two oil crises, but the commercial/residential

[9] *(same as above)*

[10] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.11)*

[11] *Nikkei Newspaper, March 21, 2010 "Japan Aiming For 70% Energy Self-Sufficiency By '30"*

sector and the transport sector are both seeing sharp increases.[12] In Sweden, however, there has been a decline in the commercial/residential sector in the past few years. (Figures 6,7)

Figure 6: Trend in Energy Consumption and GDP in Japan (2007 data)[13]

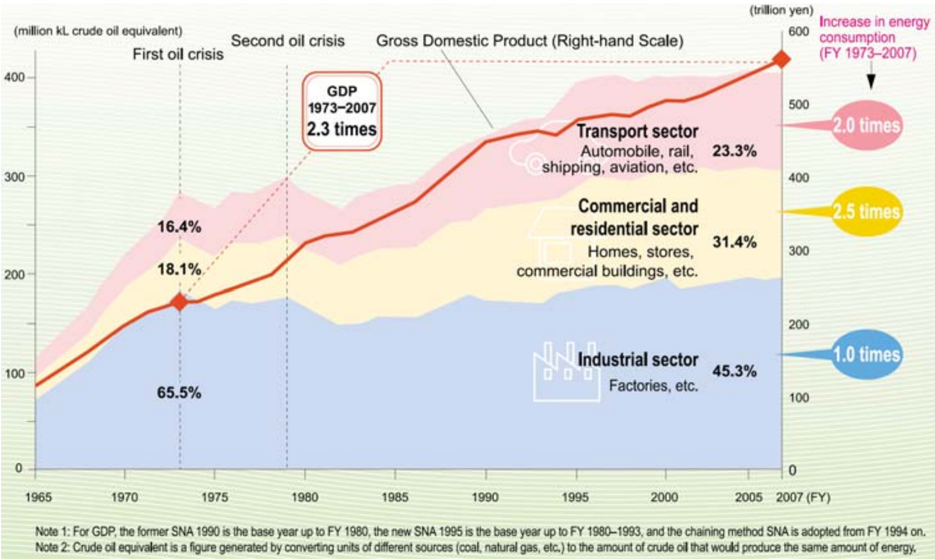
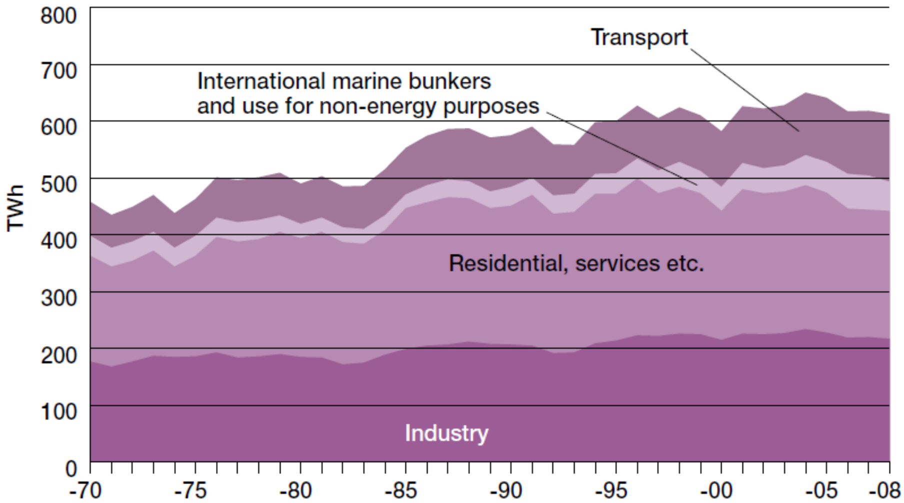


Figure 7: Trend of Energy Use in Sweden (2008 data)[14]



[12] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 5, original data from the Agency for Natural Resources and Energy, "Comprehensive Energy Statistics"; Cabinet office, "Annual National Accounts Bulletin"; The Institute of Energy Economics Japan, "EDMC Handbook of Energy & Economic Statistics in Japan")*

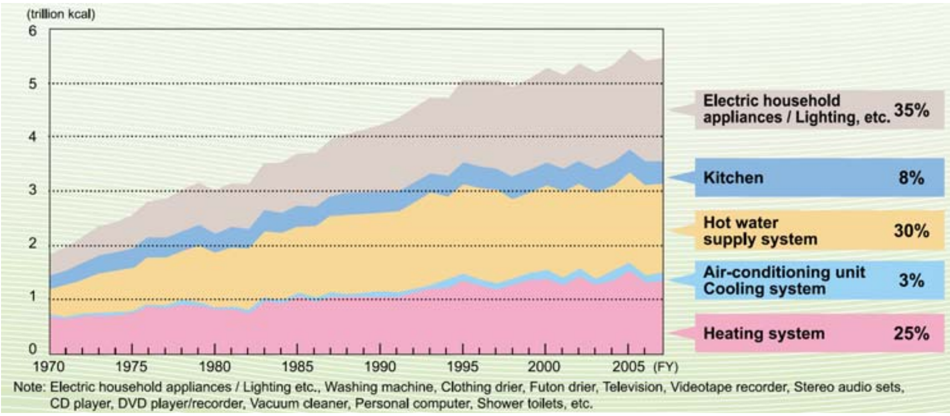
[13] *(same as above)*

[14] *Energy in Sweden 2009, Swedish Energy Agency, 2009 (p.68)*

Commercial/Residential Sector

Despite the usage of energy-saving household appliances and gas apparatuses, energy consumption in the residential sector has continued to rise, with a large amount of the consumption taking place by the electric household appliances (35%), hot water supply system (30%), and heating systems (25%).[15] (Figure 8)

Figure 8: Energy Consumption of the Residential Sector (2008 data)[16]



In the commercial sector, comprising office buildings, hotels and department stores, energy consumption has almost tripled since the early 1970s and the first oil crisis. This is due to the increase in the total floor area of buildings, accompanied by the increase in air-conditioning and lighting equipments.

Transport Sector

In the transport sector comprising the passenger service sector (passenger cars, busses, etc.), the cargo sector (land transport, marine transport, air cargo), energy consumption has almost doubled since the early 1970s and the first oil crisis. The main reason is the increase of passenger cars and the decline in the use of railways and busses. In addition, land transport (trucks) usage has increased, while rail and marine transport usage has decreased in the cargo sector.[17]

Industrial Sector

The manufacturing industry accounts for approximately 90% of the industrial sector and consumes about 45% of the energy. Despite the doubling of Japan's economic scale after the first oil crisis in 1973, energy consumption in the manufacturing industry has increased only slightly. The steel, chemical, ceramic-earth and sand (including cement), and paper-

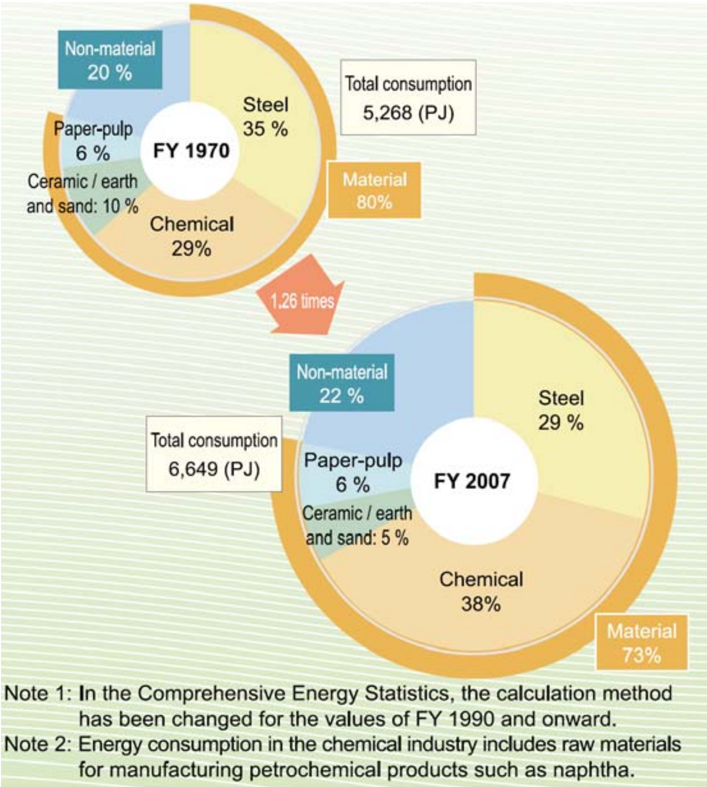
[15] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 7-8, original data from The Institute of Energy Economics Japan, "EDMC Handbook of Energy & Economic Statistics in Japan")*

[16] *(same as above)*

[17] *(same as above)*

pulp manufacturing industry continue to account for 70% of the energy consumption of the manufacturing industry as a whole.[18] (Figure 9)

Figure 9: Trends in Energy Consumption in the Manufacturing Sector by Category of Business (2007 data)[19]



1.4 Energy Policy and Strategy

1.4.1 Energy Policy Overview

Japan being dependant largely on overseas resources and energy, and having experienced two oil crises, places importance on assurance of a stable oil supply, promotion of the development and introduction of energies alternative to oil, and promotion of energy conservation.[20]

Basic Energy Plan

The first comprehensive energy policy the "National Fundamental Law on Energy" ("Basic Energy Plan") was enacted in June 2002. This law outlined the basic principles

[18] *(same as above)*
[19] *(same as above)*
[20] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 9)*

regarding Japan's energy policy as (1) Energy Security (securing stable supply), (2) Environmental Sustainability, and (3) Utilization of Market Mechanisms.[21]

Amendments to this Plan are made every three years. In the most recent amendment announced in June 2010 "economic growth based on energy and structural reform of the energy industry" was added as new perspectives to be considered and the following targets were made for 2030:[22]

- ✓ Double the energy self-sufficiency ratio in energy supply and the self-developed fossil fuel supply ratio, and as a result raise the energy independence ratio from current 38% to about 70%.
- ✓ Raise the zero-emission power source (nuclear and renewable energy) ratio from current 34% to about 70%.
- ✓ Half CO_2 emissions from the residential sector.
- ✓ Maintain and enhance energy efficiency in the industrial sector at the highest level in the world.
- ✓ Maintain or obtain top-class shares of global markets for energy-related products and systems.

Cool Earth 50

Concerning energy related technologies the "Cool Earth 50" (proposed in May 2007) stated that the development of innovative technologies is essential in achieving the long-term target of halving global greenhouse gas emissions by 2050 from the current levels.[23]

New Growth Strategy

In June 2010, the Japanese government finalized its "New Growth Strategy" which aims to achieve economic growth by FY2011 (ending in March 2012) by boosting demand in "green innovation" (including renewable energy) and other key areas, with escape from deflation as top priority. The "green innovation" targets for 2020 and the new details concerning energy are as follows: [24]

- ➢ 2020 Target for "Green Innovation

  "Create over 50 trillion JPY（4.15 trillion SEK） in new environment-related markets and 1.4 million new environment sector jobs. Reduce worldwide greenhouse gas emissions by at least 1.3 billion tons of CO_2 equivalent (equivalent to the total emissions of Japan) using Japanese private-sector technology."

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[21] *The Energy Conservation Center Japan Website, "Energy Efficiency & Conservation Policy in Japan"*
http://www.asiaeec-col.eccj.or.jp/nsp/index.html
[22] *METI Press Release, June 18, 2010 " Establishment of the Strategic Energy Plan of Japan"*
[23] *International Energy Agency Website, "Policies and Measures Database: Cool Earth Energy Innovative Technology Plan"*
http://www.iea.org/textbase/pm/?mode=pm&id=3939&action=detail
[24] *The New Growth Strategy: Blueprint for Revitalizing Japan, Japanese Cabinet, June 18,2010*

- ✓ Expand the purchase of all renewable energy derived electric power through a feed-in tariff system, promoting low-carbon investment and financing, and expanding the use of information communications technologies.
- ✓ Continue to pursue the steady use of nuclear power, with safety as top priority.
- ✓ Speed the development of innovative technologies for energy efficiency (e.g. storage batteries, next-generation vehicles, improved thermal power plant efficiency, and information and communications systems to lower electric power consumption).
- ✓ Introduce smart grids and standards to achieve efficient electric power supply and demand.
- ✓ Promote zero emission homes/buildings through use of renewable energies, heat pumps, light-emitting diodes (LEDs), and other forms of efficient lighting.

"21 National Strategic Projects for Revival of Japan for the 21st Century" were also selected in the "New Growth Strategy" to contribute towards the 2020 targets, and the Strategic Projects regarding energy and its resources are as follows:[25]

1. Strategic Project for Increasing Renewable Energy through a Feed-in Tariff System
    - ✓ Boost renewable energy market to 10 trillion JPY（833 billion SEK） by 2020.
    - ✓ Introduce smart grids, formulate rules for grid management and expand the volume of renewables-derived power connected to grids.
    - ✓ Implement zoning of locations for wind power and geothermal power farms, and development off-shore wind power through collaboration with fishery cooperatives and other stakeholders.
    - ✓ Strengthen a financing mechanism that contributes to fostering new global business ventures and support local businesses and communities.
    - ✓ Promote the use of heat from wood biomass and heat geothermal and solar thermal power.
2. Strategic Project for Creating a "Future City"
    - ✓ Establish a city energy management system which consists of a combination of smart grids, renewable energies, and next-generation vehicles.
    - ✓ Create demand, promote investment, and expand the use of environmentally friendly products and services by strengthening regulations (e.g. energy-saving standards) and introducing special measures (e.g. green tax system).
3. Strategic Project for Forest and Forestry Revitalization Plan.
    - ✓ Achieve a timber self-sufficiency ratio over 50%.
    - ✓ Develop a system to support forest owner through training, establishment of rules for logging/restoration, and subsidies for forest management and environmental protection.

[25] *(same as above)*

Expanding opportunities in the Asian economy is also highlighted in the "New Growth Strategy" as one of the key strategies to boost the Japanese economy. Development and provision of infrastructures that use Japan's environmental technologies are expected to be expanded in Asia and public-private cooperation in building infrastructures such as high-speed railway and urban transport, water supply, and energy are considered high priorities.[26]

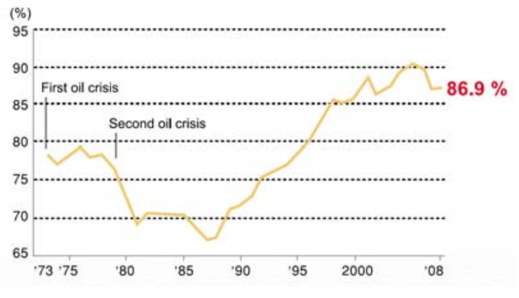
1.4.2 Fossil Fuels Policy

Japan's reliance on fossil fuels is very high at 84%. Introduction of non-fossil energy has been promoted through the "Law for the Promotion of the Use of Non-Fossil Energy Sources and Effective Use of Raw Materials for Fossil Energy by Business Operators of Energy Supply". This law obligates energy suppliers (electric power, gas, and oil companies) to use non-fossil energy while using fossil fuel effectively.[27]

<u>Oil</u>

The degree of dependence on oil as the primary energy source in Japan has decreased since the first oil crisis as a result of energy conservation measures and promoted diversification of energy sources. However, despite these efforts, oil still accounts for about 50% of the total energy supply and efforts to diversify energy sources have become a challenge due to the rise of energy consumption in China and Indonesia, and the decline in the import of oil by Japan from these regions. As a result, Japan's dependence on the Middle East as an oil supplier has been climbing again since the 1990s and is now at 86.9%. (Figure 10) Russia, Indonesia, and Sudan at approximately 3% share each are countries outside the Middle East Region where Japan imports oil. As this dependence is expected to continue, relationship building with oil producing countries both at the government and the private level is receiving attention. Joint research and development projects and technological cooperation in the energy field such as the development of high-precision refining technologies are also being considered.[28]

Figure 10: Changes in the Degree of Dependence on the Middle East for Crude Oil (2008 data)[29]



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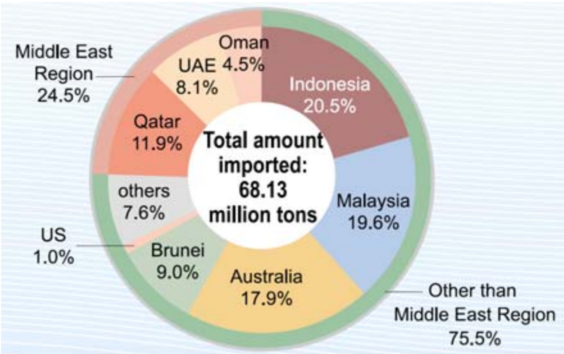
[26] (same as above)
[27] Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.45)
[28] Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.32 , original data from METI "Resource/Energy Statistics")
[29] (same as above)

Natural Gas

The ratio of natural gas supply in Japan was 2% until the first oil crisis, but reached 17% in 2008 as it continued to be introduced as an alternative to oil with less emission of carbon dioxide or nitrogen oxide. Efforts have been made to disperse the supply source and natural gas is now imported from multiple regions such as Southeast Asia, Oceania, and the Middle East. There have been several schemes to expand the use of natural gas in Japan, such as converting thermal power plants from the use of oil and coal to natural gas, replacing oil with natural gas as the raw material for urban gas supplies, and promoting the use of vehicles fuelled by natural gas.[30] (Figure 11)

Figure 11: Countries from which Japan Imports Natural Gas (2008 data)[31]



Coal

Japan depends on imports for almost all of the coal it consumes, which is 21% of the primary energy supply. Demand of coal is higher than that of other fossil fuels which is why it is an indispensible source when considering a stable supply of energy. However, as coal has the environmental drawback of emitting more carbon dioxide per unit amount of heat than other types of fossil fuels, Japan has been focusing on research and development for technologies which reduce environmental burden and at the same time achieve high efficiency in coal-fired power generation.[32]

1.4.3 Nuclear Power Policy

Nuclear power generation plays a major role in supplying electric power in Japan. As nuclear power does not produce greenhouse gases and has high supply stability, its use has been promoted in the "Action Plan for the Development of a Low-Carbon Society" (approved in July 2008).[33]

In order for Japan to stably secure Uranium resources required for nuclear power generation, it is important to obtain mining rights in various countries and develop mines

[30] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.33, original data from Ministry of Finance "Monthly Report of Japanese Trade")*
[31] *(same as above)*
[32] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.35)*
[33] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.19)*

independently. For this purpose, the Agency for Natural Resources and Energy is making efforts for promoting and supporting private Japanese companies to participate in the development of Uranium mines. More specifically, the Agency is trying to strengthen the systems to support overseas exploration projects of private Japanese companies through Japan, Oil, Gas and Metals National Corporation (JOGMEC).[34]

According to the Japanese government's New Growth Strategy finalized in June 2010, Japan plans to build eight new nuclear plants by 2020 and at least six more on top of that by 2030.[35]

1.4.4 Renewable Energy Policy

Renewable Energy Policy Overview

Basic Guideline for New Energy Introduction

In December 1994, Japan adopted the "Basic Guideline for New Energy Introduction" and laid out the government's approach to tackling new and renewable energy issues for the first time. The Guideline calls for the mobilization of government-wide efforts to introduce new and renewable energy at the national level, the invigoration of local level efforts by local governments, and understanding and co-operation by private businesses and the general public. The Basic Guideline in 1996 set a target of around 3% of renewable energies in the total primary energy supply by FY2010 (excluding hydro electric and geothermal energy). [36]

New 2010 Renewable Energy Targets

In 2008 the "New 2010 Renewable Energy Targets" reaffirmed the 1996 target and set the new target for the amount of renewable energy in the total primary energy supply as 19.1 million kL oil equivalents by FY2010. The 2010 targets for each of the renewable energy sources can be found in Figure 12.[37]

[34] *(same as above)*
[35] *Nikkei Newspaper, March 21, 2010 "Japan Aiming For 70% Energy Self-Sufficiency By '30"*
[36] *New Energy Foundation Website, "Implementation of New/Renewable Energy": http://www.nef.or.jp/english/new/implement.html*
[37] *Energy in Japan 2008, Agency for Natural Resources and Energy, 2008 (p.32)*

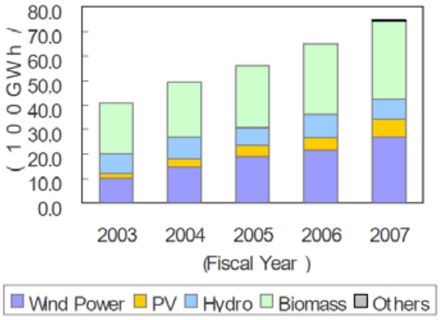
Figure12: Target Figures for Renewable Energies (2008 data)[38]

New energies on the supply side			
		FY 2005	Target for FY 2010
Fields of power generation	Photovoltaic power generation	347,000 kL (1,422 MW)	1,180,000 kL (4,820 MW)
	Wind power generation	442,000 kL (1,079 MW)	1,340,000 kL (3,000 MW)
	Generation from waste products and biomass power generation	2,520,000 kL (2,010 MW)	5,860,000 kL (4,500 MW)
Fields of heat utilization	Solar thermal energy	610,000 kL	900,000 kL
	Thermal energy from waste products	1,490,000 kL	1,860,000 kL
	Biomass thermal energy	1,420,000 kL	3,080,000 kL ※1
	Unused energies ※2	490,000 kL	50,000 kL
	Black liquid, waste wood, etc. ※3	4,720,000 kL	4,830,000 kL
Total (proportion of total primary energy supply)		11,600,000 kL (2.0 %)	19,100,000 kL (around 3 %)

Renewable Portfolio Standards (RPS) Act

The RPS Act (enacted in 2003) obligates electric utilities to use electricity generated from renewable energies. Increase in the production of renewable energy from 2003 to 2007 as a result of the RPS Act can be found in Figure 13. METI has revised the RPS Act in 2007 setting the utilization target of renewable energy to 16 billion kW by 2014, and has also developed measures to double count electricity generated by PV systems.[39]

Figure 13: Result of the RPS Act



Future Regulations and Support Systems

According to Japan's Energy White Paper 2010 published annually by METI, measures to expand introduction of renewable energies in the future includes implementation of

[38] *(same as above)*
[39] *International Energy Agency Website, "Policies and Measures Database: Renewable Portfolio Standards (RPS)-2007"*
http://www.iea.org/textbase/pm/?mode=re&id=3591&action=detail

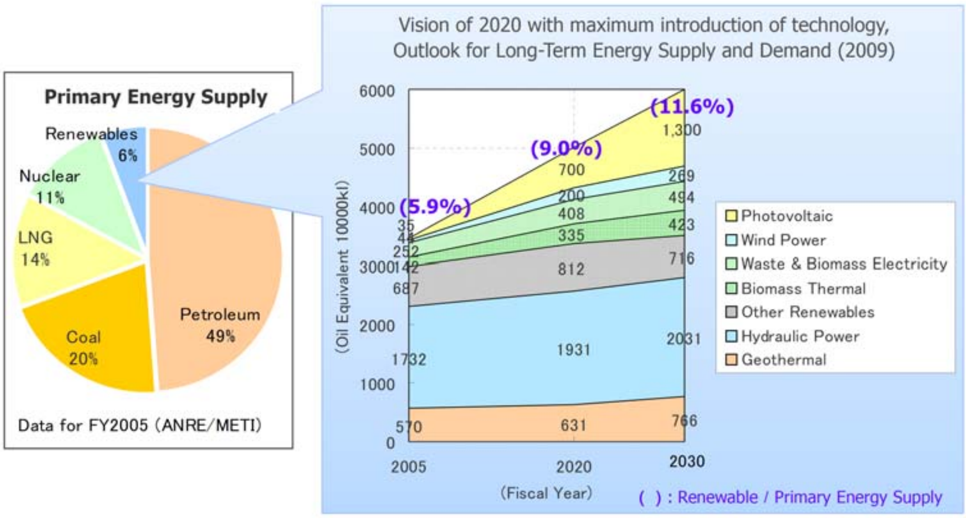
regulations and support systems suitable for the characteristics of energy sources. Details include: [40]

- ✓ Establishing a feed-in-tariff law in accordance with the Japanese circumstances. (e.g. the "New Purchase System for Solar Power Generated Electricity"(Nov 2009))
- ✓ Building a next-generation smart energy system and community.
- ✓ Mitigating constraint conditions based on geographical conditions. (e.g. wind power projects in natural park)

Outlook for Long-term Renewable Energy Supply and Demand

In August 2009 the "New and Renewable Energy Subcommittee Interim Report" (chair: Takao Kashiwagi, professor at the Integrated Research Institute, Tokyo Institute of Technology) was released by the Advisory Committee for Natural Resources and Energy of METI. The report announced a long-term outlook to increase the amount of renewable energy for supply of primary energy to 9% by 2020.[41] (Figure 14)

Figure 14: Long-term Outlook for Renewable Energy Supply and Demand[42]



[40] *Energy White Paper 2010, METI, June 2010*

[41] *METI Press Release, August 31, 2009 "'New and Renewable Energy Subcommittee Interim Report' released by the Advisory Committee for Natural Resources and Energy"*

[42] *Presentation by Toshiyo Imada, Director, International Projects Management Division, NEDO, March 22, 2010 "Government policies for solar energy in Japan"*

Photovoltaic Energy Policy

Action Plan for Dissemination of PV Power Generation

In 2008 Former Japanese Prime Minister Fukuda announced that Japan would broaden and expand the use of PV, as enunciated in the so-called Fukuda Vision. METI, MEXT, MLIT and the MoE released the joint announcement, "Action Plan for Dissemination of PV Power Generation". Key matters on PV deployment include: goals to set PV installations amounting to 14 GW by 2020 and 53 GW by 2030, and the launch of projects by a number of local governments to promote installation of PV systems (e.g. Tokyo Metropolitan Government will promote the installation of about 1 000 MW of PV).[43]

New Purchase System for Solar Power Generated Electricity

The "New Purchase System for Solar Power Generated Electricity" was promulgated in November 2009. This policy obligates utilities to purchase excess power produces from solar PV energy at specified prices. Excess electricity generated from households is to be purchased at a rate of 48JPY /kWh (4 SEK/kWh) and that from non-household sources (e.g. schools and hospitals) at 24JPY /kWh (2 SEK/kWh). The cost of the scheme will be covered by a monthly surcharge of approximately 30JPY (2.5 SEK) collected by electric utilities starting in April 2010. The scheme is set to run for 10 years.[44]

Role of Electric Utilities

Electricity utilities continue to support the deployment of PV systems through the Green Power Fund and net billing is voluntarily offered for surplus electricity generated by PV systems. In addition, utilities have decided to construct thirty PV power plants with a total capacity of 140 MW throughout Japan, aiming to accomplish these goals by FY2020.[45]

[43] *Trends in Photovoltaic Applications, International Energy Agency, 2009 (p.12)*

[44] *International Energy Agency Website, "Policies and Measures Database: New Purchase System for Solar-Generated Electricity" http://www.iea.org/textbase/pm/?mode=cc&id=4426&action=detail*

[45] *Trends in Photovoltaic Applications, International Energy Agency, 2009 (p.12,32)*

Global Comparison of PV Policy

An outline of the range of PV support mechanisms in place in various countries during 2008 can be found in Figure 15.

Figure 15: Global Comparison of PV Support Mechanisms[46]

	AUS	AUT	CAN	CHE	DNK	DEU	ESP	FRA	GBR	ISR	ITA	JPN	KOR	MEX	MYS	NLD	NOR	PRT	SWE	USA
Enhanced feed–in tariffs	•	•	•	•		•	•	•		•	•		•			•		•		•
Direct capital subsidies	•	•		•		•		•	•		•	•	•		•				•	•
Green electricity schemes	•	•	•	•		•	•		•		•	•								•
PV-specific green electricity schemes	•	•		•																•
Renewable portfolio standards (RPS)	•								•			•							•	•
PV requirement in RPS																				•
Investment funds for PV			•			•	•													•
Tax credits			•	•				•	•			•			•			•		•
Net metering	•	•	•	•	•				•		•			•	•					•
Net billing			•	•		•			•	•		•			•					•
Commercial bank activities	•					•			•			•				•				•
Electricity utility activities	•		•	•	•	•	•		•	•		•								•
Sustainable building requirements	•		•	•		•	•		•				•					•		•
Indicative household retail electricity price USD cents (1.)	10–14,2	26,5	7		30,7	32,4	13,7		23,8	15,3	25		15,3–22,6	up to 36	8,7		12,4–15,9		21,2–25,8	10,2

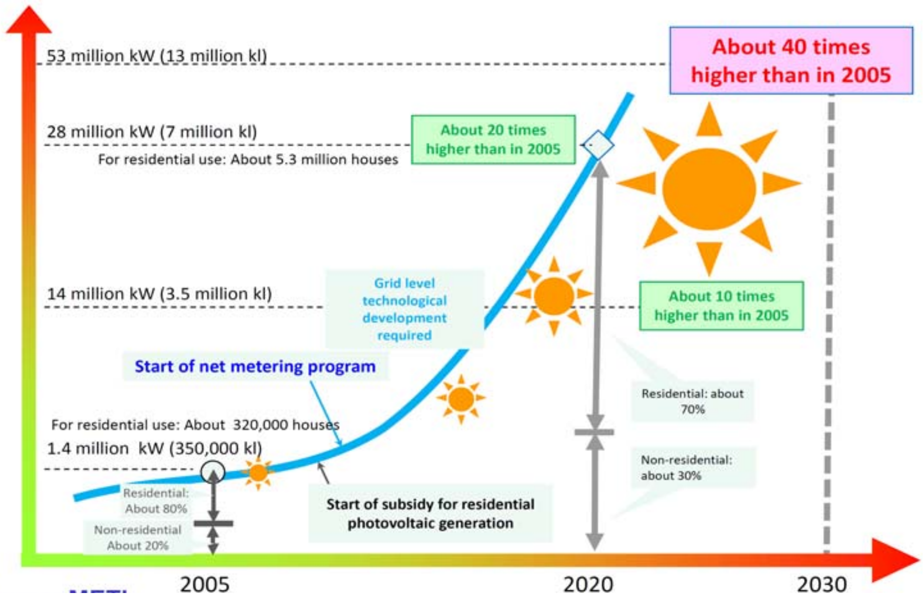
Notes:
1. Typical residential kWh price expressed in USD cents (1 USD/100), including all taxes but not including variations due to time of use, total electricity consumption or any fixed rates

[46] *(same as above)*

2020 Targets for PV Power

Japan has set ambitious objectives to reach 28GW of installed PV power by 2020 and 53GW by 2030 in the "New and Renewable Energy Subcommittee Interim Report" in August 2009 by the Advisory Committee for Natural Resources and Energy, METI.[47] (Figure 16)

Figure 16: 2020 Goal to Install 28GW[48]



Wind Energy Policy

Japan's development of wind energy was initiated by a government requirement for electricity companies to source an increasing percentage of their supply from renewable energy. The official government target for wind power in Japan by 2010 is 3GW, while actual implementation by 2009 remained 2.1GW.

METI had promoted research and development in wind energy from 1976 to 2000 within the "Sunshine Program" (renamed "New Sunshine Program" in 1993). This includes research of a 100kW-class wind generation plant in Miyake island (1981-1986), technology developments of large scale generation systems (1990-1998), and development of wind power generation system in remote islands (1999~).

METI has also conducted research programs called the "Field Test and New Energy Business Support Programs" since 1995 in order to test wind conditions in promising

[47] *METI Press Release, August 31, 2009 "'New and Renewable Energy Subcommittee Interim Report' released by the Advisory Committee for Natural Resources and Energy"*

[48] *Presentation by Tomoya Ichimura, NEDO, June 29, 2010 "Renewable Energy and Smart Community*

locations. Since 1997, financial support mechanisms for local governments and private businesses have been implemented.[49]

The "Long-term Prospect of Supply and Demand of Energy" released in 2009 expects wind power growth of up to 5GW by 2020, and 6.7 GW by 2030.[50]

Biomass Energy Policy

Biomass Nippon Strategy

In 2002, Japan launched the "Biomass Nippon Strategy", the first national strategy for utilizing biomass as a valuable resource from a technological, social, and economic perspective. This Strategy set specific action plans for production, collection and transportation, conversion technologies, and stimulation of demand for energy use or material use.[51] In March 2006, the Japanese Cabinet approved a revision of this Strategy, with the view that it is important to promote the use of biomass energy for transportation fuels. Other initiatives proposed included acceleration of the Biomass Town Program and the promotion of biomass energy in Asian countries.[52]

Biofuel Technology Innovation Plan

In order to promote development of cellulosic biofuel that does not compete with food, the METI cooperated with the MAFF in developing the "Biofuel Technology Innovation Plan" in March 2008. The Plan aims to achieve a production cost of 100 JPY/L (8.3 SEK/L) for biofuel made from raw materials that are mainly generated from existing agriculture and forestry (rice straw, forest residues, etc.) by 2015 and the production cost of 40 JPY/L (3.3 SEK/L) for biofuel made from resource crops which can be produced in large volumes. Under the plan, METI will promote development of technologies to make biofuel from cellulosic resource crops and other raw materials without affecting food production.[53]

Budget for Renewable Energy

134 billion JPY (11 billion SEK) were allocated for renewable energies in FY2010. (Figure 17) The global comparison of public budgets for research and development concerning PV in 2008 is outlined in Figure 18. The most significant countries in terms of expenditure are the US, Germany, Korea and Japan.[54]

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[49] *Agency for Natural resource and Energy Website "Wind Energy Generation" (only in Japanese) http://www.enecho.meti.go.jp/energy/newenergy/newene03.htm*

[50] *METI Press Release, August 31, 2009 "'New and Renewable Energy Subcommittee Interim Report' released by the Advisory Committee for Natural Resources and Energy"*

[51] *MAFF Website "Biomass Nippon Strategy" http://www.maff.go.jp/biomass/eng/biomass_outline.htm*

[52] *The International Society for Agricultural Meteorology Website "Biomass Nippon Strategy" http://www.agrometeorology.org/news/whats-new/biomass-nippon-strategy*

[53] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p.26)*

[54] *Trends in Photovoltaic Applications, International Energy Agency, 2009 (p.22)*

Figure 17: FY 2010 Budget Request for Renewable Energy[55]
(billion JPY (1JPY≒0.08SEK), budget request was accepted without changes)

	FY2010 Budget Draft	FY2009 Supplemental Budget
Deployment (Subsidy)		
Subsidy for Installation of Residential Photovoltaic System	40.1	22.0
Subsidy for Purchasing of Clean Energy Vehicle	13.7	
Subsidy for Installation of Residential Fuel Cell	6.8	2.0
Subsidy for Installation of New Energy (non-residence)	34.5	16.1
Research and Development		
Photovoltaic	**6.4**	**0.9**
Innovative Photovoltaic Cells	(1.9)	(0.9)
R&D on Next Generation High Efficiency Solar Cell	(4.1)	
Wind Power	**2.6**	
Off Shore Wind Power Technologies	(2.3)	
Bio Energy	**6.2**	
Bio-ethanol Production System from Celluloses	(1.9)	
Storage Battery	**10.6**	
R&D for Scientific Innovation on New Generation Batteries	(3.0)	
Research on Storage Batteries with Various Appliances	(4.3)	
Fuel Cell	**10.7**	**0.3**
Support for Start-up Business on New Energy	**1.6**	

Figure 18: Public Budget for PV R&D in 2008[56]

Country	Million EUR	Million USD
AUS	4,20	6,18
AUT <2007>	1,59	2,34
CAN	1,56	2,29
CHE	9,2	13,5
DEU	59,4	87,4
DNK	3,3	4,9
ESP	12	17,6
FRA (ANR, ADEME)	12	17,6
GBR	14,8	21,8
ISR	0,24	0,35
ITA	5	7,4
JPN (METI)	24,33	35,78
KOR	35,92	52,83
MEX	0,32	0,47
NLD	12	17,6
NOR	6,7	9,9
SWE	3,0	4,4
USA	83,3	122,5

[55] *Presentation by Toshiyo Imada, Director, International Projects Management Division, NEDO, March 22, 2010 "Government policies for solar energy in Japan"*
[56] *Trends in Photovoltaic Applications, International Energy Agency, 2009 (p.22)*

Incentives for Renewable Energy

Subsidy for Residential PV systems

As a result of the "New Purchase System for Solar Power Generated Electricity" (promulgated in November 2009) a new subsidy scheme to encourage the installation of solar PV systems in the residential sector is to be offered, following from the previous scheme which ended in 2006. A subsidy of 70 thousand JPY/kWh (5,800 SEK/kWh) installed will be provide provided to individuals who install PV systems in their homes.[57]

Taxation System for Reform of the Energy Supply and Demand Structures

The "Taxation System for Promoting Investments in the Reform of the Energy Supply and Demand Structures" provides the following tax incentives for any energy conservation equipment purchased: [58]

1. Tax credit that is equivalent to 7% of the reference purchase value (on which the calculation of the tax credit is based) - applies only to small and medium businesses.
2. Special depreciation that is not greater than 30% of the reference purchase value, in addition to the normal depreciation of the equipment.

Figure 19: Incentives for Renewable Energy[59]

	for Residence	for Institution (non-residence)
Subsidies	Photovoltaic 70,000 yen per kW *1 (system under 700,000 yen+) *2 Fuel Cell 1.4 million yen for 1 unit *3	All the New Energies for non profit bodies etc. half of installation cost for companies 1/3 of installation cost
Taxations	Photovoltaic Tax Reduction for Home Loan and for Reform to save the energy	All the New Energies 7% Tax Reduction (Small & Medium Entities) or Special Depreciation

+ planed to be 650,000 yen fiscal year 2010

*1 58,300 SEK per kW
*2 (system under 583,000 SEK)
*3 116,000 SEK for 1 unit

1.4.5 Energy Efficiency Policy

Energy Efficiency Policy Overview

Energy Conservation Law

The two oil crises in the 1970s triggered the enactment of the legislation "Energy Conservation Law" in 1979. It promotes energy conservation to reduce total energy

[57] *International Energy Agency Website, "Policies and Measures Database: Subsidy for Residential PV Systems" http://www.iea.org/textbase/pm/?mode=cc&id=4230&action=detail*

[58] *Q&A for Application of the Taxation System for Promoting the Investment in the Reform of the Energy Supply and Demand Structures, METI, 2009*

[59] *Presentation by Toshiyo Imada, Director, International Projects Management Division, NEDO, March 22, 2010 "Government policies for solar energy in Japan"*

demand through measures for factories, buildings, and machinery/equipment. Many amendments have been made to this Law, and the most recent amendment in 2008 was made as a result of the "Cool Earth 50" proposal. The amendment expands the regulations in the industrial sector to promote company-wide energy management systems and strengthens energy conservation measures for the residential sector.[60]

New National Energy Strategy / Top Runner Program

In May 2006, the "New National Energy Strategy" was formulated. In this Strategy, the "Energy Conservation Top Runner Program" ("Top Runner Program") was created as a means to improve energy efficiency more than 30% by 2030. Under the "Top Runner Program" which first began in 1999, the Japanese government established efficiency standards for various products based on the current available product in the market with the highest energy efficiency. Manufacturers are obligated to refer to these standards when making decisions so that energy efficiency improvement is attained. As a result, improvement in energy efficiency of air-conditioning, lighting, hot water and office equipment were achieved.[61]

Figure 20: Past Energy Conservation Effects Attained by the Top Runner System[62]

Name of appliance	Improvement in energy consumption efficiency (actual performance)	Details
Television (with Braun tubes)	25.7% (FY 1997 → 2003)	Annual power consumption amount (140kWh → 104kWh)
Video Tape Recorder	73.6% (FY 1997 → 2003)	Power consumption amount (4.55W → 1.20W)
Air conditioner (Room-air conditioner) *	67.8% (Refrigeration Year 1997 → 2004)	COP (3.01 → 5.05)
Electric refrigerator	55.2% (FY 1998 → 2004)	Annual power consumption amount (647.3kWh → 290.3kWh)
Electric freezer	29.6% (FY 1998 → 2004)	Annual power consumption amount (524.8kWh → 369.7kWh)
Gasoline-powered passenger car *	22.8% (FY 1995 → 2005)	Fuel efficiency (12.3km/l → 15.1km/l)
Diesel-powered truck *	21.7% (FY 1995 → 2005)	Fuel efficiency (13.8km/l → 16.8km/l)
Vending machine	37.3% (FY 2000 → 2005)	Annual power consumption amount (2,617kWh → 1,642kWh)
Fluorescent lighting fittings *	35.7% (FY 1997 → 2005)	Lumen / Watt (63.1lm/W → 85.6lm/W)
Electronic computer	99.1% (FY 1997 → 2005)	Watt / Mega computing (0.17 → 0.0015)
Magnetic disk device	98.2% (FY 1997 → 2005)	Watt / Gigabyte (1.4 → 0.0255)
Copier	72.5% (FY 1997 → 2006)	Power consumption amount (155Wh → 42.7Wh)
Electric toilet seat	14.6% (FY 2000 → 2006)	Annual power consumption amount (281kWh → 240kWh)
Gas water heater (Instantaneous gas water heater, Bathtub gas water heater)	5.5% (FY 2000 → 2006)	Heat efficiency (77.7% → 82.0%)
Gas cooking appliance (gas heater part)	15.7% (FY 2000 → 2006)	Heat efficiency (48.3% → 55.9%)
Gas stove	1.9% (FY 2000 → 2006)	Heat efficiency (80.9% → 82.4%)
Oil heater	5.4% (FY 2000 → 2006)	Heat efficiency (78.5% → 82.7%)

With regard to the appliances marked with *, energy conservation standard is determined by the energy consumption efficiency (example: km / liter) per unit, while for those not marked with * by energy consumption amount (example: kWh / year). "Improvement in the energy consumption efficiency" in the table above indicates the improvement ratio in accordance with each standard (example: When 10 km / liter or 10 kWh / year is improved to 15 km / liter or 5 kWh / year respectively (It is not thought that 33% improvement is achieved when the fuel consumption amount to drive over 100 km is improved from 10 to 6.7 liters.), improvement ratio is thought to be 50 %).

The "Top Runner Program" also created the "New Fuel Efficiency Standards for Passenger Vehicles", which are expected to result in a 23.5% improvement in the fuel efficiency of passenger vehicles by 2015 compared to 2004 levels.[63]

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[60] *The Energy Conservation Center Japan Website, "Energy Efficiency & Conservation Policy in Japan"*
http://www.asiaeec-col.eccj.or.jp/nsp/index.html

[61] *Japan Energy Conservation Handbook 2009, The Energy Conservation Center Japan, 2009*

[62] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.39)*

Energy Conservation Technology Strategy

From the "Basic Energy Plan (described in 1.4.1)" and the "New National Energy Strategy (described above)" was declared the "Energy Conservation Technology Strategy", finalized in March 2007, which identified and classified the energy technology expected to be commercialized as follows: [64]

1. Super combustion system technology
2. Technology of energy utilization beyond space-time restrictions
3. Energy conserving information living space creation technology
4. Technology to establish an advanced transport society
5. Future energy conserving device technology

Based on these concepts, "technology maps", "roadmaps", and "introduction scenarios" were created.

Incentives for Energy Efficiency

Eco-Points Scheme

In 2009, the MoE, METI, and the MIAC together established the new "Eco-Points Scheme" to promote environmentally-friendly home appliance products. The scheme is designed to tackle global warming alongside other important objectives such as revitalizing the national economy and promoting terrestrial digital broadcasting TVs. Consumers can obtain "eco-points" by purchasing environmentally friendly home appliances such as air-conditioners, refrigerators, terrestrial digital broadcasting TVs (the official selection is reliant to the timing of the Diet approval of the supplementary budget).[65] In December 2009 the cabinet approved the establishment of a system to give housing eco-points to those who build or renovate environmentally friendly houses.[66] The system was launched in March 2010 and "depending on the type of energy-conservation measures applied, users can receive up to 300,000 JPY (25,000 SEK) worth of eco-points, which can be used for additional renovations or exchanged for gift certificates or local specialties such as rice, fruit and marine products".[67]

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[63] *International Energy Agency Website, "Policies and Measures Database: New Fuel Efficiency Standards for Passenger Vehicles – Top Runner Program" http://www.iea.org/textbase/pm/?mode=cc&id=4144&action=detail*

[64] *The Energy Conservation Center Japan Website, "Energy Efficiency & Conservation Policy in Japan" http://www.asiaeec-col.eccj.or.jp/nsp/index.html*

[65] *International Energy Agency Website, "Policies and Measures Database: Eco-Points Scheme" www.iea.org/textbase/pm/?mode=pm&id=4475&action=detail*

[66] *Ministry of Economy, Trade and Industry Press Release, December 15, 2009 "Eco-point system for housing"*

[67] *Asahi Newspaper, March 9, 2010 "Eco-point system starts for housing"*

Tax Incentives for "Eco-cars"

In order to stimulate the domestic consumption of environmentally friendly cars ("eco-cars") the Japanese government has temporarily (from April 2009-2012) introduced tax reductions and exemptions for fuel-efficient vehicles with good environmental performance and subsidies for purchasing "eco-cars".[68]

Figure 21: Incentives for Purchasing New "Eco-cars"[69]

<Passenger Cars> (registered vehicles, light vehicles)

Requirement	Registered vehicles	Light vehicles
Vehicles achieving 2010 fuel efficiency standard targets ＋15% and four star emission standard vehicles.	100,000 JPY (8,300 SEK)	50,000 JPY (4,150 SEK)

<Heavy-duty vehicles> (buses, trucks, etc)

Requirement	Small (GVW3.5t class)	Middle (GVW8t class)	Large (GVW12t class)
Vehicles achieving 2015 fuel efficiency targets and NOx or PM emissions down by 10% from 2005 emission standards.	200,000 JPY (16,600 SEK)	400,000 JPY (33,300 SEK)	900,000 JPY (75,000 SEK)

[68] *Presentation by Shin Hosaka, METI, February 25, 2010 "Views and Policies on Japan's Automotive Industry"*

[69] *Created by E-Square Inc. based on presentation by Shin Hosaka, METI, February 25, 2010 "Views and Policies on Japan's Automotive Industry"*

2 Energy Technology in Japan

2.1 Overview of Energy Technology

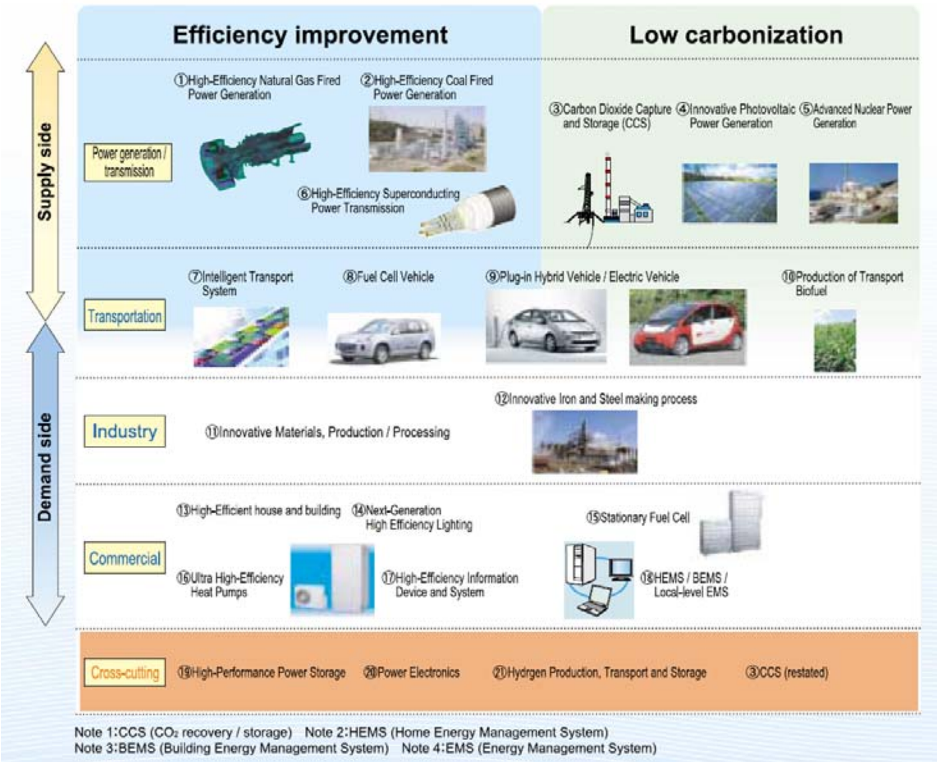
Energy Technology Trends

Based on the "Cool Earth 50" (see 1.4.1), an investigative commission comprising key intellectual figures announced the "Cool Earth Innovative Technology Program" (enacted in March 2008). The commission selected 21 innovative technologies that will be prioritized for research, development, and deployment. In addition, the Program aims to strengthen international cooperation to accelerate research and development of innovative technology.[70]

Energy Technology Categories

The 21 innovative technologies selected in the Cool Earth Innovative Technology Program can be found in Figure 22. The 21 technologies are largely classified on the basis of their impact on the expansion of low-carbon energy utilization and improvements in energy efficiency and on whether they are on the supply side or the demand side of energy distribution.

Figure 22: 21 Innovative Technology Areas[71]



[70] *International Energy Agency Website, "Policies and Measures Database: Cool Earth Energy Innovative Technology Plan" http://www.iea.org/textbase/pm/?mode=re&id=3939&action=detail*

[71] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.48)*

2.2 Supply Side Energy Technology

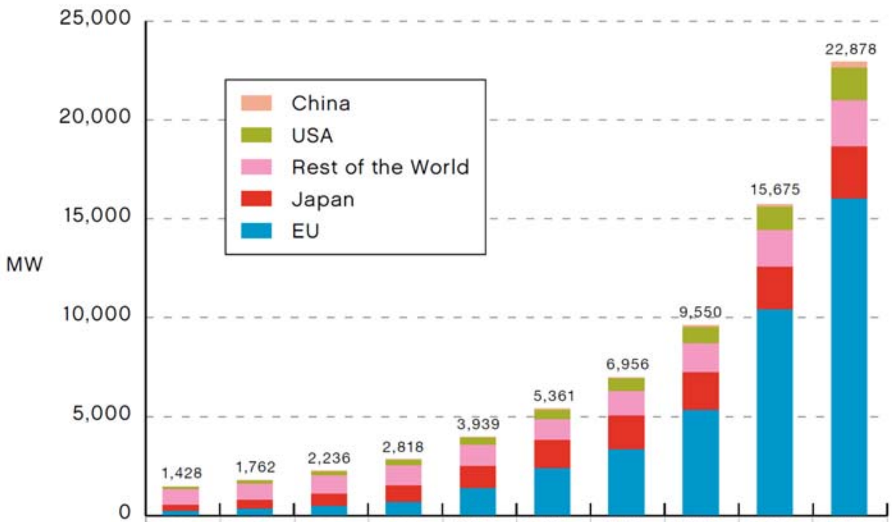
2.2.1 Photovoltaic Energy

Current Situation

The full-scale development of photovoltaic (PV) cell technology in Japan began with the Sunshine Project in 1974. Technology developments have been made over the past 30 years that have sought to improve efficiency, reduce costs, and encourage deployment. As a result, the production volume and the amount of installed PV power in Japan are among the highest in the world.[72]

In 2009, the re-launch of the Japanese residential PV program, the launch of net metering, and support systems for local governments and the private sector were successful in strengthening the Japanese PV market. Japan has now reached a cumulative PV power of 2.6GW and positions itself as the third largest market with 484 MW. (In 2008 there was a flat growth in installed PVs due to the termination of the subsidy for the Residential PV System Dissemination Program.)[73]

Figure 23: World Cumulative PV Power Installation[74]



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
China	19	30	45	55	64	68	80	100	145	305
USA	139	168	212	275	365	479	624	831	1,173	1,650
ROW	763	825	913	1,000	1,044	1,051	1,235	1,422	1,870	2,347
Japan	318	452	637	860	1,132	1,422	1,708	1,919	2,149	2,633
EU	189	286	429	628	1,334	2,341	3,309	5,279	10,338	15,943
Total	1,428	1,762	2,236	2,818	3,939	5,361	6,956	9,550	15,675	22,878

[72] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p.13)*
[73] *Global Market Outlook for Photovoltaics until 2014, European Photovoltaic Industry Association, May 2010 (p. 9, 45)*
[74] *(same as above)*

Market Players

In terms of PV cell production volume Germany replaced Japan as the leading producer in 2008, and China is rapidly growing as well. Some of the main companies of PV cell and module manufacturers in Japan can be found in Figure 24. In 2006, Sharp, Kyocera, Sanyo Electric, and Mitsubishi Electric were all among the top five producers, but in 2008 only Sharp remained in the top five.

Figure 24: Japanese Manufacturers in PV Cells / Modules[75]

Company	Manufacturing Area
Sharp Kyocera Sanyo Electric Mitsubishi Electric (MELCO) Kaneka Mitsubishi Heavy Industries (MHI)	silicon PV cells
Space Energy	bifacial silicon PV cells
Fuji Electric Systems	flexible a-Si PV modules
Honda Soltec Showa Shell Sekiyu	CIGS PV modules
Clean Venture 21	spherical Si PV modules
Fujipream YOCASOL	PV modules

Figure 25: World Market Share of PV Cell Product[76]

	2005		2008
1	SHARP (Japan)	1	Q-Cells (Germany)
2	Q-Cells (Germany)	2	First Solar (USA)
3	Kyocera (Japan)	3	Suntech (China)
4	SANYO (Japan)	4	SHARP (Japan)
4	Mitsubishi (Japan)	5	MOTECH (Taiwan)
6	Schott Solar (Germany)	6	Kyocera (Japan)
7	Suntech (China)	7	Baoding Yingli (China)
8	MOTECH (Taiwan)	8	JA Solar (China)
9	Isofoton (Germany)	9	SunPower (Philippine)
10	Shell Solar (USA)	10	SolarWorld (Germany)

[75] *Created by E-Square Inc. based on information in the Trends in Photovoltaic Applications, International Energy Agency, 2009 (p. 25)*

[76] *Presentation by Toshiya Imada, Director, International Projects Management Division, NEDO, March 22, 2010 "Government policies for solar energy in Japan"*

Research and Development

Japan's production of PV cells can be described in the following categories:[77]

<First generation> PV cells that utilize crystalline silicon.

- The market for first generation crystalline silicon PV cells has matured and their installation in residences, public and industrial facilities are increasing. Figure 26 shows a 79 kW moving walkway PV system in Yokohama.

Figure 26: Moving Walkway PV System in Yokohama[78]

<Second generation> Thin-film silicon, ultra-thin crystalline silicon, compound thin-film PV cells and organic PV cells utilizing organic materials and dyes.

- Thin-film silicon PV cells and tandem thin-film silicon PV cells which are produced with less silicon are becoming more commercially available as cost of silicon have risen in Japan due to a global shortage To further reduce the amount of silicon used and increase efficiency, developments are being made on ultra thin crystalline silicon PV cells, ultra high-efficiency thin-film PV cells, and PV cells that adopt materials other than silicon-like organic thin-films and dye-sensitized materials.

<Third generation> PV cells that achieve drastic improvements in efficiency and cost reduction by using innovative materials and structures.

- Technological developments are in progress to foresee 40% conversion efficiency by 2030 by developing concentrated multi-junction light-collecting PV cells that improve efficiency by adopting multiple junctions of materials to collect solar radiation at different absorption wavelengths, giving wide wavelength sensitivity to the cell. The development of ultra high-efficiency technologies (such as quantum nanostructure) is being considered. In particular the Quantum Dot Super Lattice Solar Cells which have a theoretical conversion efficiency of more than 60% are being developed.

[77] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p.13-14)*
[78] *Trends in Photovoltaic Applications, International Energy Agency, 2009 (p.32)*

Future Outlook

Measures to be taken for effective technological development and further diffusion of PV cells are as follows:[79]

- ✓ Research and Development of PV Cells and Modules: Basic research in the technologies to improve efficiency and lower cost of PV cells.
- ✓ Grid Connection: Development of technologies to improve grid connection and stabilize the output with efficient power storage.
- ✓ Deployment Measures: Provide proper combination of support for deployment including field tests, pilot projects, subsidies and incentives.
- ✓ Public-private Partnerships: Implementation of partnership projects with the government and the private sectors to facilitate the diffusion and smooth introduction of products into the market.

2.2.2 Wind Energy

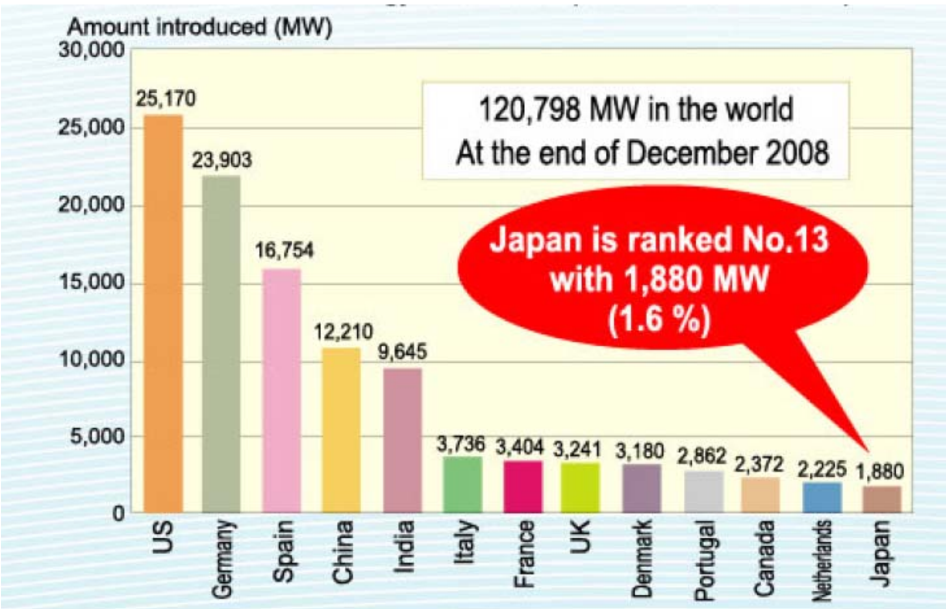
Current Situation

Asia is the fastest growing market in the world, driven primarily by China and India. This growth is expected to be complemented in other markets including Japan, Taiwan and South Korea. Japan installed a wind power capacity of 178MW in 2009, taking the total to 2.1GW, becoming the 13th largest in the world.[80]

Japan has few regions suitable for the installation of wind power generators due to its topographical features (i.e. there are fewer flat places, geography is more complicated, and there is less reserve in the system of electric utilities as compared with the US and European countries). Large scale facilities (wind farms) continue to be constructed predominantly in Hokkaido and Tohoku, but the speed of deployment has recently slowed down because of strict area restrictions.[81] (Figure 27)

[79] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p.13-14)*
[80] *Global Wind 2009 Report, Global Wind Energy Council, March 2010 (p. 10)*
[81] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.28)*

Figure 27: International Comparison of the Amount of Wind Power (2008 data)[82]



Market Players

Market share of Japanese companies in wind power generation is still very small. Some of the main producers are Mitsubishi Heavy Industries and Fuji Heavy Industries.

Research and Development

Offshore wind capacity in Japan is at 1MW and has not grown in 2009 due to the hostile natural environment in the seas near Japan. (Figure 28) However efforts are being made to consider further growth in this area. For example, the Tokyo Electric Power Company, Inc. (TEPCO) launched the "Experimental Study on Offshore Wind Power Generation Systems" in June 2010. As a joint research project with NEDO, the study will also take steps to commercialize offshore wind power generation with a fixed-type offshore wind power generation facility (operating from June 2010 to March 2014) about 3 km off the southern coast of Choshi, Chiba. Its objective is to establish methods for designing, installing, operating and maintaining wind power generation systems in the hostile natural environment in the seas near Japan, and to identify the environmental effects of offshore wind power generation facilities.[83]

[82] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.28, original data from World Energy Association)*

[83] *Tokyo Electric Power Company Press Release, May 19, 2010 "Experimental Study on Offshore Wind Power Generation"*

Figure 28: World Installation of Offshore Wind Turbines[84]

Position 2009	Country	Total Offshore Capacity [MW] end 2009	New Offshore Capacity [MW] installed in 2009	Total Offshore Capacity [MW] end 2008	Rate of Growth [%]
1	United Kingdom	688,0	104,0	574,0	18,1
2	Denmark	663,6	237,0	426,6	55,6
3	Netherlands	247,0	0,0	247,0	0,0
4	Sweden	164,0	30,0	134,0	22,4
5	Germany	72,0	60,0	12,0	500,0
6	Belgium	30,0	0,0	30,0	0,0
7	Finland	30,0	0,0	30,0	0,0
8	Ireland	25,0	0,0	25,0	0,0
9	China	23,0	21,0	2,0	1050,0
10	Spain	10,0	0,0	10,0	0,0
11	Norway	2,3	2,3	0,0	/
12	Japan	1,0	0,0	1,0	0,0
	TOTAL	1955,9	454,3	1491,6	30,5

Research and development concerning wind power is also being done in the following areas: wind velocity measurement technology, noise reduction technology, measures against lightning, and methods to estimate small-scale wind power.[85]

Future Outlook

Measures to be taken for effective technological development and use of wind power are as follows:[86]

- ✓ Research and Development of Wind Power Generator: Basic research in the technologies to improve cost and efficiency of the wind power generators.
- ✓ Adaption to Natural Environment: Research and design wind power generation which fit the Japanese natural environment to increase areas in which wind power could be operated.

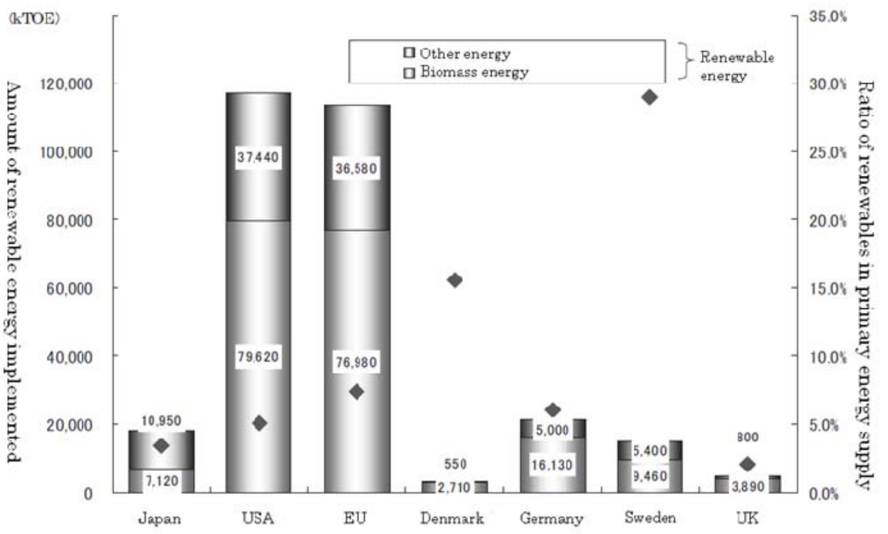
2.2.3 Biomass Energy (Biofuel)

Current Situation

Biomass energy accounts for less than 40% of the total renewable energy used in Japan, which is much lower than other countries. The ratio of renewable energy in the primary energy supply is also much lower compared to countries like Sweden or Denmark. (Figure 29)

[84] *World Wind Energy Report 2009, World Wind Energy Association, 2010 (p.9)*
[85] *Presentation by Takashi Kawabata, Agency for Natural Resources and Energy, November 2009 "Policies on New & Renewable Energy in Japan"*
[86] *Renewable Energy Technology White Paper, NEDO, July 2010 (p.167-168)*

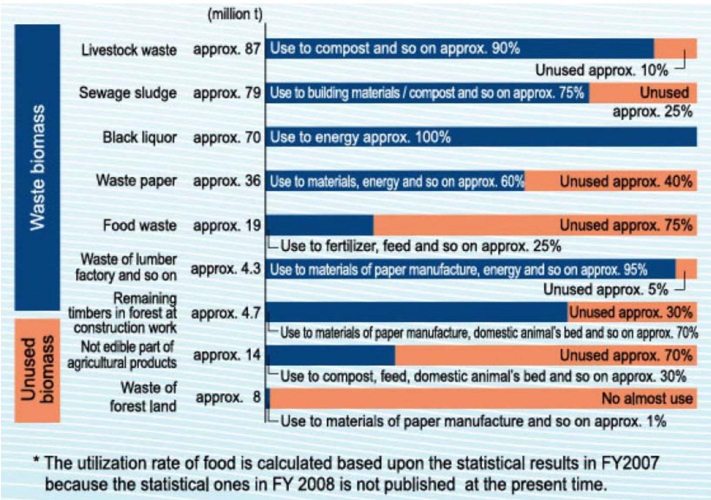
Figure 29: Global Comparison in the Use of Biomass Energy (2007 data)[87]



Research and Development

In Japan, waste wood at construction sites (i.e. sawmills and houses) are utilized, however, large amounts of sewages and food waste, which can be transformed into gas, and forest residue, which can be combusted at coal thermal power plants, are not being utilized.[88] (Figure 30) Instead, there is a stronger focus on research and development to create cellulose biomass that can be used for biofuel.

Figure 30: Amount of Biomass Endowment and Available Quantity[89]



[87] *Renewable Energy Technology White Paper, NEDO, July 2010 (p. 191)*
[88] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 28, original data from the 12th Biomass Nippon Strategy Council and Industry Group Joint Meeting)*
[89] *(same as above)*

The "Biofuel Technology Innovation Plan" (also mentioned in 1.4.4.4) developed by METI and MAFF in March 2008 aims to achieve a production cost of 40 JPY/L (3.3 SEK/L) for biofuel made with resource crops which can be produced in large volume. Under this plan, METI will promote the development of technologies to produce biofuel from cellulosic resource crops and other raw materials without affecting food production.[90]

The main problem with bio-ethanol is the high cost of ethanol production from cellulosic biomass, although it ensures high production volumes without using resources that compete with food supply. To address this problem, technology to separate cellulose from biomass is being developed. Research for developing microorganisms and enzymes with gene recombination techniques to enable high-efficiency conversions of cellulose into sugar or ethanol is also being conducted.[91] In 2008 a 13 billion JPY (1.08 billion SEK) technology development project to produce cellulose system ethanol was established to secure quality.[92]

Furthermore, the development of low-temperature gasification technology to allow for the utilization of unused exhaust heat is being conducted for Biomass-to-Liquid (BTL) applications to produce biodiesel through biomass gasification and chemical synthesis reaction.[93]

<u>Future Outlook</u>

Measures to be taken for effective technological development and use of biomass energy:[94]

- ✓ Research and Development of Biomass Technology: Basic research in the technologies to improve cost and efficiency of biomass energy production.
- ✓ Regulatory System: Regulatory systems to ensure quality and safety.

2.2.4 Geothermal Energy

<u>Current Situation</u>

There are approximately 120 active volcanoes in Japan, and the estimated potential of geothermal power generation is 20,000 MW or more from hydrothermal reservoirs at a a depth of 3 km. Currently, twenty-one electric power units are in operation at eighteen geothermal sites, mainly located in northern Honshu and Kyushu Islands. (Figure 31) The total capacity is 537 MW, which amounts to about 5.3% of the world total capacity of geothermal power plants.[95]

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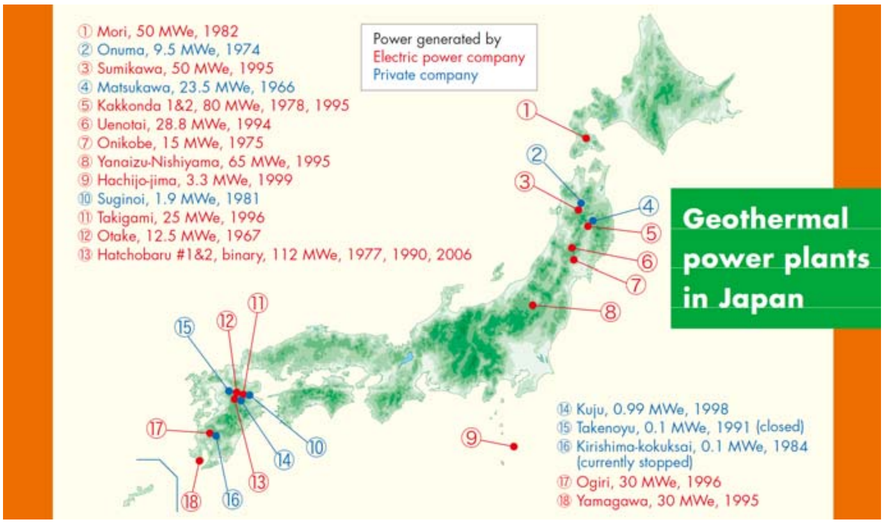
90 *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 25-27)*
91 *(same as above)*
92 *Presentation by Makoto Kawahara, Director, Hydrogen& Fuel Cell Promotion Office, Agency for Natural Resources and Energy, May 18,2009 "Hydrogen & Vehicle Technology Policy in Japan"*
93 *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 25-27)*
94 *(same as above)*
95 *Geothermal Energy Japan Handbook, The Geothermal Research Society of Japan, 2009*

Figure 31: Geothermal power plants in Japan[96]



<u>Research and Development</u>

Japan has one of the most advanced technologies on geothermal exploration, development, utilization, and monitoring. Examples of these technologies can be found in Figure 32.

Figure 32: Areas of R&D for Geothermal Energy in Japan[97]

Exploration	➢ Geology: remote sensing, alteration dating Geochemistry: fluid inclusion, isotope analysis Geophysics: 3D magnetotelluric (MT) method, high temperature well logging, seismic and VSP methods
Development	➢ Directional drilling in very high temperature reservoir (The world's highest drilling temperature (over 500℃) was recorded in 1995 at a depth of 3700m at Kakkonda field, Japan.) ➢ Hot dry rock (HDR) / Enhanced geothermal system (EGS) (Research of HDR/EGS system was carried out with circulation and tracer test, micro-earthquake monitoring, and binary power generation tests at Hijiori and Ogachi fields in north-eastern Japan.)
Utilization	➢ Power plants (turbines): Japanese turbines have been used worldwide with a share of 75% of capacity for conventional steam power plants and in the recent 10 years 67% for all geothermal power plants including binary systems. ➢ Scale prevention: scale inhibitor (polyacrylate), etc.
Monitoring	➢ Geochemistry (chemical monitoring of produced fluid, two-phase tracer test, etc)

[96] *(same as above)*
[97] *Created by E-Square Inc. based on information from Geothermal Energy Japan Handbook, The Geothermal Research Society of Japan, 2009*

Future Outlook

Measures to be taken for effective technology development and use of geothermal energy:[98]

- ✓ Geographical Consideration: Development of geothermal projects which preserve scenic beauty and hot spring resources for local residents.
- ✓ Development Cost: Improving technology and changing related regulations for bigger and wider utilization of geothermal energy.

2.2.5 Nuclear Energy

Current Situation

As of 2008, Japan has 55 reactors operating around the country with a total output of 49,467MW. Nuclear power accounts for approximately one-third of the country's total electric power output.[99] Nuclear power generation is regarded as a highly effective countermeasure to global warming, but Japan being an earthquake prone country struggles with power plants which remain out of service due to earthquakes. Consequently Japan's nuclear facility utilization rate is at 70.2% is lower than that of Korea (92.3%), USA (90.8%), France (77.6%), and Russia (75.9%).[100]

Research and Development - Reactors

Japan is successfully using reprocessed uranium, which saves 10-20% of Uranium resources which would otherwise be disposed at existing nuclear power plants (called Light Water Reactors) through the pluthermal process. Utilization of MOX fuel (a mixed chemical compound of uranium and plutonium, recovered from spent fuel) in Light Water Reactors has achieved operational results of seven hundred seventy assemblies over about twenty-four years at Advanced Thermal Reactor Fugen, at two assemblies at Tsuruga Nuclear Power Plant No.1 reactor and four assemblies at Mihama Nuclear Power Plant No.1 reactor.[101]

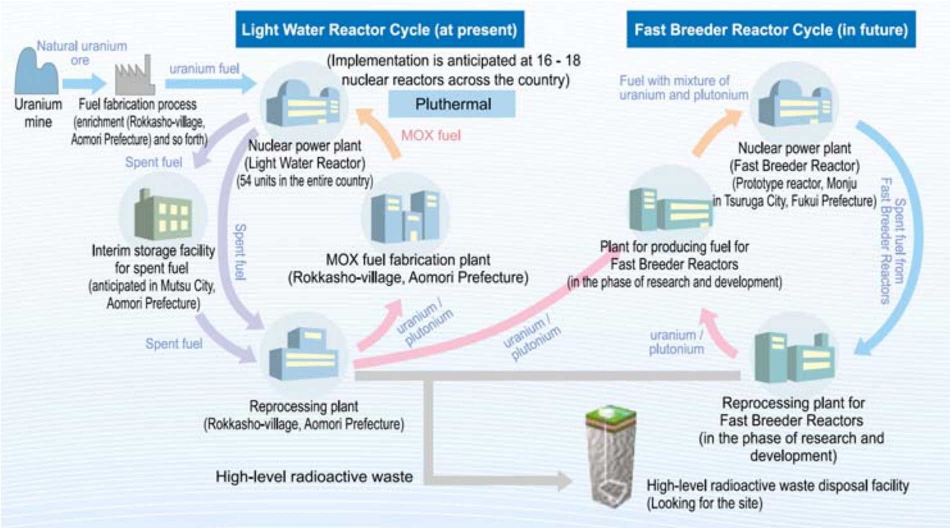
A nuclear fuel reprocessing plant is being constructed in Rokkasho, Aomori Prefecture. Although it was scheduled to be completed in December 1997, a revised completion set for October 2010 has recently been delayed by another two years.[102]

To address the domestic needs for the replacement of reactors expected to take place around 2030, technologies to reduce the generation of spent nuclear fuel and to address seismic isolation are being developed. The development of fast-breeder reactors which produce more nuclear fuel than it consumes while generating electricity are also being re-

[98] *Geothermal Energy Japan Handbook, The Geothermal Research Society of Japan, 2009*
[99] *Japan Atomic Industrial forum webpage "Nuclear Energy Production Sites in Japan" (only in Japanese)*
http://www.jaif.or.jp/ja/nuclear_world/data/f0301.html
[100] *Annual Report of the Status of Nuclear Facilities in Japan, Japan Nuclear Energy Safety Organization,2008*
[101] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.19-24)*
[102] *Asahi Newspaper, September 3, 2010 "Reprocessing plant delayed once again"*

considered.[103] (Figure 33) For example, the fast-breeder reactor called Monju, which was shut down in 1995 following a fire, has been restarted in May 2010.[104]

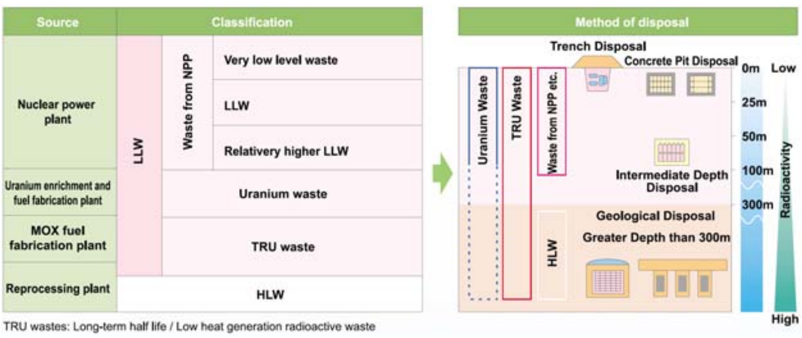
Figure 33: Nuclear Fuel Cycle Conceptual Diagram[105]



Research and Development – Nuclear Waste

Concerning radioactive waste disposal, Japan combines the use of a stable deep underground geological formation (a natural barrier) with multiple engineered barriers and geological disposal of high-level radioactive wastes to fully confine radioactive materials and minimize the influence on human life and environment. As high-level radioactive wastes require geological disposal, Nuclear Waste Management Organization of Japan (NUMO) is recruiting disposal site candidates from all municipalities throughout Japan.[106] (Figure 34)

Figure 34: Types of Radioactive Wastes and Methods of Disposal[107]



[103] Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.19-24)
[104] Asahi Newspaper, May 7, 2010 "Monju fast-breeder reactor restarts amid safety worries"
[105] (same as above)
[106] (same as above)
[107] (same as above)

Future Outlook

Measures to be taken for effective technological development of nuclear power are as follows:[108]

- ✓ Research and Development of Fast Breeder Reactors: Steady technological development in Japan as well as expanding cooperation on technological development with other countries (e.g. US and France).
- ✓ Research and Development of Light Water Reactors: Development of technologies to become the global standard for use not only in the domestic but international markets.

2.2.6 High Efficiency Natural Gas Power Generation

Current Situation

Thermal power plants in Japan have been converting their energy source from oil and coal to natural gas, replacing oil with natural gas as the raw material for urban gas supplies, and promoting the use of vehicles fueled by natural gas. Thermal efficiency for power generation gas turbines has been improving since the beginning of 1980s due to the continued increase in combustion temperature every year by 20°C. Japan has led the world in this field by putting 1500°C-class gas turbines on the market ahead of other nations and achieving 52% power generation efficiency.[109]

Research and Development

Further developments in the following areas are being considered:[110]

- ➢ Development of 1700°C-class gas turbines with 56% power generation efficiency to be commercialized by around 2015 (high-temperature resistant and corrosion resistant materials, cooling techniques, ceramic thermal barrier coating will need to be developed). This technology can also be used in other power generation technologies such as integrated coal gasification combined cycle (IGCC).
- ➢ Development of turbines with 60% efficiency which use a combination of fuel cell and gas turbines or steam turbine by around 2025 (large-capacity fuel cell will need to be developed)

Other plans include modifying gas into liquid fuels, known as "Gas to Liquid (GTL)", or using Dimethyl Ether (DME), which are expected to provide fuel for transport and industry in the future. The realization of these plans will require the establishment of a domestic pipeline network to supply the natural gas. (Currently there are anticipations for considerable amount of methane hydrate reserves in the ocean around Japan, but development of a new production technology will be required as the methane hydrate buried underground is in a solid form and does not flow out spontaneously.)[111]

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[108] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 13-14)*
[109] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 5-7)*
[110] *(same as above)*
[111] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 33)*

Future Outlook

Measures to be taken for effective technological development of high-efficiency natural gas energy:[112]

- ✓ Research and Development of Gas Turbines: Development of combustion technology that recalculates exhaust gas to create low-pollution combustion. Continuation of basic research to improve efficiency of carbon dioxide separation and capture by increasing the concentration of carbon dioxide in the exhaust gas.

2.2.7 High Efficiency Coal Power Generation

Current Situation

Japan depends on imports for almost all of its coal, which is 21% of the primary energy supply. Of the total amount imported in 2008 (186Mt), 84 Mt was used for power generation and 65 Mt was used for steel production.[113]

Market Players

Along with European manufacturers such as Alstom Power and Siemens, Japanese manufacturers such as Mitsubishi Heavy Industries, Toshiba and Hitachi have global businesses in steam turbine and boiler technologies. In addition, Chinese companies and the Indian national power company BHEL are beginning to obtain a large share of the global market through technical cooperation with major Japanese, European and American manufacturers.[114]

Research and Development

Japan was one of the first countries to adopt the 600℃-class ultra-supercritical (USC) development. The following technologies are being also being developed:[115]

- ➢ New high-temperature resistant materials and innovative welding technology for steel materials (700°C-class turbines with 46% power generation efficiency by around 2015 and 48% efficiency by around 2020).
- ➢ Integrated Coal Gasification Combined Cycle (IGCC) a technology suited to low ash melting point coals which are difficult to use in pulverized fired power plants, and is expected to contribute to the stable supply of energy by expanding the types of coals that can be used.(a demonstration plant of 250MW, 41% power generation efficiency Is being considered)
- ➢ Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC) is currently at the stage of basic development in a pilot plant. It has already been confirmed that the fuel cell operates on hydrogen gas generated from coal, but it is necessary to improve the reliability of the system and reduce its cost by developing a large-capacity fuel cell

[112] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 7)*
[113] *Energy White Paper 2010, METI, June 2010 (Division 2, Chapter 1, Section 3)*
[114] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 7-9)*
[115] *(same as above)*

and establishing a system to combine it with the coal generator. The goal is to reach a power generation efficiency of 55% by around 2025. Next-generation IGFC (A-IGFC) will be developed in the long-term to improve power generation efficiency by collecting exhaust heat from the fuel cell and utilizing it in gasification through steam reforming process, leading to a power generation efficiency of 65%.

Future Outlook

Challenges for effective technology development of high-efficiency coal power:[116]

- ✓ Research and Development of IGCC/IGFC: Conducting IGCC/IGFC demonstration projects in combination with carbon dioxide capture and storage (CCS). Continuing basic research on materials and catalyst technology.

[116] *(same as above)*

2.3 Demand Side Energy Technology

2.3.1 Plug-in Hybrid Vehicle / Electric Vehicle

Current Situation

Following the introduction of clean diesel passenger vehicles, hybrid vehicles, compressed natural gas (CNG) vehicles, electric vehicles (EVs), and plug-in hybrid vehicles (PHVs) have been introduced into the Japanese market. The government is providing support programs, such as subsidies and tax incentives, and technical development programs to develop higher efficiency and achieve lower cost to allow more "next generation vehicles" into the market. Alternative-energy and next generation vehicles are less than 10% of the overall sales of passenger cars and commercial vehicles. However sales of conventional vehicles almost halved from 2008 to 2009 with approximately 2 million vehicles sold, while sales of hybrid vehicles rose more than 50% and sold approximately 200,000 vehicles. The high price and low mileage of EV/PHVs still pose a challenge for the diffusion in the market.[117] (Figure 35)

Figure 35: Price, Fuel Cost, and Mileage of "Next Generation Vehicles"[118]

	Gasoline Vehicles	Hybrid Vehicles	Electric Vehicles	Plug-in Hybrid Vehicles
Price	1.8 mil JPY (150,000 SEK)	2.1 mil JPY (175,000 SEK)	4.5 mil JPY (375,000 SEK)	5.0 mil JPY (416,000 SEK)
Fuel Cost	6.6JPY/km (0.55 SEK/km)	3.3JPY/km (0.28 SEK/km)	2.2JPY (0.18 SEK) /km (day) 0.7JPY (0.06 SEK) /km (night)	3JPY (0.25 SEK) /km (day) 1.3JPY (0.11 SEK) /km (night)
Mileage	(1,000km)	(1,600km)	160km at max.	(more than 1,600km)

* Fuel cost : fuel price/fuel efficiency ratio
  Gasoline price: 120JPY/l (10 SEK/l)
  Electricity price: 22JPY (1.83 SEK)/kWh (day), 7JPY(0.58 SEK)/kWh (night)
** Mileage of gasoline vehicles, hybrid vehicles, plug-in hybrid vehicles is calculated by "efficiency ratio x fuel capacity"

In March 2010, the Japanese automobile and electric industries have also come together to create a global industry standard called "CHAdeMO" (the name stands for "CHArge de MOve" and in Japanese it means "Would you care for some tea - while recharging your EV?") to develop a quick charging method (a specification solely for level III high voltage direct current automotive charging) of electric vehicles. This was proposed by an association of the same name which was formed by TEPCO, Nissan Motor, Mitsubishi Heavy Industries, Fuji Heavy Industries, and later joined by Toyota as executive members. The association now has ninety-six regular members and one hundred thirty-nine

[117] *Presentation by Shin Hosaka, Director, Automobile Division, Manufacturing Bureau, METI, February 25, 2010 "Views and Policies on Japan's Automotive Industry"*

[118] *(same as above) Created by E-Square Inc. based on data from Presentation*

supporting members which represent the the global EV industry.[119] The Japanese industry and government have focused and invested heavily in EVs and battery technology and have committed themselves to CHAdeMO's technology and one standard to promote the adoption of EVs. The SAE International in North America has not yet defined a standard for level III charging, and it is still to be seen what decisions European automobile manufacturers will make. In the meantime, several thousand Nissan LEAF will be coming to the US and Europe in 2011 using the CHAdeMO specification.

Market Players

Japanese automobile manufacturers have developed various "next generation vehicles" (Figure 36) and Japanese companies are leading the world market in lithium batteries (Figure 37).

Figure 36: Japanese "Next Generation Vehicles"[120]

Figure 37: World Market Share of Lithium Battery (2008 data)[121]

	2005		2008
1	SANYO Group (Japan)	1	SANYO Group (Japan)
2	SONY (Japan)	2	Samsun SDI (Korea)
3	Samsun SDI (Korea)	3	SONY (Japan)
4	Panasonic (Japan)	4	BYD (China)
5	BYD (China)	5	LG Chemical (Korea)
6	LG Chemical (Korea)	6	BAK (China)
7	Lishen (China)	7	Panasonic (Japan)
8	NEC Tohkin (Japan)	8	Hitachi Maxell (Japan)
9	Hitachi Maxell (Japan)	9	ATL (Hongkong)

[119] *CHAdeMO Association Website* *www.chademo.com*
[120] *(same as above)*
[121] *Presentation by Toshiya Imada, Director, International Projects Management Division, NEDO, March 22, 2010 "Government policies for solar energy in Japan"*

Research and Development –Batteries

The main focus of research and development for ”next generation vehicles” in Japan is the battery, especially batteries designed to many specifications since the required battery capacity in each EV/PHV varies by the vehicle type.

A five-year (2007-2011) technology development project for next-generation batteries is currently under way by NEDO with a yearly budget of approximately 2.7 billion JPY (225 million SEK). Research areas of this project include: [122]

- Elements technology: Development of advanced lithium ion batteries and its structure materials and peripheral instruments (motor, battery control device).
- Next generation technology: Development of revolutionary batteries based on innovative concepts and materials and improving battery response control technology.
- Basic technology: Development of improved test methods for the acceleration battery life on storage batteries and battery performance/safety.

Research and Development –Infrastructure

Research and development for the charging infrastructure of EV/PHVs have also been taking place. The basic concept is to build charging infrastructures mainly for overnight charging in order to minimize the number of public charging facilities and leveling the impact on the electric grid. The present deployment site, time, and cost of charging EV/PHVs in Japan can be found in Figure 38.[123]

Figure 38: Deployment Site, Time, and Cost of Charging EV/PHVs[124]
*Electricity price varies by contract. The figure shows average.

Deployment of Charging Infrastructure		Home Outlets (full charging)		Fast charging (80% charging)
		100V	200V	
		Home garage	Toll Parking	Shopping mall
		Automobile dealers, Auto parts stores, Convenience stores, Hospitals, Commercial Facilities, etc		Gasoline stations, Highways (rest area), Commercial Facilities
EV	Mileage: 160km	14 hours	7 hours	30 minutes
		Electricity price* (day: 350 JPY (29 SEK), night: 110 JPY (9 SEK))		
	Mileage: 80km	8 hours	4 hours	15 minutes
Installation cost		500,000 JPY (41,600 SEK)	500,000 JPY (41,600 SEK)	6,000,000 JPY (500,000 SEK)

[122] Presentation by Makoto Kawahara, Director, Hydrogen& Fuel Cell Promotion Office, Agency for Natural Resources and Energy, May 18,2009 "Hydrogen & Vehicle Technology Policy in Japan"

[123] Presentation by Shin Hosaka, Director, Automobile Division, Manufacturing Bureau, METI, February 25, 2010 "Views and Policies on Japan's Automotive Industry"

[124] (same as above) Created by E-Square Inc. based on data from Presentation

The development of EV/PHV related infrastructure is being pursued under the "EV/PHV Town Project". This Project, which was stipulated in the "Action Plan for the Development of a Low-Carbon Society" (approved in July 2008), is creating model regions that will introduce EV/PHVs into services such as taxis, car rentals, and car sharing. The Project will also develop battery charging infrastructures in cooperation with municipalities, automobile manufacturers, power companies, and local enterprises (shopping malls, parking spaces, etc.). There are presently eight EP/PHV towns (Aomori, Niigata, Tokyo, Kanagawa, Aichi, Fukui, Kyoto, and Nagasaki) and three research areas (Kochi, Okayama, Okinawa) involved in this Project.[125]

Future Outlook

Measures to be taken for effective technology development and diffusion of EV/PHVs: [126]

- ✓ Research and Development of EV/PHVs: Improvements in cost and performance of batteries and developing alternative materials to rare metals that are used in electrical motors.
- ✓ Infrastructure for EV/PHVs: Public-private partnerships for introducing EV/PHVs and reducing cost of charging infrastructure installation to create initial demand.

2.3.2 Stationary Fuel Cell

Current Situation / Market Players

The word "Ene Farm" has been coined in Japanese, meaning "residential fuel cells" by the Fuel Cell Commercialization Conference of Japan (FCCJ) and is being widely used by residential fuel cell manufacturers (Ebara Ballard, Eneos Celltech, Panasonic, Toshiba, and Toyota – Figure 39), gas companies, and oil companies.

In Japan, steady research and development and policies have led to the commercialization of residential fuel cells (Polymer-Electrolyte Membrane Fuel Cell (PEFC) units in home cogeneration) starting in May 2009, along with a subsidizing scheme to stimulate the initial domestic market demand. The price including installation cost is about 3 million JPY/unit (250,000 SEK/unit), and the subsidy will provide half of the equipment and installation expenses (upper limit per unit 1.4 million JPY (116,600 SEK)).[127]

[125] *(same as above)*
[126] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 25)*
[127] *Presentation by Makoto Kawahara, Director, Hydrogen& Fuel Cell Promotion Office, Agency for Natural Resources and Energy, May 18,2009 "Hydrogen & Vehicle Technology Policy in Japan"*

Figure 39: Japanese "Ene Farm" (Residential Fuel Cell) Manufacturers[128]

Research and Development

In FY2009, a budget of 6.7 billion JPY (558 million SEK) was allocated for strategic development of PEFC technologies for practical applications and a separate budget of 0.9 billion JPY (75 million SEK) was allocated for the PEFC Cutting-Edge Research Center to conduct detailed analysis and modeling of reaction mechanism inside the fuel cells. Research on high performance fuel cells with advanced analysis of reaction and degradation with nanometer scale is also being conducted by the Yamanashi University.[129]

Molten Carbonate Fuel Cell (MCFC) has the ability to concentrate and capture the carbon dioxide in exhaust gas into its fuel electrode side when combustion exhaust gas is injected into its air electrode side. Trials have been already made to apply MCFC to carbon capture and storage (CCS) and applications in combined power generation with gas turbines are expected to be achieved around 2030.[130]

Future Outlook

Measures to be taken for effective technology development and diffusion of stationary fuel cells: [131]

- ✓ Research and Development of stationary fuel cells: Research and improvements in durability and reliability of fuel cells other than PEFC, including solid-oxide fuel cell (SOFC).

[128] *(same as above)*
[129] *(same as above)*
[130] *Cool Earth-Innovation Energy Technology Program, METI, March 2008 (p. 33-34)*
[131] *(same as above)*

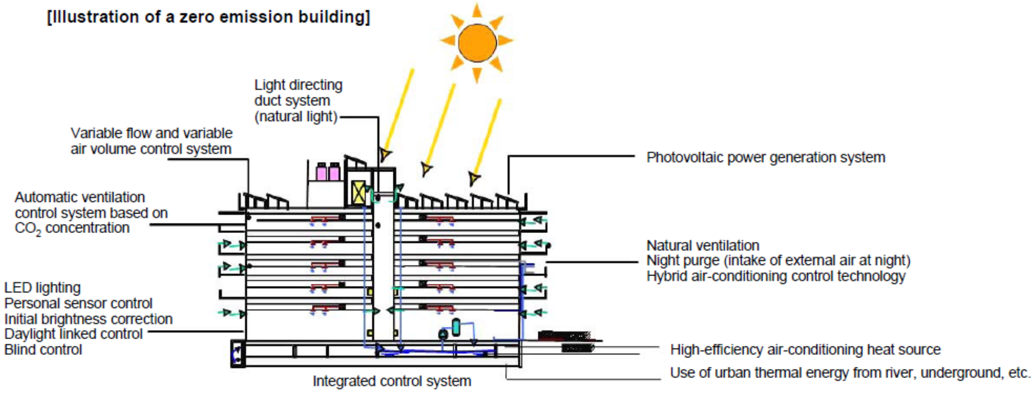
2.3.3 High Efficiency Housing/Building

Current Situation

Mandatory standards for energy efficiency in Japan apply to buildings over 2,000 meter squared. However the majority of Japanese houses have a much smaller surface area and in many cases the lowest and cheapest standards are observed with minimally acceptable insulation.[132] Development of long-lasting houses and rehabilitation of old houses and condominiums in line with the energy efficiency policy are spreading due to recent policy measures which prioritize securing comfortable housing for the elderly, developing environmentally friendly houses, and building/re-building 95% of all houses to become earthquake-resistance.[133]

In April 2009, the Japanese government put forward the Zero Emission Building (ZEB) target to accelerate the development of zero emission buildings. The aim is to drastically raise energy efficiency of buildings through advanced design technologies, equipments, and operational control systems. (Figure 40)[134]

Figure 40: Concept of a Zero Emission Building (ZEB)*[135]



* Zero Emission Building (ZEB) is a building that emits zero CO_2 on an annual net basis by reducing energy consumption through enhancement of energy efficiency performance of the building, and the use of renewable energy on site.

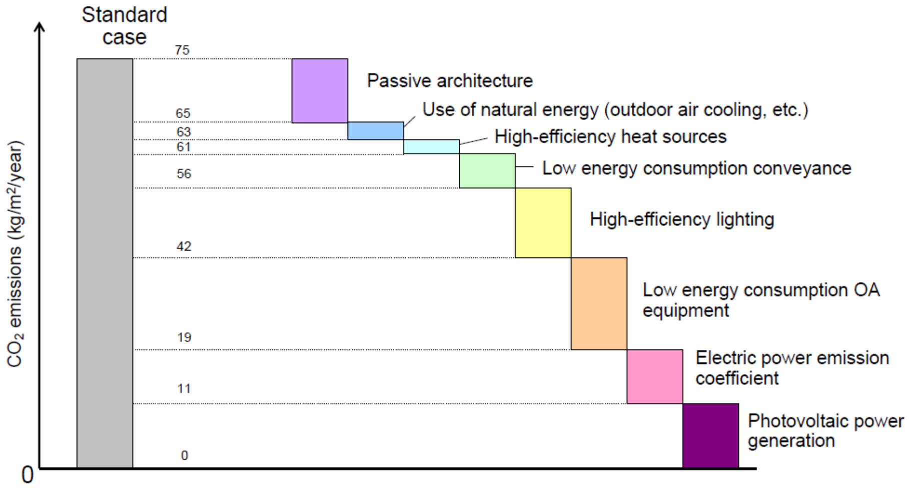
Research and Development

Annual CO_2 emissions and energy consumption could be reduced by 30-40% even with existing technologies. However, to realize ZEB, research and development in individual technologies, as well as comprehensive design and integrated control to effectively combine such technologies (Home Energy Management System (HEMS) / Building Energy Management System (BEMS)) are required. According to the government

[132] *Seminar Report on "Energy Efficiency in Buildings: European Experience and Japanese Situation", EU-Japan Centre for Industrial Cooperation, November 28, 2008*
[133] *The New Growth Strategy: Blueprint for Revitalizing Japan, Japanese Cabinet, June 18,2010*
[134] *Presentation by Toshi Sakamoto, Director, Energy Efficiency and Conservation Division, Agency for Natural Resources and Energy, October 2009 "Overview of Japan's Energy Efficiency Policies on Buildings and Appliances"*
[135] *(same as above)*

estimates, the concept of ZEB will be implemented by 2030 in medium and low-rise office buildings with certain technological progress as outlined in Figure 41.[136]

Figure 41: Technology to Achieve a Three-story Zero Emission Building[137]



Furthermore, the possibility of achieving ZEB is considered to become even greater, when networking with neighboring buildings is taken into account. Some recent examples of networking of buildings for energy usage include: [138]

- Yokohama City: Sharing of energy facilities among existing buildings in the same area.
- Vicinity of Nagoya Station: Sharing of several district heating and cooling systems.
- Akasaka Intercity: Supply of co-generation waste heat from new buildings to existing district heating and cooling systems.

Future Outlook

Measures to be taken for effective technology development and realization of high-efficiency housing/buildings:[139]

- ✓ Production Cost: Research and development of energy efficient technologies for homes/buildings and the introduction of HEMS/BEMS to reduce cost of both the design and operation of high-efficiency homes/buildings.
- ✓ Networking of Buildings: Development of more pilot projects which aim to share energy use among neighboring buildings.

[136] *(same as above)*
[137] *(same as above)*
[138] *(same as above)*
[139] *(same as above)*

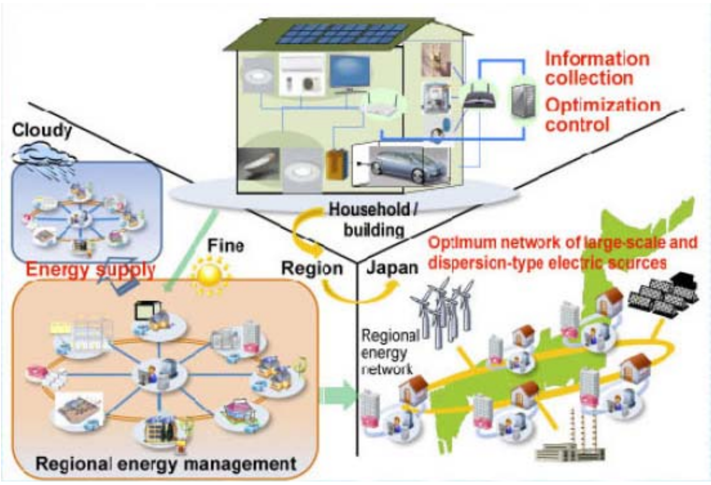
2.4 Cross-cutting Technology

2.4.1 Smart Grid

Current Situation

When actively increasing the introduction of renewable and new energy, there are risks of voltage fluctuation or uncertainty of frequency in the local grid. This is because renewable and new energy when introduced in large amounts do not have a stable power output, affected largely by natural conditions. Therefore, the current power supply system is not considered sufficient for the supply of renewable and new energy, and the use of the. "Smart Grid" is being proactively introduced. The "Smart Grid" uses information and communication technology to create an efficient power transmission and distribution network that provides real time management of power supply and demand.[140] (Figure 42)

Figure 42: Image of the "Smart Grid"[141]



Research and Development

Japan's research and development projects concerning the "Smart Grid" are focused in the following areas:[142]

- ✓ Introducing a demand response system to better manage frequency fluctuations.
- ✓ Building charging infrastructure to enable further diffusion of EVs.
- ✓ Utilizing smart meters and ICT network to create new services.

Starting in April 2010, NEDO has selected thirty-one companies, including Toshiba and Kyocera, to conduct "Smart Grid" pilot-projects that will be implemented in close coordination with the New Mexico Green Grid Initiative.[143]

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[140] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 26)*
[141] *(same as above)*
[142] *Nikkei Sangyo Newspaper, April 23, 2010 "The Cutting Edge Energy Industry"*

Electric companies including TEPCO have also started projects to introduce smart-meters that have multidirectional networks, and are aiming to introduce smart-meters to twenty seven million households in the future.[144]

Future Outlook

Measures to be taken for effective technology development and realization of the "Smart Grid":[145]

- ✓ Research and Development of "Smart Grid": Improving performance of the "Smart Grid" and the related technologies/devices such as the HEMS/BEMS and smart-meters to efficiently control electric flow.
- ✓ New Services: Enabling various new services for power suppliers and demand side users utilizing the "Smart Grid".

2.4.2 Smart Community

Current Situation

The concept of a "Smart Community" links the "Smart Grid" to the social system of people's lifestyles, and considers the energy efficiency of not only electric power but also thermal energy and traffic systems. This concept is expanding internationally, and Japan's energy conservation technology and the "Smart Grid" technology will contribute to the growth in the field of energy efficiency and conservation in Japan.[146]

In November 2009, METI launched the "Next Generation Energy and Social System Coordination Council", a study group on "Smart Community" led by the Information Economy Division of METI working on the implementation of demonstration projects inside and outside Japan, formulating roadmaps to think beyond the "Smart Grid" and is aiming to achieve international standards.[147]

METI has also launched a Smart Community Alliance in April 2010 with more than one hundred corporations to foster public-private partnerships to develop "Smart Communities" and tackle various issues such as deployment and research on smart grid standardization. NEDO serves as the secretariat for this Alliance.[148]

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[143] *Presentation by Tomoya Ichimura, NEDO, June 29, 2010 "Renewable Energy and Smart Community"*
[144] *Nikkei Sangyo Newspaper, April 23, 2010 "The Cutting Edge Energy Industry"*
[145] *(same as above)*
[146] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p. 26)*
[147] *Presentation by Shinsuke Ito, Deputy Director, Information Economy Division, METI December 15, 2009 "Japan's Initiative on Smart Grid"*
[148] *Presentation by Tomoya Ichimura, NEDO, June 29, 2010 "Renewable Energy and Smart Community"*

Research and Development

The design of a "Smart Community" can vary depending on the natural environment, industry, culture, economy, population density, and the infrastructure of a community. Therefore, pilot projects are considered necessary to conceptualize and develop these communities, and create international standards. Japan has started four unique large-scale pilot-projects in Yokohama City, Toyota City, Kyoto Keihanna District, and Kitakyushu City.[149] (Figure 43)

Figure 43: "Smart Community" Pilot-Projects in Japan[150]

<Yokohama City>

Players	Yokohama City, Toshiba, Panasonic, Meidensha, Nissan, Accenture, others)
CO_2 Emission Target	30% reduction by 2025 (from 2004)
Activities	Energy management system that integrates HEMS, BEMS, and EV PV (27,000kW) Use of heat and unused energy 4,000 smart houses, 2,000EVs

<Toyota City>

Players	Toyota City, Toyota Motor, Chubu Electric Power, Toho Gas, Toshiba, Mitsubishi Heavy Industries, Denso, Sharp, Fujitsu, Dream Incubator, and others
CO_2 Emission Target	Residential: 20% reduction Transportation: 40% reduction
Activities	Use of heat and unused energy in addition to electricity Demand response at more than 70 homes 3,100 EVs, V to H, V to G

<Kyoto Keihanna District>

Players	Kyoto Prefecture, Kansai Electric Power, Osaka Gas, Kansai Science City, Kyoto University
CO_2 Emission Target	Residential: 20% reduction (from 2005) Transportation: 30% reduction (from 2005)
Activities	Install PV on 1,000 homes EV car sharing system Management of grid connected PV and fuel cells in houses and buildings Grant "Kyodo eco points" for green energy usage

[149] *(same as above)*
[150] *(same as above)*

<Kitakyushu City>

Players	Kitakyushu City, Fuji Electric Systems, GE, IBM, Nippon Steel
CO_2 Emission Target	50% reduction (from 2005)
Activities	Real-time management of 70 companies and 200 houses Energy management using HEMS, BEMS Energy system that coordinates demand side management with overall power system

Future Outlook

Measures to be taken for effective technology development and realization of the "Smart Community":[151]

- ✓ Pilot Projects: Development of pilot-projects to understand the various conditions in which "Smart Communities" will be developed.
- ✓ New Standards: Setting "Smart Grid" standards that will be the key to realizing a seamless "Smart Community".

[151] *(same as above)*

3 Opportunities to Expand Swedish Business and Technology in Japan

3.1 Overview of Challenges in Japan's Energy Situation

Supply Side

Considerable steps are being made in promoting renewable energies while research and development on the effective usage of fossil fuels and nuclear power in Japan are taking place. The development and deployment of photovoltaic energy is gaining strong momentum, along with the acceleration in the research and development of biofuels. Wind energy and geothermal energy are also being introduced, although with special considerations to Japan's natural environment. These are all areas in which METI, as the key figure in Japan's energy policy, has influenced progress.

Biomass energy (excluding biofuel production), however, is an area that is still relatively undeveloped. Section 3.2 of this report will look into the potential opportunity for Swedish businesses to engage with Japan's development of biomass energy.

Demand Side

Research and development on the effective consumption of energy has made progress in various areas in Japan. EV/PHVs, stationary fuel cells, and high-efficiency houses/buildings mentioned in this report have undergone considerable technological improvements. Other areas such as innovative production of materials (such as iron and steel), intelligent transport systems, fuel cell vehicles (to be commercialized in 2015), high-efficiency household appliances, and energy management systems have also undergone substantial improvements.

Cross-cutting

The need to improve performance of the electric grid to accommodate large-scale introduction of renewable energies and to enhance communication between diverse power supplies have led to the realization of the "Smart Grid" and the "Smart Community", both considered as an opportunity and a challenge. Research and development on related technologies and the pilot-projects have focused on energy management systems, EV/PHVs, and PV cells, all which are related to energy-efficiency of electric power. As a result, there has been less emphasis on addressing the need for energy-efficiency of thermal energy and the use of unused energy.

Considering the need for more efficient houses/buildings and the focus on the "Smart Community" in Japan, Section 3.3 of this report will look into the potential opportunity for Swedish businesses to engage with Japan's regional development of unused thermal energy.

3.2 Use of Swedish Technology for Biomass Production in Japan

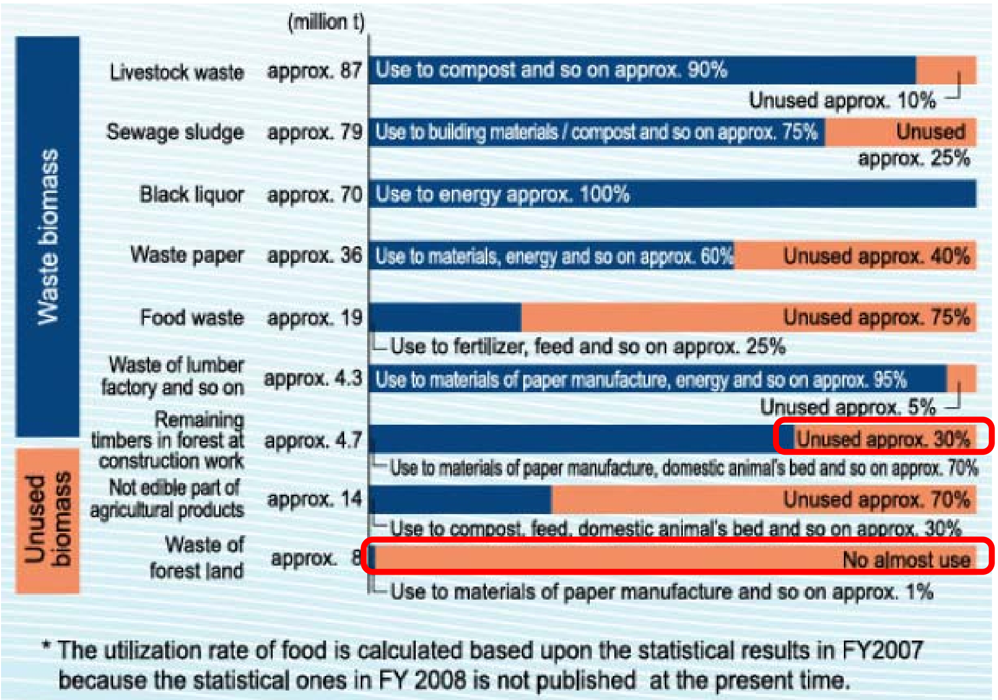
Present Challenges and Future Outlook for Japan

In Japan, production of biomass energy has focused on medium to large size plants using lumber mill residue with power generation and heat usage through direct combustion. Biogass production (e.g. methane fermentation) is also taking place with animal wastes and human waste at smaller plants.

Japan's forest residue is considered to have great biomass potential. Japan has an abundance of forest residue, but due to the high cost of shipping and processing, it has remained almost untouched. As a result, although there are technologies for producing bioethanol from forest residue (similar to the SunPine Project in Sweden), it is considered that the cost effectiveness is a difficult problem to overcome. In addition, the use of black liquor (similar to BioDME Project in Sweden) may be considered; however, this method has already been adopted in many areas in Japan, and growth may not be expected in the near future.

As a result, prospective area for growth is the production of thermal biomass energy through unused wood biomass (such as remaining timber in forests at construction sites and forest residue). (Figure 44)

Figure 44: Unused Wood Biomass in Japan[152]



[152] *Energy in Japan 2010, Agency for Natural Resources and Energy, 2010 (p.28)*

Opportunities for Swedish Businesses

Production of wood pellets is the most reasonable way to produce thermal energy from unused wood biomass. However, as the production of wood pellets in Japan is very costly, Swedish technology and systems may contribute to introducing a more economically sustainable production and use. If shipping and processing (especially drying) costs of woods can be reduced, the usage of these woods as chips/pellets for thermal plants or as local resources for heat can be foreseen in the future.[153]

There is also a need to introduce the concept of a "value chain creation" throughout production, supply, and deployment of biomass energy in Japan. Research and development of biofuels with the concept of the "value chain creation" is being promoted as a result of strong support by METI and the involvement of key industries. However, other biomass products (such as forest residue based thermal energy) which are solely under the responsibility of MAFF are receiving considerably less attention. As a result, the value chain of biomass products other than biofuel is focused mainly on the efficient usage of the biomass resource itself, and less on the creation of demand or other socio-economic values it can provide. As can be seen in projects like BioDME and SunPine, Swedish businesses have a stronger understanding of the concept of "value chain creation", and may have the potential to introduce the role of biomass energy (in particular those based on forest residue) to Japan from a wider perspective such as city planning, community development, and infrastructure maintenance.

Challenges/Issues

Although the percentage of biomass energy will most likely continue to remain small among the renewable energies produced, its overall volume cannot be neglected. (The Roadmap to 2030 for biomass related technologies in Japan can be found in Appendix A.) The following issues are being discussed regarding thermal energy production concerning wood biomass:

1. Stable procurement and supply of unused wood biomass without destruction of environment and surrounding communities.
2. Improvements in cost effectiveness through research and development on drying unused wood resources and pellet production.
3. Efficient production of thermal biomass energy from unused wood biomass.
4. Public-private partnerships to effectively introduce the use thermal biomass energies in line with the development of cities and local communities.

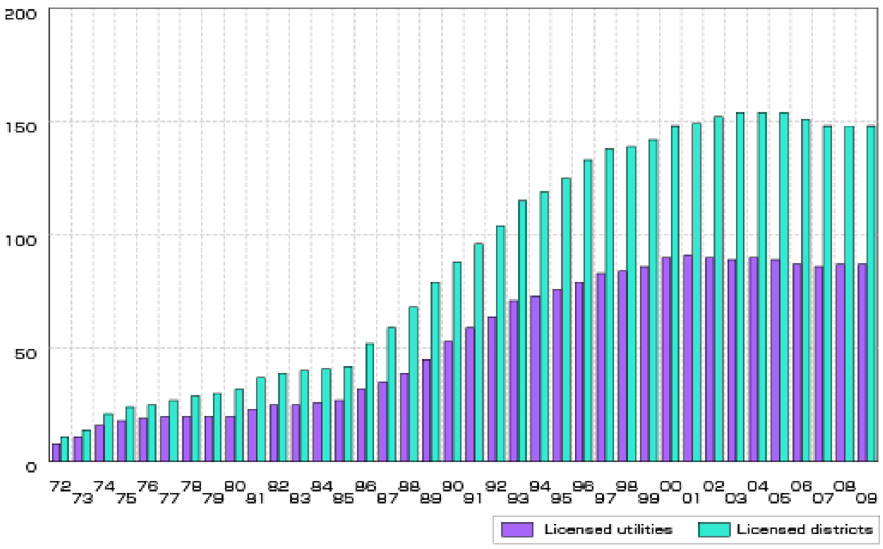
[153] *Interview with Akihiko Nemoto, Professor of Environmental Management, Tottori University of Environmental Studies*

3.3 Applying Swedish Thermal Energy Use Concept to Japan

Present Challenges and Future Outlook for Japan

According to the Japan Heat Service Utilities Association (JHSUA), the first district heating and cooling system was introduced in Osaka in 1970, mainly for pollution prevention reasons. Since then, with the rise in the interest and recognition of its environmental benefits, numbers of districts and utilities providing the system has been gradually increasing, but its growth has leveled off in the past decade. (Figure 45)

Figure 45: Districts and Utilities Providing Heating and Cooling Systems[154]



On the other hand, according to the research on unused energies in nine prefectures in Japan (Tokyo, Saitama, Chiba, Kanagawa, Aichi, Kyoto, Osaka, Hyogo, Fukuoka), there is a large amount of unused heat. In the nine prefectures, the total amount of high-temperature waste heat energy (from factories, wastewater treatment plants, power plants) was 2,022,220TJ/year and approx. 246,915TJ/year of this could have been used as energy. This unused thermal energy is equivalent to almost half of the amount of total heat load (approx. 500,000TJ/year) in the relevant prefectures. In addition, the total amount of low-temperature waste heat energy (from sewage water heat at sewage plants) is approx. 173,147TJ/year and approx. 119,098TJ/year of this could have been used as energy as well.[155] Therefore, acquisition of this unused thermal energy from waste heat can be considered an important and competitive energy source for city development in Japan, expanding opportunities and contributing towards sustainable development.

[154] *Japan Heat Service Utilities Association Website "District Heating and Cooling in Japan" http://www.jdhc.or.jp/en/area.html*

[155] *Report on the Potential Usage of Unused Local Heating Energy, Agency for Natural Resources and Energy, 2008*

Opportunities for Swedish Businesses

Urban city developments such as Hammarby Sjostad in Stockholm and Vastra Hamnen in Malmo, Sweden, provide examples of city developments which have a holistic view for efficient use of local renewable energy (electricity, heating and cooling) including secondary energy. In Japan, secondary energy (e.g.. unused thermal energy) is often neglected in the Japanese energy supply system, and is not mentioned in the "Smart Community" plan. District heating and cooling systems, passive energy systems generated by the secondary heat (spillenergi) from factories and power plants, and "micro energy" such as human heat have also not yet been widely introduced in Japan. Swedish technologies, system design, and management in these fields would contribute to a new paradigm in energy usage for Japan.

Figure 46: Local Energy Usage in Sweden

Local Energy Used in Sweden	Examples of Usage
・organic waste ・waste water ・secondary energy from factories and power plants ・micro energy such as human heat ・oceans and lake floor heating and cooling	・District heating / cooling system for households ・Fuel for public transportation such as a buses and subway ・Fuel for Taxis, boats and private cars ・Cooking gas for households ・Heating and cooling for offices, public transportation stations, airports etc. ・Sports stadiums etc

Challenges/Issues

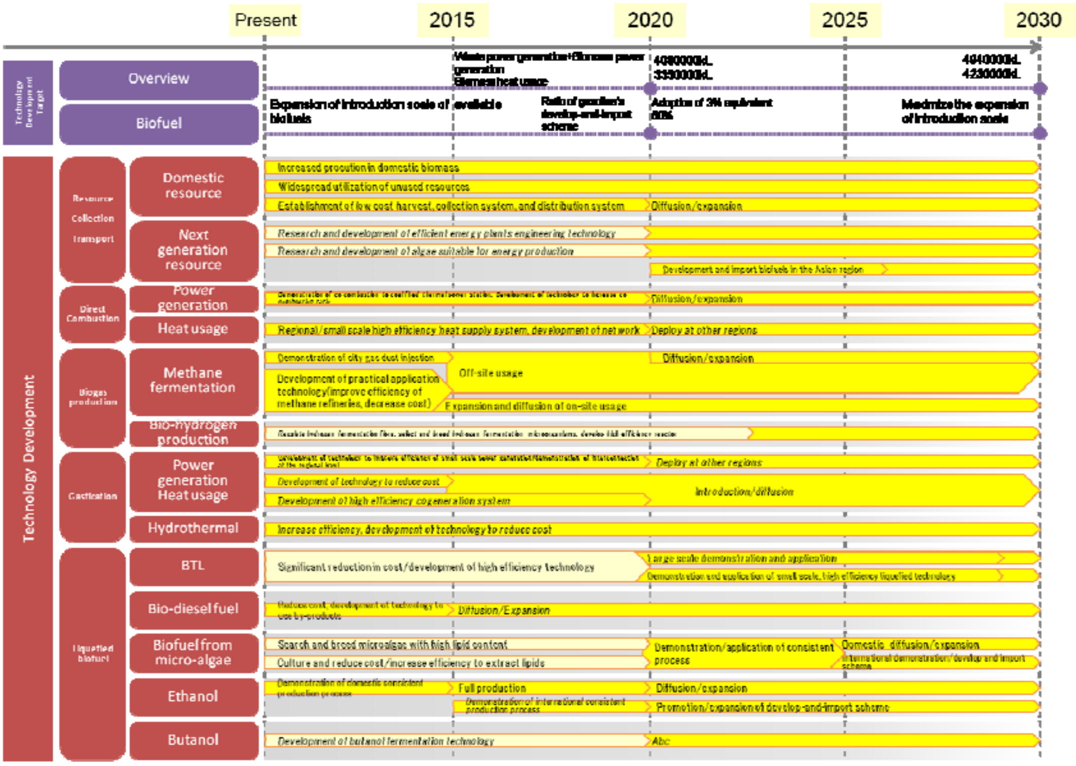
The district heating/cooling system could play a very important role not only in the energy supply in cities and smaller communities, but also in shaping energy and environment related policies and strategies for urban development. However, the following issues and concerns are being discussed in introducing district heating/cooling systems in Japan[156]:

1. Increase in initial cost such as construction cost of infrastructures (pipes).
2. Large scale changes in building design to adjust to a new system.
3. Concerns from building owners on the stable supply and long term benefits.
4. Reliable function and price competitiveness compared to the present system.
5. Loss of energy due to more pipes and infrastructures in apartment buildings, resulting in energy loss.
6. Competition against other individual air conditioning systems in commercial buildings such as the "building multi package air conditioning" system which is rapidly developing in Japan.

[156] *Report on the Potential Usage of Unused Local Heating Energy, Agency for Natural Resources and Energy, 2008*

Appendix A

Roadmap of Biomass Related Technologies to 2030[157]



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Growth Analysis Studentplan 3, S-831 40 Östersund
Phone: + 46 10 447 44 00 | info@growthanalysis.se | www.growthanalysis.se