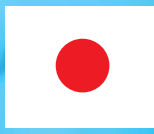
INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries



JAPAN

2003 Review

OECD

INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

JAPAN

2003 Review

INTERNATIONAL ENERGY AGENCY
9, rue de la Fédération,
75739 Paris, cedex 15, France

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

** IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

TABLE OF CONTENTS

1 *SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS* 7

2 *ORGANISATION OF THE REVIEW* 15

3 *GENERAL ENERGY POLICY* 17

4 *ENERGY AND THE ENVIRONMENT* 33

5 *ENERGY DEMAND AND END-USE EFFICIENCY* 45

6 *FOSSIL FUELS* 61

7 *NEW AND RENEWABLE ENERGY SOURCES* 95

8 *NUCLEAR POWER* 105

9 *ELECTRICITY* 115

10 *RESEARCH AND DEVELOPMENT* 147

A *ANNEX: ENERGY BALANCES AND KEY STATISTICAL DATA* 161

B *ANNEX: INTERNATIONAL ENERGY AGENCY "SHARED GOALS"* .. 165

C *ANNEX: GLOSSARY AND LIST OF ABBREVIATIONS* 167

Tables and Figures

TABLES

1. Long-term Energy Supply and Demand Outlook 21
2. Energy Taxes in Japan, FY2002 27
3. Proposed Revision of Excise Taxes 27
4. Japan's Greenhouse Gas Inventory, 1990 to 1999 34
5. Breakdown of Japan's Energy-related CO_2 Emissions, 1990 to 2001 34
6. Breakdown of Japan's 6% Emissions Reduction Objective 38
7. CO_2 Emissions for Industry under the Keidanren Voluntary Action Plan 39
8. Major Energy Conservation Policy Measures and Effects by FY2010 .. 48
9. Energy Conservation Targets for Designated Equipment 49
10. Refining Capacity 69
11. Coal Imports to Japan by Country, 1980 to 2001 73
12. Power Stations Using Clean Coal Technologies 74
13. Major Gas Companies 75
14. Long-term LNG Contracts 79
15. LNG Import Terminals 83
16. Power Generation Cost of New and Renewable Energy Sources .. 98
17. New and Renewable Energy Prospects for FY2010 100
18. Measures to Promote New and Renewable Energy Sources, FY2001 to FY2002 101
19. Commercial Nuclear Power Plants in Operation on 31 March 2002 .. 106
20. Nuclear Power Plants under Construction or Planning 109
21. Cost of New Nuclear Power Units 109
22. General Electric Utilities, FY2001 115
23. Average Costs per kWh Sold by the General Electric Utilities, 1990 to 2001 129
24. Unbundling of Transmission System Operators in IEA Countries ... 131
25. Regulatory Institutions in IEA Countries 132
26. New Entrants to the Power Market 135
27. Co-generation System Capacity, end of FY2000 136
28. Government Energy R&D Budget 149

FIGURES

1. Map of Japan 18
2. Total Primary Energy Supply, 1973 to 2001 19
3. Total Final Consumption by Sector, 1973 to 2001 19
4. Total Final Consumption by Source, 1973 to 2001 20
5. Energy Production by Source, 1973 to 2001 24

6. CO_2 Emissions by Fuel, 1973 to 2001 35
7. CO_2 Emissions by Sector, 1973 to 2001 36
8. Energy-related CO_2 Emissions per GDP in Japan and in Other Selected IEA Countries, 1973 to 2001 36
9. CO_2 Emissions from Iron & Steel and Cement Industries in Keidanren's Voluntary Action Plan 40
10. Energy Intensity in Japan and in Other Selected IEA Countries, 1973 to 2001 46
11. Total Final Consumption by Sector and by Source, 1973 to 2001 ... 47
12. Factors in the Increase of Energy Use by Private Vehicles, FY1990 to FY1998 56
13. OECD Unleaded Gasoline Prices and Taxes, First Quarter 2003 .. 64
14. OECD Automotive Diesel Prices and Taxes, First Quarter 2003 .. 65
15. Fuel Prices, 2001 66
16. Final Consumption of Oil by Sector, 1973 to 2001 67
17. Final Consumption of Natural Gas by Sector, 1973 to 2001 77
18. Natural Gas Infrastructure 82
19. Gas Prices in IEA Countries, 2001 84
20. Gas Prices in Japan and in Other Selected IEA Countries, 1980 to 2001 85
21. Electricity Market Structure 116
22. Supply Areas of General Electric Utilities 117
23. Final Consumption of Electricity by Sector, 1973 to 2001 119
24. Development of Load Curves 120
25. Development of the Annual Load Factor, 1980 to 2001 120
26. Electricity Generation by Source, 1973 to 2001 122
27. Transmission Interconnection Capacities 124
28. Electricity Prices in IEA Countries 126
29. Electricity Prices in Japan and in Other Selected IEA Countries, 1980 to 2001 127

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

Since the last in-depth review in 1999, the major developments in Japan's energy policy have been partial liberalisation of the electricity market, new steps in gas market liberalisation, the ratification of the Kyoto Protocol and development of an enhanced policy package to achieve the Kyoto target. However, balancing the "3 Es" (energy security, economic efficiency and environment) remains a challenge.

The most recent *Long-Term Energy Supply and Demand Outlook* up to 2010, which forms the basis for the government's policy package to achieve the "3 Es", was published in 2001. It is important that Japan continues to update it with sensitivity analyses as the first Kyoto commitment period approaches. The timeframe beyond 2010 could also be considered in the next review of the *Outlook*.

ENERGY SECURITY

Japan is making great efforts to ensure security of supply by diversifying its energy mix away from oil. Furthermore, oil stocks exceed the IEA stockholding obligation, many flexibility tools (such as supply diversity and possibilities for fuel-switching) are used for natural gas, and policies to promote nuclear power and renewables help towards diversification. However, growing oil import dependence from a single area is still a concern. Japan is also encountering new issues of energy security. The disruption in gas supply from Arun (Indonesia) shows a potential security threat as the share of gas is increasing in the fuel mix. The outage of TEPCO nuclear plants is another example. In addition, sharpening summer peak demand for electricity may cause a risk in matching demand and supply. Energy security issues are more critical in Japan than in most IEA countries owing to its isolated location and limited domestic energy resources.

ENVIRONMENT

In June 2002, Japan ratified the Kyoto Protocol with a commitment to achieve a 6% greenhouse gas emissions reduction from 1990 levels by 2008-2012. This is a challenging target since in 1999, emissions were 6.8% above the target year levels. The path towards the target has been laid down by the government in the "New Guideline for Measures to Prevent Global Warming" of March 2002.

Japan's CO_2 emissions per capita and per unit of GDP are good compared with the IEA average and the country has developed an impressive range of policies to address its rising CO_2 emissions from the energy sector. These include the innovative Top-Runner Programme to encourage manufacturers to develop more efficient technologies, energy efficiency labelling, new technologies (*e.g.* the Home and Business Energy Management Systems), voluntary energy performance standards for buildings and portfolio standards for renewable energies. However, some of the measures could be strengthened with energy efficiency labelling extended to a wider range of appliances and energy performance standards made mandatory for new buildings and extended to refurbishment of existing buildings. One of the key measures is Keidanren's (Japan Business Federation) Voluntary Action Plan for stabilising industry's emissions by 2010. A major question will be whether the objective will be met if industrial output recovers from the current recession. Nuclear power is important to the country's climate change policy but its increased use depends on several issues which are discussed below. The recently introduced tax on coal, liquefied natural gas (LNG) and liquefied petroleum gas (LPG), albeit not targeted to lower CO_2 emissions and relatively modest, corrects the heavy focus on oil taxes while coal and gas imports have been untaxed up to now. Since the marginal cost of emissions reduction by domestic means is increasing, the participation of industry in international emissions trading and other Kyoto mechanisms would be welcome, as it may give access to the cheapest mitigation options available in Kyoto Protocol Parties.

Nuclear power has a central role in Japanese energy policy both in terms of security of supply and climate change mitigation. Nuclear power is also broadly competitive with other electricity generation forms in Japan. The government's target is to increase nuclear generation by 30% (equivalent to 10-13 new nuclear plants) between 2000 and 2010. This target, however, has become more difficult to reach because of safety-related incidents in recent years, undermining public confidence and jeopardising energy security after significant plant outages. The first challenge is to restore public confidence. Secondly, since the load factor of Japanese nuclear power plants is much lower than the best performers in the world, more attention should be given to shortening the statutory and other outage periods and reducing their frequency. A third challenge is to ensure the role of nuclear power in liberalised electricity markets, a subject that has not been addressed in the recent debate on further market reform in the electricity sector.

ECONOMIC EFFICIENCY

While energy security and environmental issues have been well addressed in Japan, more needs to be done to improve economic efficiency, including efficiency in the energy markets and cost-effectiveness of government policies. Japanese energy policy includes a complex web of financial and fiscal incentives

to encourage certain energy supplies and end-use technology choices. It is not clear how well these mechanisms are working individually or collectively. Japan should develop a comprehensive map of all the various incentives and disincentives – financial, tax, regulatory, R&D, etc. – to determine the cost-effectiveness of these measures and rationalise these policy options for maximum impact and leverage.

Despite some recent reductions, energy prices in Japan are still among the highest within IEA member countries. To increase market efficiency, the government has launched market reform. This process is most advanced in the oil sector which has been fully liberalised. However, the implications have not yet been fully ascertained because the industry is still in the middle of restructuring which involves closing excess refining capacities and rationalising retailing.

Natural gas market liberalisation started in 1995 and some 39% of the market is now open. If measured in terms of the market share by new entrants, *i.e.* 2% of the liberalised market segment in March 2002, little competition has emerged. The government has recognised the need for further action to fully capture the potential benefits of market reform and announced new measures such as the introduction of regulated third-party access (TPA) to the pipelines and the promotion of negotiated TPA to the LNG terminals. These appear helpful but their effectiveness needs to be closely monitored and corrective measures need to be introduced promptly if competition does not develop. Expansion of the domestic gas network is also a challenge to further introduction of natural gas, enhancing security of supply and competition.

Electricity market reform was initiated in March 2000. At present, 30% of the market has been opened for competition and regulated TPA has been introduced. Some price reductions have taken place for both liberalised and captive consumers, mainly because of low interest costs, but price positioning due to market liberalisation may also have had an impact. Because new entrants are having difficulties in entering the market and there is little revealed competition between the incumbents, the government has announced further steps. Many of the proposed measures, including clearer criteria for TPA tariffs, removal of pancaking[1], establishment of national power exchange and relaxation of balancing power rules, can help make market access easier, fairer and more transparent. However, the proposal does little to address the fact that the incumbents are very large and powerful companies with significant market powers compared to new entrants. Given the slow entry rate, competition between the incumbents has to be fostered. The effectiveness of the planned unbundling arrangements, the "neutral transmission organisation" and the regulatory institutions should be ensured. If competition

1. Pancaking means that two or more access charges are collected in electricity transactions when two or more transmission systems are used.

does not develop, stronger measures such as establishing an independent national transmission system operator should not be precluded. Furthermore, the weak interconnection between most supply regions should be strengthened to facilitate competition and ensure energy security.

In short, the report suggests that there is room for improved economic efficiency in the whole energy field, provided good measures are taken and implemented.

RECOMMENDATIONS

The government of Japan should:

General Energy Policy

- *Develop integrated measures – beyond oil stockpiling – to address the security of supply issues arising from Japan's isolated location, high import dependence, electricity transmission bottlenecks and lack of a trunk network for gas transmission.*
- *While recognising energy security is of the utmost importance for Japan, implement further steps in market reform to ensure a level playing field.*
- *Continue to review 2010 projections in the* Long-Term Energy Supply and Demand Outlook *and carry out sensitivity analyses, and consider preparing projections beyond this time frame.*
- *Evaluate the cost-effectiveness of subsidies, fiscal incentives and R&D in support of energy policy goals.*
- *Assess the fuel tax revision with a view to clarifying its objectives and ensuring its cost-effective achievement.*
- *Ensure the timely availability of good quality statistical information to all interested parties, including international organisations.*

Energy and the Environment

- *Address foreseeable and unforeseeable changes in reviewing the* New Guideline of Measures to Prevent Global Warming *in 2004.*
- *Continue to monitor the GHG emissions, in particular in the transport and electricity sectors, and take further action, if necessary, both domestically and through the Kyoto flexible mechanisms to close the gap with the Kyoto target.*

- *Continue to closely follow progress under the Keidanren's "Voluntary Action Plan on the Environment". Consider encouraging companies to take further actions, including the use of Kyoto mechanisms. Monitor the seemingly rising emissions from businesses outside the Action Plan.*

- *Consider how Japan can take advantage of possible international emissions trading to ensure cost-effective climate change mitigation and lower adverse economic impacts.*

- *Select climate change mitigation measures – including for other GHGs – taking into account their cost-effectiveness and their contribution to energy security.*

Energy Efficiency

- *Assess the efficacy of combining energy efficiency standards/guidelines with subsidies.*

- *Strengthen the standards for appliances and vehicles in the Top-Runner Programme by:*
  - *Considering other approaches to set new standards, such as minimum life cycle cost or using the international appliance market to identify the top-runner.*
  - *Making labelling mandatory and extending it to a wider range of products.*
  - *Considering different approaches for vehicles to avoid a shift towards increased weight, such as by basing the top-runner on the consumption of the average fleet or by engine size.*

- *Examine the possibility of introducing mandatory efficiency standards for new residential and office buildings, intensify the efforts in certification of new buildings and develop a certification scheme for existing buildings.*

Fossil Fuels

- *Continue addressing security of fossil fuel supply by encouraging the procurement of fuels from diverse sources and creating favourable international relations.*

- *Ensure consistency with the energy security goals in setting up the new entity replacing Japan National Oil Corporation.*

- *Evaluate the cost-effectiveness of Japan National Oil Corporation's operations and take this into account in establishing its successor which should also function consistently with the competitive energy markets.*

- *Ensure real competition in the petroleum market and see to it that consolidation and mergers will not hamper it.*

- *Facilitate further restructuring of the refining and retailing sectors to improve efficiency.*
- *Encourage the commercial demonstration and deployment of advanced coal power plants that have higher efficiency and lower GHG emissions.*
- *Stimulate the development of trunk pipelines for natural gas.*
- *Introduce account unbundling between pipeline transmission/distribution of gas and other activities of gas companies.*
- *Reduce regulatory barriers for new entrants to acquire customers in franchised areas.*
- *Follow closely the effectiveness of efforts to promote third-party access to LNG terminals. If the measures are not adequate to ensure effective competition, consider implementing TPA obligation.*

New and Renewable Energy Sources

- *Review in due time the implementation of the renewables portfolio standard to ascertain its effectiveness and what further measures may need to be taken.*
- *Taking account of their potential energy security and GHG benefits, ensure renewables have access to the grid as envisioned for nuclear power.*

Nuclear Power

- *Address safety-related shortcomings, paying particular attention to ensure the effective working of the Nuclear and Industrial Safety Agency and the new organisation, Japan Nuclear Energy Safety Organisation.*
- *Work to restore public confidence in nuclear energy, especially by addressing the political tensions between national and local governments.*
- *Maintain efforts to improve nuclear plant availability, particularly of the boiling water reactor tranche.*
- *Clarify the role of nuclear power in the liberalised market and the respective responsibilities of government and industry in meeting its back-end costs.*
- *Pursue the ultimate disposal of high-level radioactive waste, seeking appropriate sites through enhancing acceptance of its nuclear policy.*

Electricity

- *Promote pricing mechanisms and other demand measures which help moderate peak loads.*

- *Ensure an effective level of unbundling to facilitate fair and effective competition. As a first step, immediately implement the account unbundling and "information firewalls" for separation of transmission from generation and retail activities to level the playing field between incumbents and new entrants. If fair and effective competition does not emerge, the government should not preclude establishing a single independent transmission system operator to manage the national network.*

- *Strengthen the regulatory framework with emphasis on an* ex ante *basis. Ensure the independence of the regulatory authority from industry and the industry development activities of METI, and as a second step, assess the benefits of creating a regulator completely independent from METI.*

- *Foster the strengthening of an inter-regional transmission grid in a cost-effective way, particularly between the two frequency areas, to improve security of supply and facilitate effective competition. Improve the possibilities for access to interconnections by measures such as auctioning the capacities.*

Research and Development

- *Continue to pursue a balanced portfolio of R&D with due attention to adequate support for long-term R&D.*

- *Seek an increasing cost-sharing from industries where possible, especially when they benefit from successful R&D.*

ORGANISATION OF THE REVIEW

REVIEW TEAM

The International Energy Agency (IEA) 2003 in-depth review of the energy policies of Japan was undertaken by a team of energy policy specialists drawn from member countries of the IEA. The team visited Japan from 20 to 24 January 2003 for discussions with representatives of government energy administrations, energy industries and non-governmental organisations.

Members of the team were:

Dr Hartmut Schneider
(team leader)
Deputy Director General, Energy
Federal Ministry of Economics
and Labour
Germany

Dr Samuel Baldwin
Chief Technology Officer, Office of
Energy Efficiency and Renewable Energy
US Department of Energy
United States

Mr Jordi Dolader i Clara
Commissioner
National Energy Commission
Spain

Dr Alan Heyes
Deputy Director, International
Nuclear Policy & Programmes
Department of Trade and Industry
United Kingdom

Ms Helen Ratcliffe
Assistant Manager, Retail, Energy
Market Reform
Department of Industry, Tourism
and Resources
Australia

Dr Peter Wilmer
Head, Nuclear Development
Division
OECD Nuclear Energy Agency

Mr Olivier Appert
Director, Long-Term Co-operation
and Policy Analysis
International Energy Agency

Mr Richard Baron
Environmental Expert
International Energy Agency

Ms Lea Gynther
Energy Policy Desk Officer – Japan
International Energy Agency

Lea Gynther managed the review and drafted most of the report. Richard Baron wrote the chapter on Energy and the Environment. Monica Petit and Bertrand Sadin prepared the figures.

ORGANISATIONS VISITED

The team consulted with the following organisations:

- Ennet Corporation

- Japan Business Federation (Nippon Keidanren)
- Ministry of Economy, Trade and Industry (METI) and its Agency for Natural Resources and Energy (ANRE)
- Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- Ministry of Environment (MOE)
- Ministry of Land, Infrastructure and Transport (MLIT)
- New Energy and Industrial Technology Development Organisation (NEDO)
- Nippon Association of Consumer Specialists (NACS)
- Petroleum Association of Japan (PAJ)
- The Fair Trade Commission
- The Federation of Electric Power Companies (FEPC)
- The Japan Gas Association
- Tokyo Electric Power Company (TEPCO)
- Tokyo Gas Co., Ltd.

The assistance and co-operation of all participants in the review are gratefully acknowledged.

REVIEW CRITERIA

The *Shared Goals* of the IEA, which were adopted by IEA Ministers at their 4 June 1993 meeting held in Paris, provide the evaluation criteria for in-depth reviews conducted by the Agency. The *Shared Goals* are set out in Annex B.

GENERAL ENERGY POLICY

OVERVIEW

In 2000, the population of Japan was 127 million, only 3% higher than in 1990. The population density of 340 persons per square kilometre is one of the highest within the OECD. The total land area is 378 000 km^2, stretching over 3 300 km north to south. The geographic setting has many implications for Japan's energy policy. Security of supply has always been a major issue as Japan is an archipelago with few indigenous energy resources. Two-thirds of the land are mountainous, thus affecting the possibilities to build energy networks. In addition, seismic instability requires high security standards. In 2001, the gross domestic product (GDP) per capita, measured using current purchasing power parities, was US$ 26 400. GDP, measured using 1995 prices and exchange rates, was US$ 5 647 billion[2] making Japan the second largest economy in the world. However, economic growth was very slow through the 1990s. In 1999-2000 there was a modest recovery but in 2001, GDP decreased by 0.3% and a 0.7% fall is estimated for 2002. The OECD estimates growth to be only 0.5 to 1% per year to the end of 2004 with deflation continuing.

ENERGY MARKET

Japan is the fourth largest energy consumer in the world. In 2001, total primary energy supply (TPES) was 520.7 Mtoe, up by 19% from 1990 levels. This exceeds the 14% growth of GDP over the same period which is quite exceptional among IEA countries. Japan's dependence on oil has decreased from 58% in 1990 to 49.2% in 2001. In 2000, coal accounted for 19.2%, followed by nuclear (16%), natural gas (12.4%), hydro (1.4%), combustible renewables and wastes (1%), geothermal energy (0.6%) and other renewables (0.2%). There were some changes in the proportions of different fuels in TPES between 1990 and 2001. Oil use was replaced mainly by natural gas whose share increased from 9.9%, nuclear power from 12.1% and coal from 16.9%.

In 2001, total final energy consumption (TFC) was 342.1 Mtoe, increasing by 17% from 1990 levels. Industry is the largest energy-consuming sector (38%), followed by residential, services and other sectors (33%) and transport (28%) (see Figure 3). In 2001, oil accounted for 63.9% of TFC, electricity 23.1%, coal 6.1%, natural gas 6%, combustible renewables and wastes 0.7%, and other energies 0.3% (see Figure 4). Between 1990 and 2001, there were

2. On average in 2002, ¥1 = US$ 0.008.

Figure 1

Map of Japan

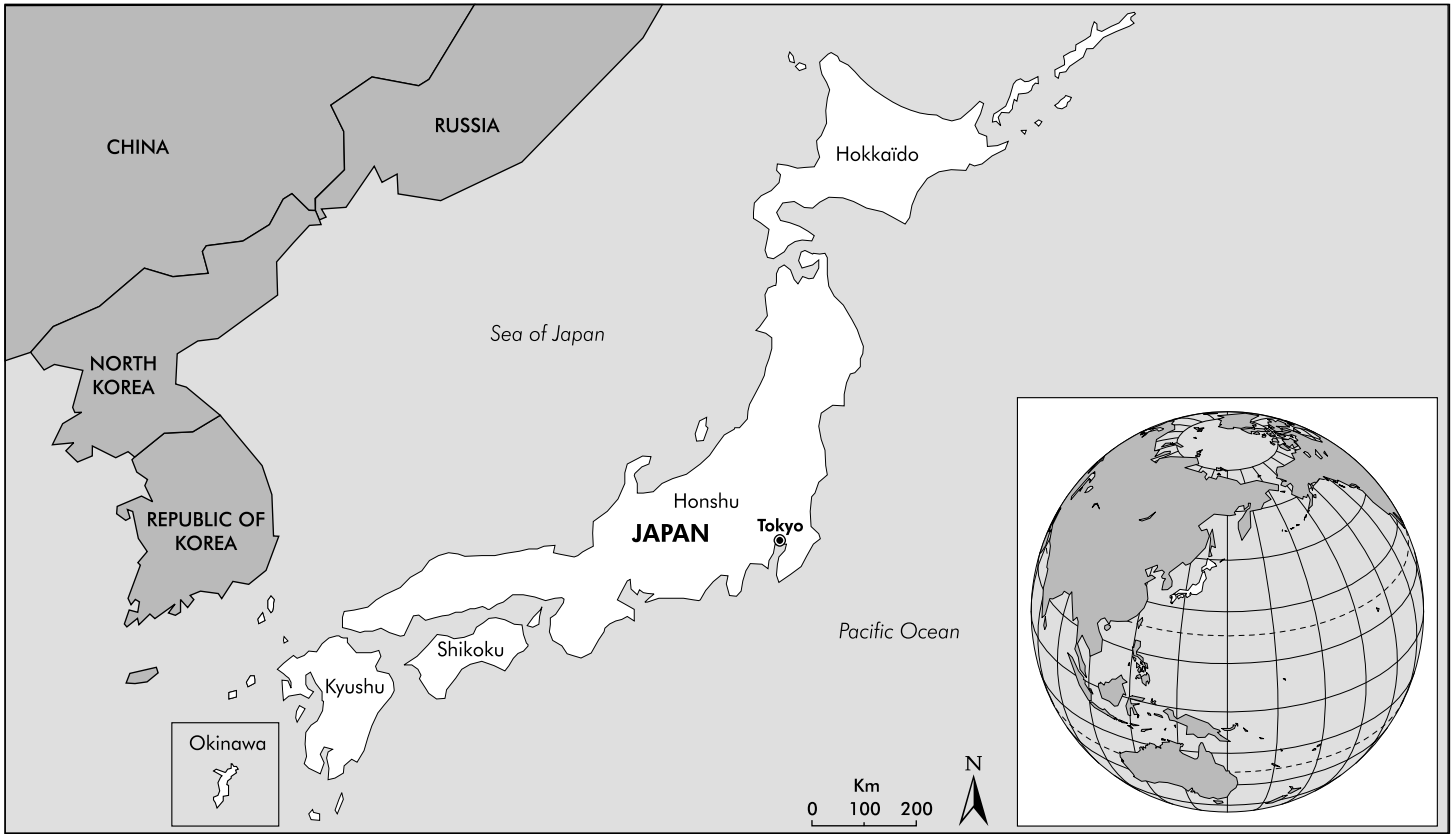
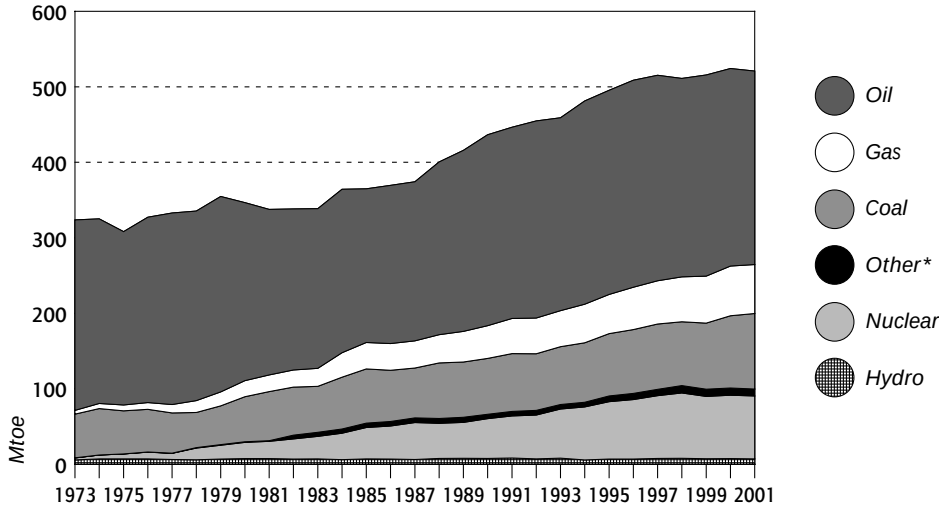


Figure 2

Total Primary Energy Supply, 1973 to 2001

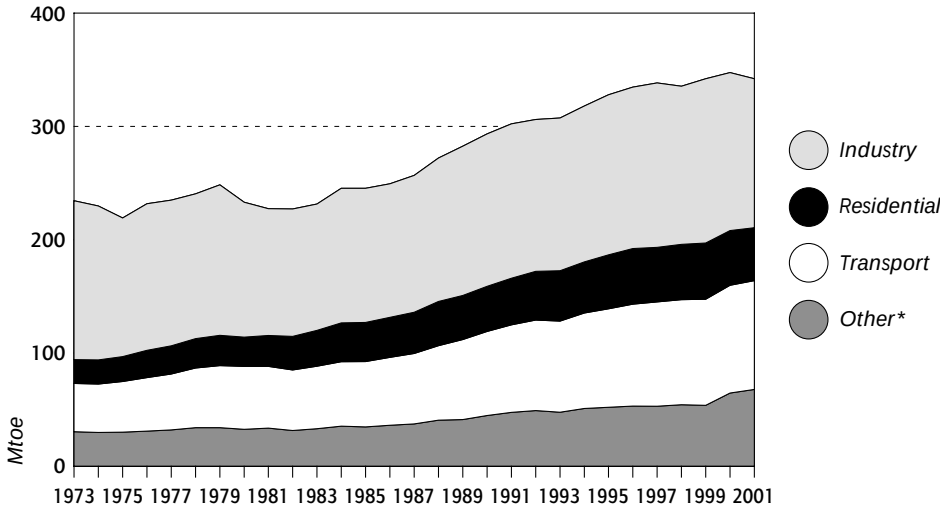


* includes geothermal, solar, wind, combustible renewables and wastes.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

Figure 3

Total Final Consumption by Sector, 1973 to 2001

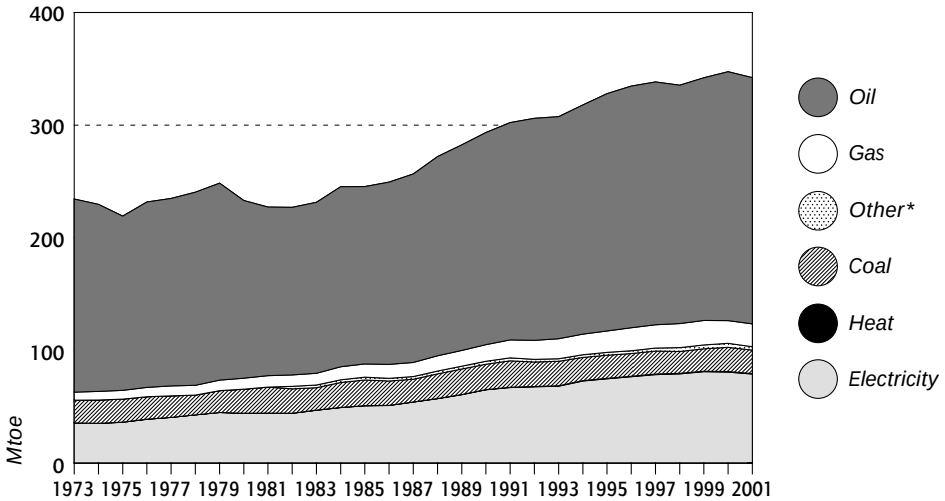


* includes commercial, public service and agricultural sectors.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

Figure 4

Total Final Consumption by Source, 1973 to 2001



* includes solar, wind, combustible renewables and wastes.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

some minor changes in the proportions of different fuels in TFC. The share of oil decreased from 64.2%, coal from 7.7% and combustible renewables and waste from 0.9%, whereas the share of natural gas increased from 5% and the share of electricity from 22.2%. The share of heat in TFC remained at 0.1% in 1990-2001.

LONG-TERM ENERGY SUPPLY AND DEMAND OUTLOOK

Every 3-4 years, the government publishes the *Long-Term Energy Supply and Demand Outlook*, the first having been published in 1967 and the latest (*10th Outlook*) in July 2001. The *Outlook* shows the forecast impact of energy policies and measures in place, the difference between their impact and the various objectives as well as how to tackle the difference. However, the *Outlook* should be seen as a scenario of Japan's energy policy aspirations, rather than as a forecast of expected outcomes. The *Outlooks* are prepared by the Advisory Committee for Natural Resources and Energy whose role is to advise the Ministry of Economy, Trade and Industry.

The last *Outlook* was published to address the need to curb energy-related CO_2 emissions in FY2010 to levels comparable to those of FY1990. This is a "sub-target" for achieving Japan's Kyoto target to reduce GHG emissions by 6% from 1990 levels by 2008-2012. The *Outlook* is composed of two scenarios, the

Base Case and the Policy Case (see Table 1). The Base Case scenario incorporates all energy efficiency and environmental measures in place up to 2001 and shows the gap between the forecast CO_2 emissions and the stabilisation target at 1990 levels. The Policy Case indicates how to fill the gap by additional policies and measures, while addressing the need for a balanced energy mix by introducing more specific demand and supply sides goals[3] for FY2010 as follows:

- TFC will be reduced slightly below the current level through energy conservation and other measures.
- Oil supply will be reduced to below the current level through stepping up the introduction of other energy sources and promoting energy conservation.
- Despite coal's low price and supply stability, supply will be suppressed through fuel conversion and other measures because of its considerable environmental impact.

Table 1

Long-term Energy Supply and Demand Outlook

(million kl of crude oil equivalent)

Fiscal year	*1990*		*2000*		*2010*			
					Base Case		*Policy Case*[1]	
Energy	*Quantity*	*Shares %*	*Quantity*	*Shares %*	*Quantity*	*Shares %*	*Quantity*	*Shares %*
Oil	306	58.3	313	51.8	280	45	271	45
Coal	87	16.6	108	17.9	136	21.9	114	19
Natural gas	53	10.1	79	13.1	82	13.2	83	14
Nuclear	49	9.4	75	12.4	93	15	93	15
Renewables,								
of which[2]*:*	29	5.6	29	4.8	30	4.8	40	7
Hydro	*22*	*4.2*	*21*	*3.4*	*20*	*3.2*	*20*	*3*
Geothermal	*1*	*0.1*	*1*	*0.2*	*1*	*0.2*	*1*	*0.2*
New energy	*7*	*1.3*	*7*	*1.1*	*10*	*1.6*	*20*	*3*
Total TPES	**526**	**100**	**604**	**100**	**622**	**100**	**602**	**100**

1. Estimates in the Policy Case should be taken with some flexibility.
2. Totals are slightly different from the breakdown because of rounding.

Source: METI.

3. If these specific goals are achieved, the carbon emissions from energy transformation and use will be reduced to the FY1990 level, *i.e.* to 287 Mt.

- Natural gas supply will be increased over current levels through fuel conversion and other measures because of its lower environmental impact compared to other fossil fuels.
- Nuclear power supply will reach 42% of total electricity generation by building new units and improving the load factor.
- The supply of new and renewable energy sources will grow threefold as a result of maximum efforts by both the public and private sectors.

ENERGY POLICY OBJECTIVES

Japan's energy policy objectives are summarised as the "3 Es": energy security, economic development and environmental sustainability. These goals are consistent with the *Shared Goals* of the IEA. Japan's objective is to achieve the three goals simultaneously, although they often contradict one another and the possibility of trade-offs between them is recognised by the government.

ENERGY POLICY INSTITUTIONS

In January 2001, the Ministry of International Trade and Industry (MITI) was transformed into the Ministry of Economy, Trade and Industry (METI)[4]. Within METI, energy policy-making is entrusted to the Agency for Natural Resources and Energy (ANRE) with a staff of 463.

Many other government departments are involved in energy issues. The Ministry of Education, Culture, Sports, Science and Technology's (MEXT) responsibilities include R&D on nuclear fusion and basic research. The Ministry of Environment (MOE) does not have specific responsibilities in the energy field but because it deals comprehensively with environmental policies, it also needs to address many energy-related issues. The Ministry of Land, Infrastructure and Transport (MLIT) formulates transport policies and makes recommendations for building standards. The Ministry of Foreign Affairs (MOFA) is involved in energy policy by enhancing energy security through international co-operation in the field of energy.

Responsibilities for nuclear safety and security are concentrated in the Nuclear and Industrial Safety Agency (NISA) which has worked as a special institution within the METI since 2001 (see Chapter 8). Formerly, some of these tasks were implemented by ANRE and the Science and Technology Agency.

4. Hereafter both the METI and the MITI will be referred to only as the METI.

Wide-ranging policy discussions take place in advisory councils which are typically composed of industries, researchers, consumer unions, etc., and METI works as their secretariat. The most important council in terms of energy policy is the Council for Natural Resources and Energy with specific committees and subcommittees for practically all areas of energy policy and energy markets.

ENERGY SECURITY

OVERVIEW

Japan's principal challenge in the energy sector is supply vulnerability because it is an archipelago and lacks domestic energy resources. Several measures to ensure energy security have, therefore, been strongly promoted since the first and second oil crisis, and at present include the following key policies:

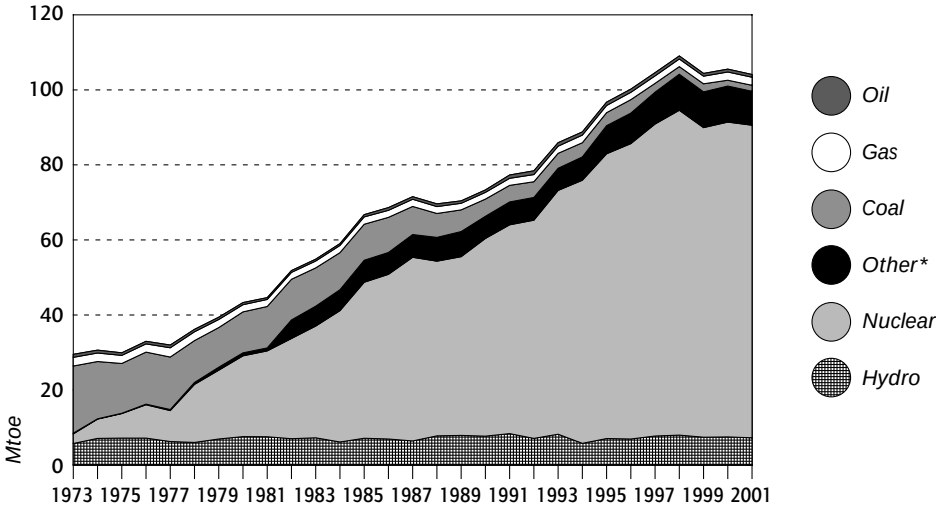
- Energy efficiency: Implemented by a Law Concerning the Rational Use of Energy (energy conservation standards and the so-called Top-Runner Programme); financial support to energy efficiency (promoting Home and Business Energy Management Systems, tax incentives for the introduction of energy-efficient equipment, etc.); and information dissemination. (See Chapter 5.)
- Diversification of energy supply sources: Implemented by further diversification away from oil; fuel-switching in the power sector (from coal to natural gas); further use of natural gas, nuclear power and renewables (renewable portfolio standard); and energy R&D.
- Development of resources: Implemented by oil and gas exploration in Japan and abroad and development of methane hydrates.
- Oil stockpiling and emergency policies: Implemented by Petroleum Stockpiling Law; Petroleum Supply and Demand Optimisation Law and IEA's Co-ordinated Emergency Response Measure (see Chapter 6).
- International co-operation for enhancing energy security: Implemented by enhancing energy security through IEA, APEC, ASEAN+3 and bilateral contacts, in particular with Asian energy-consuming countries; and promotion of co-operation with oil and gas-producing countries.

DOMESTIC ENERGY PRODUCTION

Domestic energy production was 104.1 Mtoe accounting for 20% of TPES in 2001. The most important domestic energy source is nuclear power, *i.e.* 80% of domestic production. There are no known large-scale unused energy resources in Japan apart from methane hydrates. However, the technologies for its use do not yet exist and there are significant uncertainties in respect to cost.

Figure 5

Energy Production by Source, 1973 to 2001



* includes geothermal, solar, wind, combustible renewables and wastes.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

OIL

Japan is highly dependent on oil imports. The share of the Middle East oil supply declined after the 1970s oil crises but increased again since the mid-1980s, reaching 88% in 2001. Oil supply security has received considerable attention. In addition to maintaining large emergency stocks, Japan tries to reduce dependence on oil and to diversify supply sources, enhances relations with oil-producing countries and gives support to oil and gas exploration (see Chapter 6.)

COAL

Coal contributes to the diversification of the country's energy mix and is also one of the few domestic energy resources. However, because of high mining costs, domestic production has almost ceased. More than half of steam and coking coal comes from Australia (see Chapter 6).

NATURAL GAS

Japan's gas market differs from other IEA regions as it is almost completely dependent on imported LNG, 70% of which is used for power generation. Natural gas comes from diverse sources, the most important being Indonesia, Malaysia, Australia, Qatar, Brunei and the United Arab Emirates.

Japan's special market structure determines its approach to gas security. Underground storage, interruptible contracts, pipeline links and other approaches that are common in other regional markets play no significant role in Japan. Reliance is placed on long-term take-or-pay contracts with several stable suppliers, on modular supply and delivery systems that limit dependence on any single installation, and on fuel substitution and sharing via the electricity generation system. These arrangements have served Japan well and no serious security problems have been encountered, even when the Arun LNG plant in Indonesia ceased to deliver from March to July 2001.

ELECTRICITY SUPPLY

Three aspects are essential regarding security of electricity supplies: primary energy sources, adequate generating capacity and system security.

The fuel mix for electricity generation has changed dramatically since FY1973 when oil accounted for 73.2% of generation. By FY2001 its share dropped to 11.3% and the use of nuclear power, coal and, more recently, natural gas increased steadily. To address climate change, the government has been actively promoting nuclear power and renewables. The series of nuclear safety and other incidents has, however, made nuclear power generation capacity increases more difficult.

The reserve margins varied annually between 3.9% and 16.6% in the period of FY1991-2001. In FY2001 the margin was 9.3% but dropped close to 3% in the winter of FY2002 owing to closures of most of the Tokyo Electric Power Company's (TEPCO) nuclear power plants for safety inspections. The government considers it necessary to maintain a supply margin of at least 10%, which is a challenge since the summer peak has become sharper. The general electric utilities are expecting a slow-down in the growth of electricity sales in the coming years and have cut their investments. The planned capital investment by the general electric utilities in FY2003 decreased by 4.1% from the previous year of ¥2 042 billion, the lowest level since FY1977. The amount is about 40% of the record ¥4 934 billion in FY1993.

Japan's transmission grid has been developed on the basis of each supply region's self-sufficiency and, consequently, interconnections between most regions are weak. There are new challenges to the network infrastructure caused particularly by market liberalisation and the need to connect intermittent renewable energy sources. Building new facilities and strengthening the existing ones takes a long time and is difficult because of the mountainous terrain, the elongated shape of Japan, stringent siting and environmental criteria and the country being split into 50 Hz and 60 Hz grid systems.

ENERGY TAXATION

Oil is subject to a complex set of taxes. All imported crude oil and petroleum products are subject to a general Petroleum Tax and a Customs Duty. In addition, gasoline is subject to a Gasoline Tax and a local Road Tax, gasoil (diesel)[5] to Gas Oil Transaction Tax, jet fuel to Aircraft Fuel Tax and LPG to Petroleum Gas Tax. Exemptions and reimbursements apply to fuel oil in agriculture and fishery use, to crude oil and naphtha used in the petrochemical industry, and to asphalt and petroleum coke produced domestically. The Customs Duty on oil products was introduced in 1960 as a temporary measure to protect the coal industry against competition from oil. As domestic coal production has almost been phased out, the government has reduced the Customs Duty rate from ¥215 per 1 000 litres in FY2001 to ¥170 per 1 000 litres in FY2002 and decided to abolish it by the end of FY2005. Petroleum tax revenues are put into the Special Account on Oil and used for energy policy objectives such as development of oil stockpiling and energy diversification.

The tax on electricity is called Electric Power Development Promotion Tax. Its revenues are put into a Special Account on Electricity for the promotion of energy policy objectives by giving subsidies to local governments to facilitate power plant siting approvals and to promote diversification away from oil use by encouraging the use of natural gas, nuclear and renewables.

A consumption tax of 5% is applied to the prices which include excise taxes for all client groups and all fuels. Diesel is the exception because the consumption tax is applied to the price prior to the excise tax. The consumption tax is not like Value-Added Tax which is reimbursed to industrial and commercial users.

The Japanese government is planning an excise tax reform (see Table 3). The objective is to remove distortions in inter-fuel competition because coal has been exempt from tax, and taxes on oil have been higher than other fuels on an energy equivalent basis. The government does not regard this as an "environmental tax reform". The coal tax will be levied only on coal used for electricity generation. The tax revision will be revenue-neutral by reducing taxes on electricity (Special Account on Electricity) and increasing them on fossil fuels (Special Account on Oil). The increased tax revenues in the Special Account on Oil will be divided equally between METI and MOE, which will use the revenues for climate change mitigation projects. In the past, almost all revenue from the petroleum tax and the electric power development promotion tax have been used by METI. One-third of the tax increases on fuels and decreases on electricity are to be levied in October 2003, another third in April 2005 and the last third in April 2007.

5. Gasoil is the name given to the middle distillate, mostly diesel. The oil product used for space heating in Japan is kerosene whereas in most other OECD countries light fuel oil is used for such purposes.

Table 2

Energy Taxes in Japan, FY2002

(in ¥)[1]

Sector/fuel	*Petroleum tax ¥/unit*	*Other excise taxes ¥/unit*
Households/electricity	–	0.445/kWh
Households/natural gas	720/tonne	–
Households/liquefied petroleum gas	670/tonne	9.8/litre (Petroleum Gas Tax)
Households/kerosene	2.04/litre	–
Non-commercial use/unleaded gasoline	2.04/litre	53.8/litre[2] (Gasoline Tax and Road Tax)
Non-commercial use/diesel	2.04/litre	32.1/litre (Gas Oil Transaction Tax)
Industry/electricity	–	0.445/kWh
Industry/natural gas	720/tonne	–
Industry/all oil products	2.04/litre	–
Industry and commercial use/liquefied petroleum gas	670/tonne	9.8/litre (Petroleum Gas Tax)
Industry and electricity generation/steam coal	–	–
Industry/coking coal	–	–
Industry and commercial use/diesel	2.04/litre	32.1/litre (Gas Oil Transaction Tax)

1. Taxes indicated do not show the consumption tax of 5% which is applied to the post-tax price for all client groups. For diesel, the consumption tax is applied to the pre-tax prices.
2. ¥45.6/litre gasoline tax and ¥8.2/litre road tax.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Table 3

Proposed Revision of Excise Taxes

Tax	*Petroleum*	*LNG*	*LPG*	*Coal*	*Electric power development promotion tax*
Current	2.04 ¥/litre	720 ¥/tonne	670 ¥/tonne		0.445 ¥/kWh
Revised	2.04 ¥/litre	1 080 ¥/tonne	1 080 ¥/tonne	700 ¥/tonne	0.375 ¥/kWh

Source: METI.

The proposed tax revision is likely to be a lighter burden for the power utilities that are not burning much coal than for those that do. It will also impact on some manufacturing industries, including pulp and paper and chemical industries. The impact on steel and cement industries will be negligible because the type of coal they burn will not be subject to new taxes.

CRITIQUE

Since the last in-depth review in 1999, major developments in Japan's energy policy have been partial liberalisation of the electricity market, new steps in gas market liberalisation, the ratification of the Kyoto Protocol and the development of an enhanced policy package to achieve the Kyoto target. The implementation of the 2002 climate change plan is moving forward. However, balancing energy security, economic development and environmental sustainability (the "3 Es") remains a challenge. Market opening is still in its initial stage.

SECURITY OF SUPPLY

Japan is making great efforts to ensure security of supply. Despite many measures already in place, growing oil import dependence from a single area is still a concern. While Japan's oil emergency measures such as oil stockpiling are very solid, efforts should continue to reduce oil dependence and diversify supply sources.

However, Japan is encountering new issues of energy security other than oil supply security. Recent disruption in gas supply from Arun LNG plants is a typical example. Gas supply security is becoming more crucial in Japan because the gas share in TPES is increasing. Concerns are emerging in the electricity sector following recent events at TEPCO nuclear plants. Energy security does not stop at national boundaries but is moving down to the final consumer. Gas and electricity have to be considered as well as oil – both in the short and longer term. These issues are more critical in Japan than in most IEA countries owing to its isolated location without gas and electricity interconnection with neighbouring countries and lack of indigenous energy resources. In particular, development, integration and strengthening of natural gas and electricity networks warrant more effort.

Japan's energy security is also very much affected by the energy security in the Asian region as a whole. Rapidly growing energy demand in the Asian region raises concerns about Asian energy stability. Despite Japan's concrete energy security measures, serious turbulence in the Asian energy market caused by a supply disruption could have a negative impact on Japanese energy security and the economy as it is heavily linked with the Asian economy. Therefore, it

is sensible that the government has a keen interest in enhancing emergency preparedness in Asian energy-consuming countries through bilateral and multilateral frameworks.

The government has taken the first steps in electricity and gas market liberalisation. To date, little competition has developed and the government has recognised the need for further reform. While this is commendable, it remains to be seen if the proposed steps will be adequate to induce active competition (see Chapters 6 and 9). The main reasons for Japan's cautious approach have been concerns over energy security. While the historical regional monopoly system with heavy government regulation has been effective in ensuring security of supply, it has been costly. International experience shows that market reform and security of supply can be compatible with sensible policy design. While ensuring energy security is of the utmost importance, Japan should implement further steps in market reform.

OUTLOOK

While the most recent *Long-Term Energy Supply and Demand Outlook* was published in July 2001, it is important that Japan continues to update it taking into account changes in the energy situation. This is particularly crucial as the first Kyoto commitment period of 2008-2012 approaches. Though Japan has done considerable modelling of the impact of various policies, additional sensitivity analyses will be needed, possibly in connection with the next update.

Japan has developed an overall energy plan to 2010, as well as plans for selected specific technologies to 2020. With this foundation, it is important that Japan continues to review its overall energy plan with continued focus on meeting the "3 Es". In this review, a time frame beyond 2010 could also be considered. Developing this policy map will have important implications for issues such as use of different energy sources and end uses in Japan.

TAXATION, FINANCIAL INCENTIVES AND COST-EFFECTIVENESS OF POLICIES

Japanese energy policy includes a complex web of financial and fiscal incentives to encourage particular energy supply and end-use technology choices. It is not clear how well these mechanisms are working individually or collectively. Japan should develop a comprehensive map of all the various incentives and disincentives – financial, tax, regulatory, R&D, etc. – that impact the energy sector; determine the effectiveness and the cost-

effectiveness of these measures; and rationalise these policy options for maximum impact and leverage.

Japan has embarked on an aggressive energy programme involving every sector of the energy economy. The cost-effectiveness of the various elements of this programme may, however, vary widely. For example, the return on some investments in energy supply may be substantially lower than the return on some investments in energy efficiency. To the extent that this has not already been done, Japan should develop a detailed analysis of the relative costs and returns from the full range of possible investments and then to use these results as an important input in developing a priority ranking of activities – possibly in the next update of the *Outlook*.

The proposed tax revision is a positive step in correcting uneven tax burdens of various fossil fuels. While the government does not regard it as an "environmental tax", the use of the incremental revenue for climate change mitigation may have some effect on energy-related CO_2 emissions. Its impact on fuel use, environment and industry, as well as its effectiveness, should also be evaluated as part of a policy evaluation described above.

STATISTICS

At the 8th International Energy Forum in Osaka in September 2002, the Oil Data Transparency Initiative was high on the agenda. Japan has always been a strong advocate of the initiative. Japan is to be commended for this support, and the recent publication of weekly oil statistics further highlights the commitment of Japan towards more transparency.

Timely, consistent and accurate statistics form the basis of reliable security planning and effective policy analysis. These statistics are collected and maintained for the benefit of IEA member countries and the global energy community in order to support discussion, conduct planning and enhance understanding. Market liberalisation increases the need for such good quality data. On the other hand, collecting some information (*e.g.* prices) is becoming more difficult owing to market liberalisation.

Japan had faced some difficulties in preparing its energy balance tables after the reporting of some basic energy statistics had been abolished. Because of these difficulties, Japan has decided to reassess the methodology used for preparing its energy balance. As a result, Japan has established a new methodology in 2002 more in line with the IEA's. Under these circumstances, the submission of the annual questionnaire to the IEA has been delayed recently and breaks in time series have occurred. The IEA, however, would expect that Japan will submit more timely statistics as from next year. In regard to the accuracy of the statistics, the quality will be dramatically improved by the above-mentioned revision of methodology. Moreover, the

overall transparency of the energy balance tables in Japan will also be improved.

RECOMMENDATIONS

The government of Japan should:

- *Develop integrated measures – beyond oil stockpiling – to address the security of supply issues arising from Japan's isolated location, high import dependence, electricity transmission bottlenecks and lack of a trunk network for gas transmission.*
- *While recognising energy security is of the utmost importance for Japan, implement further steps in market reform to ensure a level playing field.*
- *Continue to review 2010 projections in the* Long-Term Energy Supply and Demand Outlook *and carry out sensitivity analyses, and consider preparing projections beyond this time frame.*
- *Evaluate the cost-effectiveness of subsidies, fiscal incentives and R&D in support of energy policy goals.*
- *Assess the fuel tax revision with a view to clarifying its objectives and ensuring its cost-effective achievement.*
- *Ensure the timely availability of good quality statistical information to all interested parties, including international organisations.*

ENERGY AND THE ENVIRONMENT

Greenhouse gas emissions (GHG) represent Japan's main energy and environment challenge. Although the country's performance in CO_2 per capita and CO_2 per unit of GDP is good compared with the IEA average, Japan's energy-related CO_2 emissions rose by 11.2% between 1990 and 2001[6].

CLIMATE CHANGE

GREENHOUSE GAS EMISSIONS

Japan's commitment under the Kyoto Protocol is to achieve a 6% reduction from 1990 levels by the first commitment period (2008 to 2012). According to Japan's 3rd National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), Japan's total GHG emissions (CO_2, CH_4, N_2O and so-called F-gases) rose by 6.8% above the base year level for its Kyoto Protocol commitment during the period 1990-1999, and most of this growth took place in the first five years. Energy-related CO_2 emissions grew by 8.1% in 1990-1995 and by 0.82% in 1995-1999, largely as a result of the economic slow-down in 1995-1998. However, other GHG emissions, most notably N_2O, CH_4 and SF_6, were significantly reduced. As a result, the energy sector's CO_2 emissions accounted for 88% of the country's total GHG emissions in 1999, a 2 percentage point increase from its contribution in the base year. IEA data confirm a sharp rebound in energy-related CO_2 emissions after the 1998 slow-down, at 11.2% above 1990 levels in 2001.

Japan's energy-related CO_2 emission intensity is one of the lowest in OECD countries. In 2001, Japan's energy-related CO_2 emissions per GDP were 0.20 kg of CO_2/US$(1995), whereas the OECD average was 0.45 kg of CO_2/US$(1995), staying more or less stable over the decade, when it was declining in most IEA countries. This is partly explained by the relatively low GDP growth. Nevertheless, demand for some energies – and related emissions – rose rapidly during that period: energy use in transport (+29%), coal (+54%) and gas use (+55%) in power and heat generation. A sectoral analysis provides further insights into the underlying trends and efforts to be made to curb emissions.

Growth in the household sector's energy consumption and related CO_2 emissions has been driven largely by an increase in the number of households and to a lesser extent by an increase in energy use per household. According to METI, the final

6. All statistical data have been taken from the IEA statistics, unless otherwise indicated.

Table 4

Japan's Greenhouse Gas Inventory, 1990 to 1999

	1990	*1999*	*Change 1990-1999*
	$MtCO_2$ equivalent	*$MtCO_2$ equivalent*	*(%)*
CO_2 (all sources):	1 124.4	1 225	8.9
CO_2 from energy:	1 053	1 148	9
CH_4	30.5	27	–11.5
N_20	20.8	16.5	–20.7
HFCs[1]	20	19.5	–2.5
PFCs[1]	11.4	11.0	–3.5
SF_6[1]	16.7	8.4	–49.7
Total	**1 223.8**	**1 307.4**	**6.8**

1. Data shown for 1995, not for 1990. As authorised under the Kyoto Protocol, 1995 is the year of reference for HFCs, PFCs and SF_6.

Source: *Japan's Third National Communication under the United Nations Framework Convention on Climate Change*, the Government of Japan (2002).

consumption of energy other than electricity per household declined between 1990 and 1998. Whereas CO_2 emissions from oil use in the residential sector declined by 5% between 1990 and 2001, those from natural gas increased by 53%, following the demand for heating and cooking services. The 35% increase in electricity consumption in the residential sector over that period is one of the reasons for the increase in the power generation's CO_2 emissions (see below).

Table 5

Breakdown of Japan's Energy-related CO_2 Emissions, 1990 to 2001

(Mt)

	1990	*2001*	*Change 1990-2001 (%)*
Public electricity and heat production	297.3	332.7	11.9
Autoproduction of electricity and heat	57.5	79.8	38.6
Other energy industries	49.9	39.5	–20.7
Manufacturing industries and construction	258.9	226.3	–12.6
Transport	201.3	260.9	29.6
Other	153.8	193.1	25.5
of which: Residential	*62.8*	*63.6*	*1.3*
Total	**1 018.7**	**1 132.3**	**11.2**

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2003.

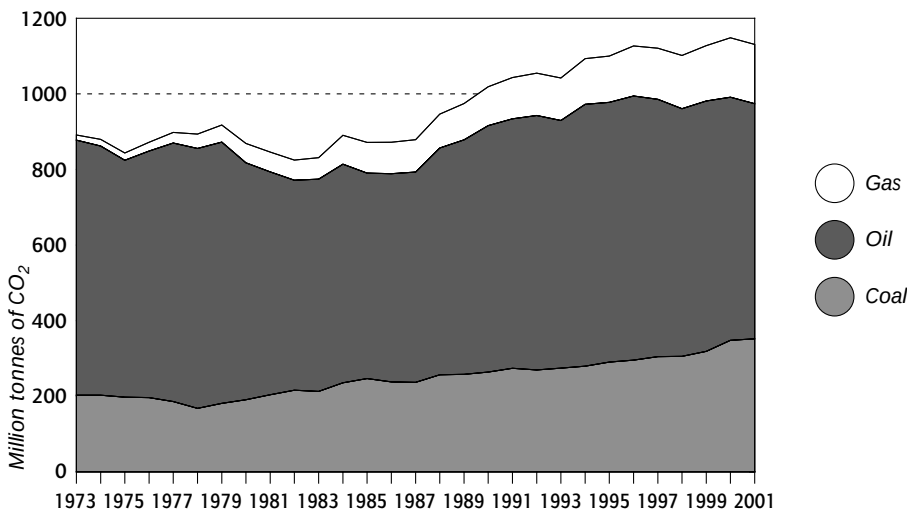
Since 1990, the transport sector has added 60 $MtCO_2$ to the country's total emissions, or 52% of the country's increase in energy-related CO_2 emissions. With a 29.6% increase in transport CO_2 emissions, Japan is situated above the IEA average growth rate over the last decade.

In 2001, industry's direct CO_2 emissions, excluding indirect emissions from electricity use, remain almost at the same level as in the 1990s. Direct CO_2 emissions from these industries declined by 12.6% between 1990 and 2001. However, emissions from the autoproduction of electricity and heat for industrial use have increased by 38.6%, adding some 22 Mt to the country's total emissions. Between 1990 and 2001, CO_2 emissions from coal and oil used in this sector have risen by 46% and 19%, respectively.

CO_2 emissions from utilities' power generation have also increased, and currently account for 29% of the country's total energy-related CO_2 emissions. The dramatic rise in coal and gas use in electricity generation in the past decade has more than offset the 53.8% reduction in emissions from oil use in power generation. The structure of electricity demand which is indirectly responsible for such emissions has changed since 1990, with residential, commercial and public services now accounting for 57% of total electricity demand. This changing pattern indicates where efforts should be made to lower electricity-related emissions – in addition to measures targeted to the fuel mix of power generation.

Figure 6

CO_2 Emissions by Fuel*, 1973 to 2001

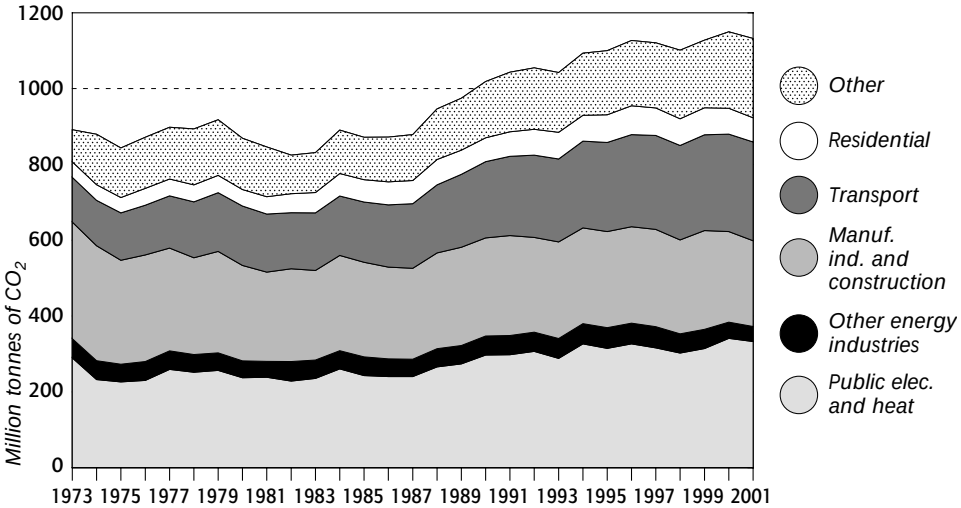


* estimated using the IPCC Sectoral Approach.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2003.

Figure 7

CO_2 Emissions by Sector*, 1973 to 2001



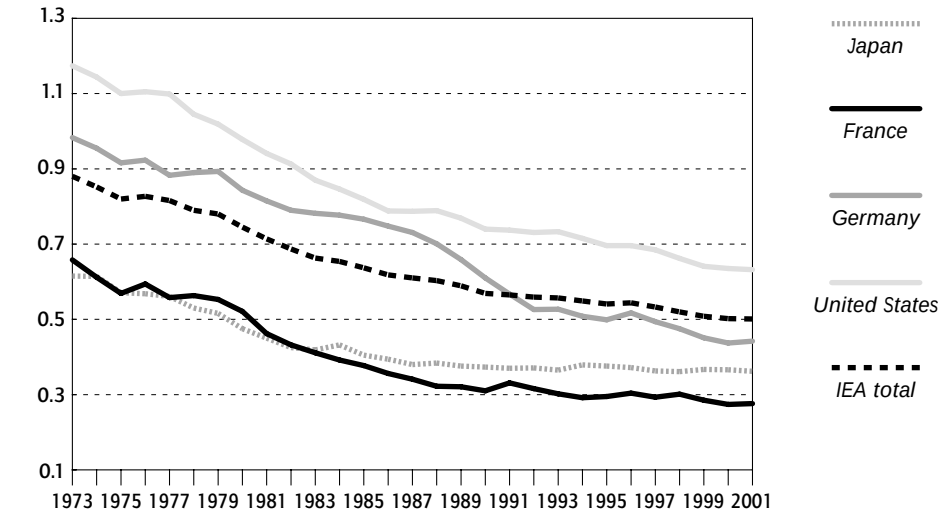
* estimated using the IPCC Sectoral Approach.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2003.

Figure 8

Energy-related CO_2 Emissions per GDP in Japan and in Other Selected IEA Countries, 1973 to 2001

(CO_2 emissions/GDP using 1995 prices and purchasing power parities)



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003; and *National Accounts of OECD Countries*, OECD Paris, 2003.

CLIMATE CHANGE POLICIES

Japan ratified the Kyoto Protocol in June 2002. Figures 7 and 8 show the serious challenge faced by Japan in order to reach its 6% Kyoto reduction target from 1990 GHG emission levels. The gap could be all the more difficult to close if GDP growth is resumed in the coming decade. Official projections under business-as-usual conditions indicate a 31% rise in final energy consumption, accompanied by a 21% increase in energy-related CO_2 emissions between 1990 and 2010.

On 19 March 2002, the Cabinet Headquarters issued a "New Guideline for Measures to Prevent Global Warming" which lays out the country's strategy to achieve its Kyoto objectives. It adopts a step-by-step approach with policy reviews set in 2004 and 2007, and additional measures to be taken if the existing ones are deemed insufficient.

The Japanese government and industry have adopted an ambitious plan to meet Kyoto GHG objectives, with an explicit goal to bring energy-related CO_2 emissions down to their 1990 levels by 2008-2012. The remaining reductions would be achieved in other gases, with some limited reliance on the Kyoto flexible mechanisms to offset any emissions above the 6% reduction objective. The main categories of policy intervention to reduce CO_2 emissions from fossil fuels are energy conservation, promotion of renewable energy and fuel-switching.

Japan has adopted a wide-ranging programme for the promotion of more energy-efficient equipment – the so-called Top-Runner Programme (see Chapter 5). Efforts are also undertaken to reduce stand-by power waste and to implement energy management systems for homes and buildings. In 1999, voluntary standards for homes and buildings were upgraded. Subsidies, in the form of low-interest loans, are available for the purchase of more efficient homes. The government estimates that these measures altogether could achieve a 2% reduction in emissions from 1990 levels in the residential and commercial sector. This means a decline from the 2001 emission levels that were 25.5% above 1990.

In the transport sector, the most challenging one in terms of growth in CO_2 emissions, the Top-Runner Programme is supplemented by the promotion of more energy-efficient and alternative fuel vehicles through a lower ownership tax and motor car acquisition tax on low-emission vehicles. However, the recent trend analysis shows that traffic, driving conditions and sub-optimal load management (trucks) have also contributed to the deterioration of on-road efficiency. Measures are now being taken to address these factors, including the support for traffic data management and providing better public transport services. The New Guideline of Measures to Prevent Global Warming expects improvements of traffic systems to help save 6.6 million kilolitres out of a total of 17 million kilolitres of oil-equivalent savings required in the transport sector. The government estimates that these measures will restrict the growth of emissions in the transport sector at 17% above the 1990 level.

Table 6

Breakdown of Japan's 6% Emissions Reduction Objective[1]

Sector/source[2]	*Breakdown*	
	Estimated emissions (change from 1990 levels)	*Contribution to 6% reduction target*
Industry	–7%	
Commercial/residential	–2%	0%[2]
Transport	+17%	
Others[3]		–2%
CH_4, N_2O, etc.		–0.5%
HFCs, PFCs, SF_6		2%
Sinks		–3.9%
Total		**–4.4%**

1. If these targets are expected to be attained within the first commitment period, instead of stopping there, further emissions reduction efforts would have to be made in each sector to fill the remaining gap. Use of Kyoto mechanisms will also be considered.
2. There are no specific estimates for emissions from the energy industry but the contribution by this sector is indirectly included in the estimates for the end-user sectors.
3. "Others" include further R&D of innovative energy and environment technologies and further extensive efforts by the general public.

Source: Government of Japan.

The government's estimate for industry's CO_2 emissions is a 7% reduction from 1990. Industry's emissions reduction efforts are primarily covered by a Voluntary Action Plan co-ordinated by Keidanren, the federation of Japanese industry. The Keidanren plan covers 34 industry branches, amounting to 499.88 $MtCO_2$ in 1990, or 80.1% of total industry emissions in 1990. The participating associations and federations include the following activities, among others: iron and steel, mining, oil, gas, chemicals, aluminium, glass, cement, industrial machinery, motor car and industrial vehicle manufacturing. The plan is to return emissions to levels below 1990 by FY2010. The types of industry commitments under the plan include absolute CO_2 emission objectives, reduction in overall energy consumption or improvements in the CO_2 or energy intensity of output. Only electricity use by industry is included in the Keidanren plan. According to Keidanren's statistics, these indirect emissions amounted to 33.7 $MtCO_2$ out of a total of 312 Mt for all emissions by utilities.

Keidanren reviews the plan's implementation and publishes the results every year. METI and relevant ministries have been assessing how the review is implemented to ensure transparency and impartiality of the plan, but in July 2002 an independent third-party committee, the Evaluation Committee for

the Voluntary Action Plan, was established for this purpose. The committee issues recommendations on the improvement of the review process and the government expects Keidanren to follow these recommendations.

Table 7

CO_2 Emissions for Industry under the Keidanren Voluntary Action Plan

	Observed						*Projected*		
	1990	*1997*	*1998*	*1999*	*2000*	*2001*	*2005*	*2010 (Goal)*	*2010 (BAU)*
CO_2 (Mt)	499.88	517.31	491.13	502.15	498.23	483.70	509	Lower than in 1990	542
Change from 1990		+3.5%	–1.8%	+0.5%	–0.3%	–3.2%	+1.8%	–	+8.4%

BAU: business-as-usual.

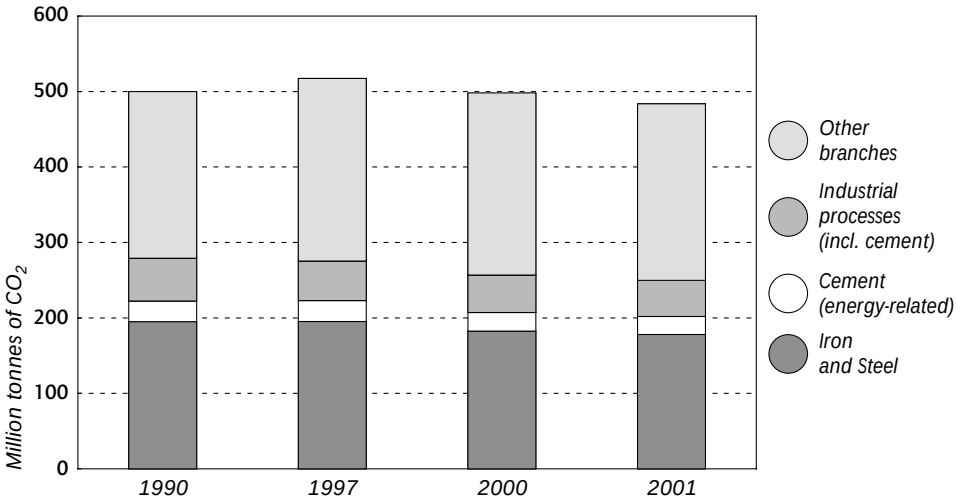
Source: *Results of the 5th Follow-up to the Keidanren Voluntary Action Plan on the Environment – Section on Global Warming Measures*. Keidanren.

In 2001, the 34 branches taken as a whole emitted 3.2% less CO_2 than in 1990, while their overall energy consumption was 2.8% higher, reflecting a reduction in the carbon intensity of these industries' energy use. A closer look at the Keidanren's achievement to date shows that two sectors have played a key role in this decrease: iron and steel, and cement with energy-related CO_2 emissions down by 8.7% and 13.5% respectively between 1990 and 2001. CO_2 emissions from industrial processes – for the most part from cement manufacturing – also decreased by 15.4%. Altogether, these amount to an impressive 29 $MtCO_2$ reduction between 1990 and 2001, while all branches taken together reduced emissions by only 16.2 $MtCO_2$. This highlights the significant contribution of the iron and steel and cement sectors to the Keidanren's overall achievement in 2001 (see Figure 9). However, these two sectors have undergone reductions in output over that period which explains at least part of the observed emissions reductions[7]. Sectors with rising emissions included petroleum products (+29.3%), chemicals (+5.8%), electronics (+18.8%) and electricity use in industry (+8.7%).

7. The production of pig iron, crude steel and ordinary hot-rolled steel products went down by 1.7%, 6.8% and 11.2%, respectively, over this period (*The Steel Industry of Japan 2002*, http://www.jisf.or.jp/sij/production.html). Between 1990 and 2000, cement production declined by 4% (*Japan Statistical Yearbook*, http://www.stat.go.jp/english/data/nenkan/1431-07.htm). Keidanren reports that the CO_2 intensity of output actually rose by 3% in the cement sector, suggesting that observed reductions come from lower output rather than specific improvements in processes. On the other hand, the CO_2 intensity of the iron and steel sector dropped by 5% between 1990 and 2001.

Figure 9

CO_2 Emissions from Iron & Steel and Cement Industries in Keidanren's Voluntary Action Plan



Source: *Results of the 5th Follow-up to the Keidanren Voluntary Action Plan on the Environment – Section on Global Warming Measures*. Keidanren.

Power generation by utilities increased by almost 22% between 1990 and 2001. End-use energy efficiency improvements introduced by the Top-Runner Programme will contribute towards emissions reduction. On the supply side, more specifically, the plan is based on three main elements: the addition of new nuclear capacity, the accelerated introduction of new and renewable energy sources and a subsidy to encourage fuel-switching from coal to gas-based generation.

The original plan for the development of nuclear power is a 30% increase in power generated from nuclear by 2010 (equivalent to 10-13 new plants under current operating conditions). The problems encountered in Japan's nuclear power sector over the last few years may make it difficult to achieve the plan (see Chapter 8). However, nuclear plants currently have an availability ratio that is lower than the practice in other countries, and improvements on that front could help make up the shortfall, if only 7-8 plants were to start operation in the Kyoto time frame.

The government aims for a rapid development of renewable energy by 2010, although Japan's starting point is relatively low. The indicative targets include an increase from 209 MW to 4.8 GW of installed capacity for photovoltaic, from 83 MW to 3 GW for wind, and from 900 MW to 4.2 GW for wastes by 2010. It is supported by a set of instruments, including a renewables portfolio standard introduced under the "Law Concerning the Use of New Energy by Electric

Utilities" of June 2002. By 2010, utilities must use new renewable sources amounting to 1.35% of their total output (see Chapter 7).

The government also introduced a subsidy to encourage the closure of old coal-fired plants and the shift to natural gas-based generation. Under this system, the government would subsidise 10% of the construction cost of a natural gas plant if a coal plant of more than 35 years of age were closed. The annual budget of this policy is ¥2.5 billion, and it is planned to run for the next ten years[8].

The Federation of Electric Power Companies (FEPC) has adopted a goal to reduce the CO_2 intensity of end-use electricity by 20% from the 1990 level (to 0.34 tCO_2 per MWh against 0.379 in 2001) by 2010. But it also projects a 16% increase (corresponding to a 1.5 % annual growth rate) in the total output of the ten electric power companies between 2001 and 2011, less than the 24% growth in the 1990s. On the whole, the FEPC projects that utilities' emissions will rise by about 14% from FY1990 by FY2010[9].

At present, no cross-cutting measures such as emissions trading exist in Japan, although the government monitors the development of such instruments in other IEA countries. A simulation was organised by the Ministry of the Environment (MOE) in the Mie Prefecture in early 2003, mostly as a learning tool for industry and government.

On the international scene, the Japanese government announced in early 2003 its intention to establish a fund to facilitate the use of Kyoto mechanisms. This fund will be operated mainly by the private sector but in co-operation with government-affiliated financial institutions, such as the Development Bank of Japan and the Japan Bank for International Co-operation, and is for purchasing credits rather than financing entire projects. In addition to the fund, METI and MOE announced they will finance part of the costs of Kyoto mechanism projects. These will include energy efficiency projects, renewable energy projects (such as wind turbines) and landfill methane recovery. About ¥2.2 million are to be allocated for FY2003. A Joint Implementation project was launched in Kazakhstan, which should bring an annual reduction of 62 000 tCO_2, and more projects of this kind are being sought, including under the Clean Development Mechanism. Although they are not legally bound to achieving emission objectives under Japan's domestic policy, a number of private Japanese companies are actively engaged in the Kyoto mechanisms, including via the World Bank's Prototype Carbon Fund[10].

8. According to the Platts, UDI Products Group's (UDI) database, Japan's coal-based capacity amounts to more than 50 GW, with about 4 GW of capacity in operation for more than 35 years.
9. Source: *Principles and Measures 2002-2003*. The Federation of Electric Power Companies (FEPC), page 4.
10. In addition to the Japan Bank for International Co-operation, six of the utilities in Japan and two trade companies are among the participants of the Prototype Carbon Fund. http://prototypecarbonfund.org/router.cfm?Page=Partic

CRITIQUE

Rising greenhouse gas emissions are one of the most important policy challenges facing Japan's energy sector. Regarding other pollutants (SO_x and NO_x in particular), Japan adopted one of the strictest emission standards; urban air quality improved in the 1990s, and the country's SO_x and NO_x intensities are far below OECD averages. On the negative side, road transport is causing rising emissions of fine particulates, including NO_x, which could make it difficult to meet the country's very ambitious local air quality targets. Emissions of non-methane volatile organic compounds from large plants are also not completely addressed [11].

Japan has developed an impressive range of policies to address its rising CO_2 emissions from energy: energy efficiency standards over a range of equipment, voluntary building codes, labelling, growing support for renewable energy and conservation policies, as well as subsidies to encourage fuel-switching. It also intends to secure the role of nuclear in the new market environment of power generation. Indeed nuclear is important to the country's climate change policy. The recently introduced tax on coal, LNG and LPG, albeit not targeted to lower CO_2 emissions and relatively modest, corrects the heavy focus on oil taxes, while, to date, coal and gas imports are untaxed (see Chapter 3).

Overall, these policies are intended to bring energy-related CO_2 emissions back to 1990 levels by 2010, and lead to further reductions beyond. Some of the reduction measures are voluntary (buildings standards, energy management systems that are only at the testing stage), involving behavioural changes that cannot be taken for granted (measures to improve traffic conditions), or hinging on public acceptance (the plan to add nuclear capacity). It is difficult to predict how effective these measures will be and the government's plan to review policies by 2004 is therefore welcome.

While there was a drop in the country's energy-related CO_2 emissions between 2000 and 2001, the question is whether this reduction will continue if the economy recovers from the current recession. A number of elements indicate otherwise: the 29.6% increase in transport-related CO_2 emissions in 1990-2001 (against a 14% growth in GDP over the same period), and the utilities' own projections for 2010 that are some 14% above the 1990 level, in spite of a voluntary plan to reduce the CO_2 intensity of power generation.

As is the case in many IEA countries, Japan is undergoing rising electricity-related CO_2 emissions. On the supply side, the sector is covered under Keidanren's Voluntary Action Plan; on the demand side, the government intends to widen the coverage of its Top-Runner Programme. The government projection based on a 30% increase of nuclear power generation within the Kyoto time frame

11. Source: OECD, 2002, *Environmental Performance Reviews – Japan*.

needs to be carefully watched. In addition, ongoing market reform of the power sector, if it brings lower prices, should lead to increased demand and CO_2 emissions. Although there exists a subsidy to encourage coal plant closure if gas plants are built, its effectiveness may need to be examined as it may attract free-riding. Although the objective for the development of renewable energy sources is very ambitious, it will not completely offset the projected growth in emissions from generation in the near term.

Industry's emissions, excluding electricity, have declined between 1990 and 2001, but low industrial output accounts for a significant part of this achievement, and emissions in sectors such as petroleum have risen steadily, in spite of lower CO_2 emissions per unit of output. The question is, therefore, whether the Keidanren's objective to stabilise emissions by 2010 will be met if industrial output recovers. CO_2 emissions from businesses outside the Keidanren's plan also warrant close monitoring. If voluntary actions are to remain the core of Japanese industry's efforts to curb emissions, activities currently outside should be encouraged to join Keidanren's action.

It may not be enough to rely solely on the Keidanren Voluntary Action Plan on Environment to achieve the government's estimated 7% reduction in industrial CO_2 emissions. Japan's industry has achieved a low level of energy consumption per unit of output, indicating that further reductions in CO_2 emissions entail higher costs than in other IEA countries[12]. Under such circumstances, Japanese industries may consider moving their production activities to developing countries which have no legally binding obligation for GHG emissions reduction rather than taking costly domestic actions. The Japanese government and industries are concerned this may further jeopardise the vitality of Japanese industry and result in more GHG emissions on a global level. The participation of industry in the Kyoto mechanisms would be welcome from that perspective, as it would give access to the most cost-effective mitigation options available in Kyoto Protocol Parties. Depending on the outcome of the progress review, GHG emissions trading may be considered as an option to organise such participation. The challenge is how to implement it in a fair and equitable manner taking into account the industry's contribution to the reduction of Japan's emissions. Furthermore, noting the high marginal cost of domestic emissions reduction, cost-effectiveness of emissions trading may be limited if it is not smoothly linked with other Kyoto mechanisms. Alternatively, the government would need to acquire emissions reductions from the international market to cover rising industry (especially electricity) and transport emissions, which may fail to send the appropriate economic signal to these domestic sources.

12. According to the findings by the Energy Modelling Forum, Japan's reduction costs are 10 to 90% higher than in other OECD countries.

Economic recovery is likely to be accompanied by increased emissions, especially in the transport and residential sectors. If new measures are needed, they should not incur unnecessarily high cost. The cost of the current policy mix and cost-effectiveness of individual measures cannot be known with certainty; some measures can bring net benefits from an economic, but also energy security, standpoint by reducing energy demand (*e.g.* energy efficiency measures). Others may end up being quite costly (subsidy to substitute coal by gas in power generation) if target sources were to free-ride on the policy. Others still would contribute to improve energy security (renewable and nuclear development). Because of the significant challenge and Japan's energy security situation, it is essential that measures be analysed on the basis of their contribution to the environment, the economy and energy security.

RECOMMENDATIONS

The government of Japan should:

- *Address foreseeable and unforeseeable changes in reviewing the* New Guideline of Measures to Prevent Global Warming *in 2004.*
- *Continue to monitor the GHG emissions, in particular in the transport and electricity sectors, and take further action, if necessary, both domestically and through the Kyoto flexible mechanisms to close the gap with the Kyoto target.*
- *Continue to closely follow progress under the Keidanren's "Voluntary Action Plan on the Environment". Consider encouraging companies to take further actions, including the use of Kyoto mechanisms. Monitor the seemingly rising emissions from businesses outside the Action Plan.*
- *Consider how Japan can take advantage of possible international emissions trading to ensure cost-effective climate change mitigation and lower adverse economic impacts.*
- *Select climate change mitigation measures – including for other GHGs – taking into account their cost-effectiveness and their contribution to energy security.*

ENERGY DEMAND AND END-USE EFFICIENCY

END-USE EFFICIENCY TRENDS

In 2001, Japan's total primary energy supply (TPES) was 520.7 Mtoe, up by 19% from the 1990 level. Japan has made efforts to use energy more efficiently since the oil crises in the 1970s and, as a result, has managed to achieve a high level of energy conservation. However, Japan's energy intensity (TPES per unit of GDP) has remained stagnant in the last two decades, whereas the IEA average has been steadily declining. Nevertheless, Japan's energy intensity is still among the lowest in IEA countries. In 2001, Japan's TPES per capita increased by 15.8% from 1990 to 4.09 toe. The OECD average increased by 8.2% to 4.68 toe over the same period.

Total final energy consumption (TFC) was 342.1 Mtoe in 2001, increasing by 17% from 1990 levels. Industry is the largest energy-consuming sector (38%)[13], followed by residential, services and other sectors (33%), and the transport sector (28%).

In the industrial sector, TFC declined by 2% between 1990 and 2001. The largest energy-consuming industries are chemical and petrochemical (which represent 36% of all industrial consumption), iron and steel (with a 16% share), paper, pulp and printing (with an 8% share), and non-metallic minerals (with an 8% share).

TFC in the residential sector increased by 17% and in the services sector by 72% (primarily because of an increase in floor space), but declined by 40% in the agricultural sector between 1990 and 2001. Households are seeking to raise living standards by acquiring more air-conditioning units and electrical equipment, and increasing the heated areas in buildings.

TFC growth was quite strong in the transport sector – 29% between 1990 and 2001 – with an average annual growth rate of 2.4%. In particular, energy use by passenger cars increased sharply and accounted for 80% of the transport sector's energy demand in the 1990s. The total number of passenger-km increased from 1 298 billion to 1 420 billion and of tonne-km from 547 billion to 578 billion in the period FY1990-FY2000 (see Monitoring and Assessment section in this chapter).

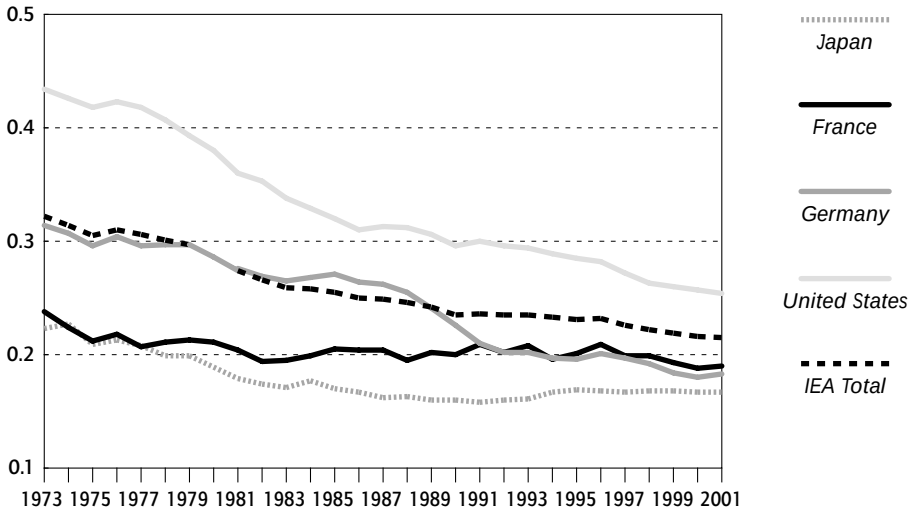
According to the *Long-Term Energy Supply and Demand Outlook* of 2001, TFC in the industrial sector is expected to decrease by 5.1% in the Base Case and

13. Including non-energy use of 8.7 Mtoe.

Figure 10

Energy Intensity in Japan and in Other Selected IEA Countries, 1973 to 2001

(toe per thousand US$ at 1995 prices and purchasing power parities)



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003 and *National Accounts of OECD Countries*, OECD Paris, 2003.

6.1% in the Policy Case, and in the transport sector by 4% and 6% respectively between FY1999 and FY2010. TFC in the residential and commercial sector is expected to increase by 20% in the Base Case and 14.3% in the Policy Case over the same period.

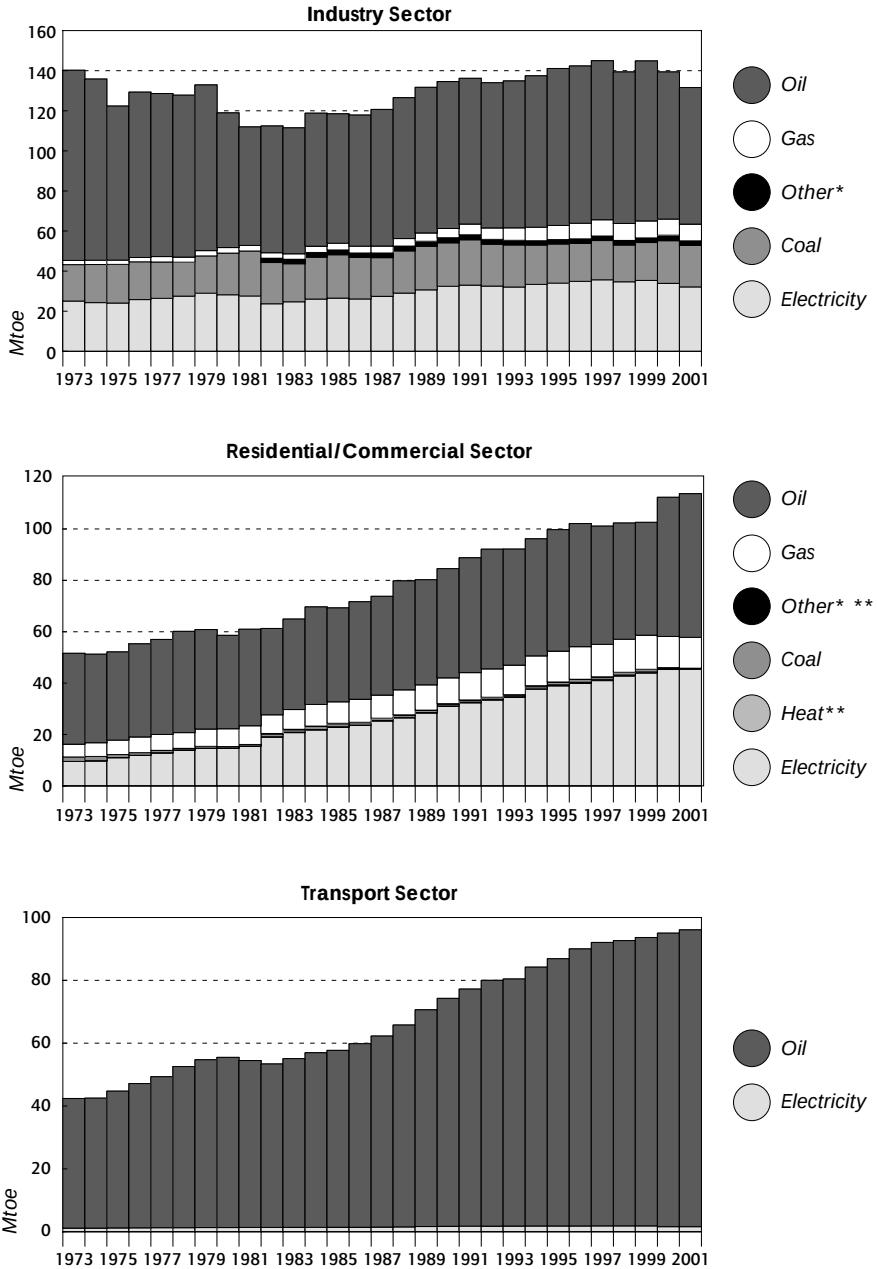
ENERGY EFFICIENCY AND CONSERVATION POLICIES

POLICY FRAMEWORK AND OBJECTIVES

In April 1999, the revised Law Concerning the Rational Use of Energy came into force to implement the Kyoto commitment and the *New Guideline of Measures to Prevent Global Warming*. The law included energy conservation measures for all sectors. The resulting energy conservation was estimated at 46 Mtoe by FY2010 as compared to the business-as-usual scenario. Following an analysis made by the Advisory Committee for Natural Resources and Energy on the effectiveness of individual measures, the government announced in June 2001 additional measures to conserve about 6 Mtoe in order to address the increasing demand in the residential, services and transport sectors. The total target of conserving 53 Mtoe by FY2010 has been

Figure 11

Total Final Consumption by Sector and by Source, 1973 to 2001



* includes solar, wind, combustible renewables and wastes.

** negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

incorporated in the *New Guideline of Measures to Prevent Global Warming* of March 2002. Table 8 shows the impact of major policy measures introduced by the 1999 law (Base Case) and the new *Guideline* (Policy Case).

Table 8

Major Energy Conservation Policy Measures and Effects by FY2010

Sector, measures	*Base Case (Mtoe)*	*Policy Case (Mtoe)*
Industry sector	**18.59**	**19.42**
• Keidanren Voluntary Action Plan	18.59	18.59
• Promotion of efficient industrial furnaces	–	0.37
• Promotion of efficient boilers and lasers	–	0.46
Residential and commercial sector	**12.96**	**17.67**
• Expansion of Top-Runner Programme for appliances	5.00	6.11
• Efficiency standards for buildings	7.96	7.96
• Promotion of efficient appliances	–	0.83
• Promotion of Home Energy Management Systems	–	0.83
• Promotion of Business Energy Management Systems	–	1.48
• Promotion of efficient lighting	–	0.46
Transport sector	**14.71**	**15.63**
• Expansion and acceleration of Top-Runner Programme and promotion of natural gas, hybrid and fuel cell vehicles	5.74	6.66
• Promotion of Intelligent Transport Systems	8.97	8.97
Total energy consumption reduction	**46.26**	**52.72**

Source: Energy Efficiency & Conservation Sub-committee.

ENERGY EFFICIENCY STANDARDS, THE TOP-RUNNER PROGRAMME AND LABELLING

The Law Concerning the Rational Use of Energy of 1993 established "energy efficiency standards" as absolute targets for certain electric equipment and vehicles. For example, in the case of computers, energy efficiency performance was supposed to improve by 30% from FY1992 to FY2000. If manufacturers and equipment importers failed to comply with the standards, they were then subject to recommendations given by METI.

The 1999 amendment to the Law introduced the Top-Runner Programme, which replaced the "energy efficiency standards". While energy efficiency standards had been set at the level slightly above the average energy efficiency

Table 9

Energy Conservation Targets for Designated Equipment

Equipment	*Base year*	*Target year*	*Approximate improvement of efficiency*
Air-conditioning (heating & cooling)	FY1997	FY2004 blower/wall type items < 4kW FY2007 all other	63% (for most types)
Space heaters	FY2000	FY2006	1.4% (gas), 3.8% (oil)
Refrigerators and freezers	FY1998	FY2004	30%
Fluorescent lamps	FY1997	FY2005	17%
Televisions	FY1997	FY2003	16%
Video players	FY1997	FY2003	59%
Magnetic disk devices	FY1997	FY2005	78%
Copy machines	FY1997	FY2006	30%
Computers	FY1997	FY2005	83%
Gas cooking appliances	FY2000	FY2006	14%
Water heaters	FY2000	FY2006	4.1% (gas), 3.5% (oil)
Electric toilet seats	FY2000	FY2006	10%
Vending machines	FY2000	FY2005	34%
Transformers	FY2000	FY2006 (oil-filled) FY2007 (mold)	30%
Passenger vehicles, gasoline	FY1995	FY2010	23%
Passenger vehicles, diesel	FY1995	FY2005	15%
Freight vehicles, gasoline	FY1995	FY2010	13%
Freight vehicles, diesel	FY1995	FY2005	7%

Source: METI.

performance of the product category, in the Top-Runner Programme the best performing items in their category set the minimum standard for a future year. The programme originally covered electric appliances (refrigerators and freezers, air-conditioning, televisions, video players, lamps and computers) as well as cars and light trucks, for both gasoline and diesel engines. The coverage of the programme has been extended to include heating equipment using oil, gas and electricity, vending machines and electric transformers. Each type of equipment is divided into several groups and the energy

efficiency target is established for each group. Development is not monitored for each product, but for the whole group. METI can issue recommendations and orders if targets are not reached. If the manufacturer or importer does not comply with the order, penalties are imposed. This is a significant improvement compared with the 1993 law. The government intends to tighten the targets every few years to ensure continued gains in efficiency. The estimated energy savings to be achieved by the current targets are shown in Table 9.

Whereas the Top-Runner Programme itself targets manufacturers and importers, it is implemented and made visible to consumers through the energy labelling of products. In July 2000, a voluntary labelling system was introduced for air-conditioning equipment, refrigerators, freezers, televisions and lighting. The label shows relative energy efficiency of these products compared to their top-runner targets. In addition to informing final consumers, the objective of the labelling system is to encourage manufacturers and importers to satisfy the top-runner standards even ahead of the target year.

ENERGY EFFICIENCY BUDGET

The total budget to promote energy efficiency was ¥131.2 billion in FY2002 compared to ¥109.2 billion in FY2001. Out of the total budget for FY2002, ¥52.5 billion was for promotion measures and ¥78.7 billion for R&D. Promotion measures included the introduction of energy-efficient systems in households (¥12.3 billion), support to enterprises for energy conservation projects (¥9.1 billion) and information dissemination (¥4.4 billion).

MEASURES IN INDUSTRY

Industry sector policies are composed of regulatory measures, voluntary actions by industry, subsidised energy audits, expansion of energy service companies (ESCOs) and a complex mix of subsidies, tax exemptions and soft loans for energy efficiency investments.

Large-scale factories (manufacturing, mining, and electricity, gas and heat supply) with an annual fuel consumption of at least 3 000 kilolitres of crude oil equivalent or industries with an annual electricity consumption of at least 12 GWh have been subject to energy efficiency requirements since 1979 under the Law Concerning the Rational Use of Energy. With the 1999 and 2002 amendments to the law, the requirements have been extended to all industry and service sector users of energy as well as to the energy sector operators with an annual fuel consumption of at least 1 500 kilolitres of crude oil equivalent or annual electricity consumption of at least 6 GWh. As a result, currently 5 200 large-scale factories and offices and 5 600 mid-size factories and offices are covered under the law. The indicative target of the law is to

improve energy intensity by 1% per year. The law obliges the operators to make efforts to conduct rationalisation according to the judgement standards instituted by METI concerning energy control and the targets for rationalisation of energy use. It also mandates them to record energy use and submit annual reports. Large-scale manufacturing facilities and energy sector operators must appoint certified energy managers and other facilities must have energy management staff. In addition, large-scale factories have an obligation to submit medium- to long-term plans for the rational use of energy.

One of the key activities in the industry sector with an impact on energy consumption is Keidanren's Voluntary Action Plan on the Environment to reduce CO_2 emissions. The Action Plan is discussed in detail in Chapter 4. The Action Plan is an entirely voluntary effort in which each industry uses its own discretion, free from any obligation by government or regulatory body. Despite its voluntary nature, some investment projects in industry can receive government subsidies if they are in line with the objectives of the Voluntary Action Plan. Industries which have not joined the plan can also apply if their projects are in line with the plan's objectives. Subsidies are given mainly to projects with long payback times to avoid subsidising projects which would be implemented regardless of additional support. The subsidy level is 33% of the investment cost and the total annual budget of the activity is ¥12.3 billion per year.

The Energy Conservation Center of Japan (ECCJ) has conducted about 5 600 energy audits of small and medium-sized enterprises. In these audits, concrete lists of priority measures are prepared, including investments required and expected benefits. These audits are free of charge for companies with a capital of less than ¥100 million or less than 300 employees, and with a charge for larger industries.

At present, about 100 companies are involved in implementing ESCOs and annual investments are ¥67 billion per year. The government has recognised the need to involve the banking sector more closely in this activity. Specific leasing companies have provided equipment for the ESCOs but with increasing demand, this is becoming a bottleneck. The government has established a working group to consider how to address these issues and further promote ESCOs.

Combined heat and power (CHP) generation is promoted through a generous taxation and financial support system. Natural gas-fired CHP plants can receive subsidies which are one-third of the installation cost for enterprises and 50% for municipal entities. Furthermore, CHP facilities enjoy a 30% tax depreciation of the cost or a tax exemption of 7% in the first year.

The 1993 Law on Temporary Measures to Promote Business Activities for the Rational Use of Energy and the Utilisation of Recycled Resources established a ten-year framework of fiscal and financial assistance to business operators who voluntarily undertake rationalisation of energy use, use recycled

resources, etc. or install a CHP facility. The businesses and activities that qualify for assistance are manufacturing, mining, electric power supply, heat supply and construction industry as well as R&D on, for example, technologies for recycling and energy-efficient manufacturing. Assistance comes in the form of low-interest loans (provided by the Development Bank of Japan and the Okinawa Development Finance Corporation), debt guarantees under the Industrial Foundation Improvement Fund and tax exemptions. In 2003, the law was extended for a further ten years and its scope was extended to cover Clean Development Mechanisms and Joint Implementation projects as well as those aimed at recycling used products and reducing emissions from wastes and residuals.

MEASURES IN THE RESIDENTIAL AND SERVICES SECTORS

In addition to the Top-Runner Programme and labelling schemes discussed above, several other measures have been introduced to curb the growth of energy consumption in buildings. These include voluntary standards for insulation, certification systems, individual billing and metering, reduction of stand-by power, better energy management, financial and fiscal incentives, and information dissemination.

In March 2000, the Committee on Advanced Demand Side Management was established as an advisory body to the Agency for Natural Resources and Energy (ANRE) to increase the focus on demand-side management, particularly in the residential and services sectors. It investigates how to make consumers better aware of the cost of energy, encourages energy conservation, promotes businesses that provide support for energy conservation activities and formulates policies that encourage users to invest in energy saving.

Voluntary energy efficiency standards for new residential buildings were first introduced in 1980 and strengthened in 1992 and 1999. The latest standards for heat insulation are estimated to save 20% of energy use in air-conditioning but only 8% of new buildings met these requirements in 2001. Voluntary insulation standards and efficient air-conditioners, mechanical ventilators, lighting systems, hot water tub equipment and elevators were established in 1993 for new offices, shops, hotels, hospitals and schools. Tax incentives and low-interest loans have been made available to support the construction of buildings with low energy consumption and environmental burden and for the purchase of certain energy efficiency equipment. There are no specific measures in place for existing buildings and the government has made little analysis about their energy efficiency.

The government has had two projects in the area of voluntary building certification, namely the "Housing Performance Indication System" (HQAL) and the "Excellent Building Mark System for Environment and Energy". HQAL

enables consumers to compare the energy performance of houses by consulting performance evaluation reports published by evaluation bodies designated by the Minister of Land, Infrastructure and Transport. The reports are prepared before the buildings are constructed and they are included into the building contracts to ensure that the buildings will meet their planned energy performance. HQAL has been implemented in approximately 90 000 buildings since its creation in October 2000. The "Excellent Building Mark System for Environment and Energy" has been applied in 68 very large buildings since its start in March 1999. Under this scheme, energy efficiency of buildings is evaluated on the basis of criteria set by the Institute for Building Environment and Energy Conservation and the results are made public.

Individual billing and metering is largely applied to all buildings, including apartment houses. The next step will be the introduction of computerised Home Energy Management System (HEMS) for residential buildings and Business Energy Management System (BEMS) for offices. Both systems provide real time information on energy consumption and cost, and break down the total consumption in more detail, for example by office, and help manage energy consumption of lighting, air-conditioning and hot water supply. An experiment on HEMS began in 2001. BEMS was introduced to the markets in 2002 and is promoted by subsidies.

Air-conditioning has made the summer demand for electricity peak sharply (see Chapter 9). The number of new air-conditioning units is expected to continue to increase steadily and their energy efficiency to improve, levelling off energy demand for air-conditioning of homes. Individual heating of each room in homes is still preferred over central heating.

Japan's consumption of stand-by power is 9.4% of average total consumption of households. Three major manufacturing associations have set voluntary targets for the reduction of stand-by power. For air-conditioning equipment the target is 1 W or less by FY2004, and for other equipment which requires stand-by power to satisfy its functions, by FY2003. For other major household appliances, industry is trying to eliminate the use of stand-by power.

Japan applies the international Energy Star Programme. The products concerned are computers, computer displays, printers, facsimile and copying machines. Enterprises that adopt Energy Star certified appliances can apply for low-interest loans from the Development Bank of Japan.

Because of the extension of the Law Concerning the Rational Use of Energy and the Utilisation of Recycled Resources to cover larger offices and the obligation to appoint energy management staff and submit periodic reports (see Measures in Industry), the number of ESCOs is likely to increase.

Two alternative special taxation measures are offered to promote investment in the installation of energy-efficient equipment. One is a tax deduction

amounting to 7% of the equipment acquisition cost (which should not be more than 20% of the income tax or corporate tax payable). The other is a special depreciation allowing the company to depreciate a maximum of 30% of the acquired value, in addition to the normal depreciation in the year of acquisition.

The ECCJ is responsible for disseminating information on energy conservation. Advertisements in the media have been sponsored by ECCJ since FY1977. Energy Saving Republic, an ECCJ's activity, is a group of people who implement energy-saving actions in elementary and high schools and is planned to be expanded to corporations and universities. ECCJ held the "Smart Life 2001 Campaign" which tried to promote the return to a simpler, less energy-intensive lifestyle. In addition, it issues a tabloid paper "Energy Conservation Ambassadors" six times a year, prepares information leaflets, provides an Energy Saving Republic website and gives subsidies to communities' energy conservation activities. Information activities launched directly by the government include a monthly energy conservation day and the nomination of February as an energy conservation month.

MEASURES IN THE TRANSPORT SECTOR

The use of the Top-Runner Programme in the transport sector is discussed above and its energy efficiency targets for vehicles are given in Table 9. Other transport sector measures are vehicle taxation, promotion of alternative fuels, promotion of public transport and traffic management.

The Japanese government is carrying out an Action Plan on Promoting Low-Pollution Vehicles. By 2010, this plan aims to deploy 10 million low-pollution vehicles (natural gas and electric vehicles, hybrid vehicles and vehicles that meet certain fuel efficiency and exhaust gas standards). The plan foresees that the government sector will set the example by replacing all its official vehicles (about 7 000) between 2002 and 2005, and by inviting local governments to follow. Low-pollution vehicles are subject to reductions on vehicle purchase taxes for which they have to comply both with fuel efficiency and emission (*e.g.* for NO_x and particles) standards. In addition, car ownership is taxed and differentiated according to car age and type favouring younger cars and low-emission vehicles. Other measures include subsidies for certain types of buses and trucks, and publicity campaigns. R&D activity in low-emission vehicles, alternative transport fuels and technologies has also been significant (see Chapter 10). As a result of these efforts, out of a total 1.8 million vehicles registered in April-September 2002, 57% qualified for tax reductions. Most of them were efficient low-emission gasoline vehicles but the number of hybrid vehicles was 9 254 and natural gas and electric vehicles 1 401.

The government has few measures to directly discourage the use of private cars but concentrates on promoting the use of public transport. It also takes

measures such as improving efficiency of freight services and reducing traffic jams through Intelligent Transport System (ITS). It tries, for example, to control traffic congestion by differing start times of office work. The government is also considering introducing congestion tolls.

MONITORING AND ASSESSMENT

Large and mid-size factories and offices are obliged under the Law Concerning the Rational Use of Energy to report their energy consumption to METI and to prepare medium- to long-term plans for rational use of energy. The government follows the implementation status of energy conservation measures carried out under the voluntary action programmes through these reports and plans. At the same time, the government carries out investigations and inspections in those industrial sectors whose energy conservation measures are lagging substantially behind the goals set in the action programmes, as well as in business sectors that have yet to draw up voluntary action programmes. The Keidanren is investigating possibilities to establish third-party monitoring of the Voluntary Action Plan and the government supports this initiative.

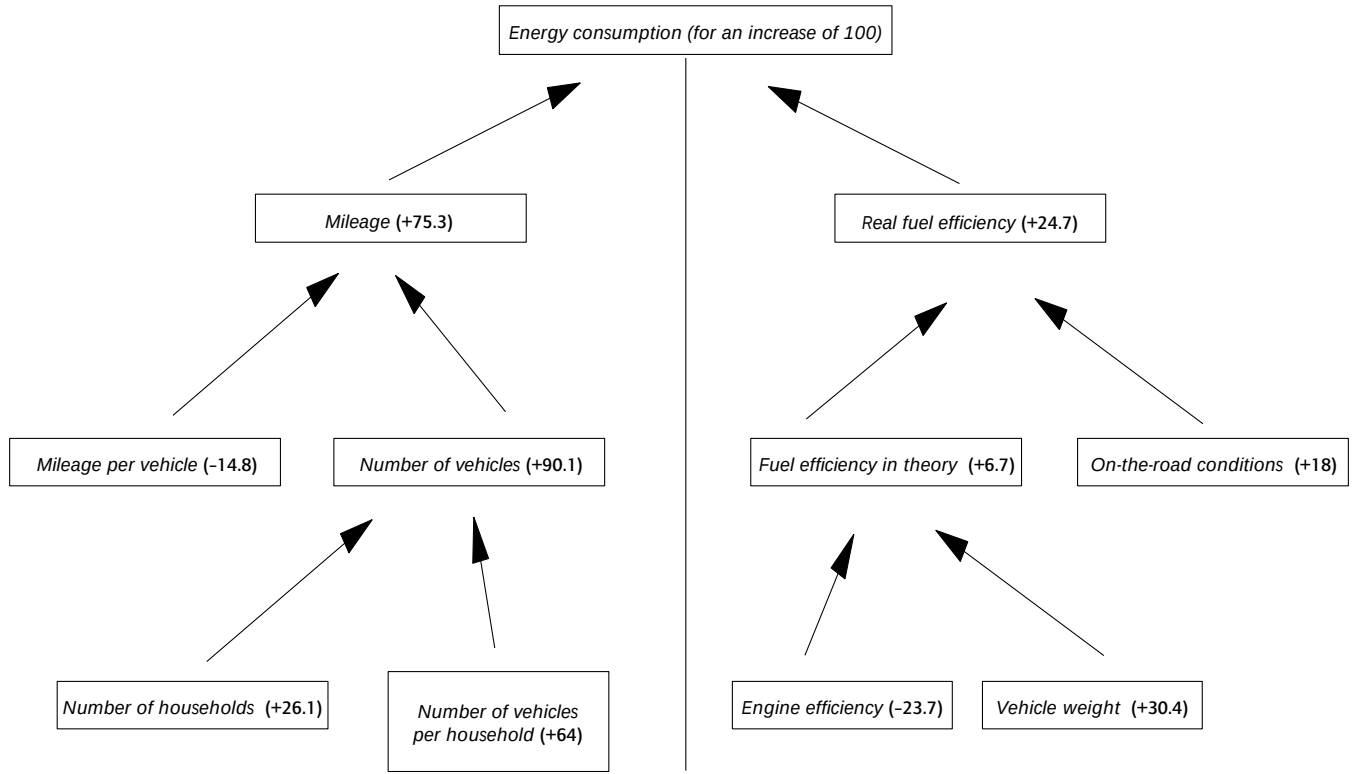
METI has carried out an analysis on which factors cause an increase in energy consumption. This analysis has also been used to evaluate the effect of energy efficiency measures such as the Top-Runner Programme. For example, 93.1% of energy increase in the service sector in 1990-1998 can be attributed to the increase of floor space and 6.9% to the increase of specific energy consumption per square metre due to, for example, longer business hours or more equipment. The transport sector analysis shows that all gains in engine efficiency were more than offset by increased vehicle weight and driving conditions (Figure 12). The users appear to be opting for larger cars but also the weight of smaller vehicles has increased due to new safety equipment. Further, the total number of vehicles – following the higher number of households but, more importantly, more vehicles per household – has contributed to a large increase in the country's total mileage of private vehicles. On the whole, the increase in fuel consumption and related CO_2 emissions is two-thirds due to increased mileage and for the remainder, to reduced on-the-road fuel efficiency. The improvement in engine efficiency in Figure 12 is an indication of the impact of the Top-Runner Programme in the transport sector.

CRITIQUE

Though energy efficiency levels in Japan are still good compared to international levels, the difference is narrowing both in terms of energy intensity and energy demand per capita. Whereas the increase in energy consumption in the industry sector has been moderate, partly reflecting the economic slow-down,

Figure 12

Factors in the Increase of Energy Use by Private Vehicles, FY1990 to FY1998



Source: METI.

people's lifestyle choices have led to quite a rapid increase of demand in the household and passenger transport sectors. The policies in place in the two latter sectors have not yet proven to be very effective and the government may need to explore new, more effective measures. Given the past trend in the transport sector, there is some concern about how realistic it is to achieve the reduction in energy demand anticipated in this sector by the *Long-Term Energy Supply and Demand Outlook*.

Japan appears to be relying heavily on a voluntary approach and various financial and fiscal incentives in order to improve the energy efficiency of industrial, residential and commercial buildings and transport, while having some regulatory measures such as the Top-Runner Programme. Japan should conduct a careful review to determine the relative effectiveness and cost-effectiveness of these voluntary programmes and incentives, including comparison with other policy mechanisms such as mandatory minimum performance standards for energy efficiency in buildings or other approaches. Regulatory approaches, for example, are often useful where price signals for energy are weak compared to other consumer preference issues as this is often the case in buildings. Evaluation and enforcement mechanisms of energy efficiency policies and measures should also be identified, particularly in respect to the cost-effectiveness of measures. This review should include an examination of international best practices in this area.

In particular, efforts in the area of energy performance standards for buildings could be intensified. At present, the standards and incentives cover only new buildings. There are no standards, for example, for the refurbishment or retrofitting of buildings. Minimum standards have been recently tightened to levels comparable with those of the cold regions of Europe and North America but they were left voluntary. Most other IEA countries have recognised the effectiveness of standards in improving energy efficiency and have made them mandatory. Some other IEA member countries – and recently the European Union in its planned standard and certification directive for buildings – have sought to raise the awareness of energy consumption in buildings by introducing energy-efficiency certification or labelling systems. Japan has activities in the area of building certification but so far with limited coverage. In energy performance standards and certification for buildings, Japan could benefit from examining the international experience in terms of implementation and monitoring.

The Top-Runner Programme encourages manufacturers to develop more efficient technologies. Its targeted efficiency levels are ambitious for most products, making significant energy savings and CO_2 emissions reductions likely. The target levels are clear, firmly set and analytically simple (requiring only a statistical appraisal of the efficiency of products on the current market). The monitoring results show that the programme has had a positive impact on the efficiency of, for example, vehicles and household appliances. Some researchers,

however, have found that life cycle engineering-economic analyses may provide both a stronger foundation and a more aggressive rate of improvement. Lack of engineering-economic analysis means that the full economic implications of adopting a given target level are not fully known. The top of the domestic market (at the time the targets are determined) may or may not be consistent with a least-cost approach to energy use, CO_2 emissions reductions or other policy goals. It is possible for the targets to be too lax or too stringent from a least-cost perspective. One more potential problem is that the manufacturers may either collude (whether tacitly or overtly) to halt efficiency improvements or attempt to create targets attainable only with proprietary technologies. Japan should consider conducting a review of standard-setting and identify which approach will provide the greatest benefit.

Labelling of products according to their energy consumption, including comparison to the top-runner, is an informative and visible way of enabling consumers to take informed purchase decisions. The Japanese scheme, however, is voluntary and excludes many large household appliances (*e.g.* washing machines, dryers and dishwashers) as well as hot water boilers. A mandatory labelling scheme would strengthen the impact of the Top-Runner Programme by approaching the issue from the demand side, *i.e.* consumer choices.

Diesel engines offer substantial energy efficiency benefits in passenger transport as compared to gasoline engines, but are not currently being pursued by Japan because of concerns about particulate and NO_x emissions. Industry should be encouraged to develop improved emissions control technologies for diesel engines to meet stringent air quality standards.

Top-Runner Programme's vehicle performance standards have categories based on weight. This may allow manufacturers and importers to shift even more rapidly into heavier, less efficient vehicles. Some countries, most recently Switzerland, have introduced energy efficiency labelling for vehicles. Implementing labelling could help consumers to take informed decisions. However, for normal passenger cars, such labels should not be limited to giving information for relative comparison within exactly the same weight or engine category, but also for a wider vehicle base.

RECOMMENDATIONS

The government of Japan should:

- *Assess the efficacy of combining energy efficiency standards/guidelines with subsidies.*

- *Strengthen the standards for appliances and vehicles in the Top-Runner Programme by:*
  - *Considering other approaches to set new standards, such as minimum life cycle cost or using the international appliance market to identify the top-runner.*
  - *Making labelling mandatory and extending it to a wider range of products.*
  - *Considering different approaches for vehicles to avoid a shift towards increased weight, such as by basing the top-runner on the consumption of the average fleet or by engine size.*
- *Examine the possibility of introducing mandatory efficiency standards for new residential and office buildings, intensify the efforts in certification of new buildings and develop a certification scheme for existing buildings.*

OIL

EXPLORATION AND PRODUCTION POLICIES

In 1994, the government plan "Future Development of Domestic Oil and Combustible Natural Gas (1994-1999)" established a target to increase the contribution from oil developed and imported by Japanese companies operating overseas to 1.2 million barrels a day (mb/d) by the beginning of the 21st century. Owing to slow progress and poor cost-effectiveness, the target was abolished in 2000. In 2001, Japan's oil output reached only 0.47 mb/d, equivalent to 11.5% of Japan's total crude oil imports. All oil developed abroad, however, is not imported directly to Japan as the oil companies are free to optimise their operations during normal times. Japan has not set new numeric targets but it still continues to support the exploration activities. In FY2001, there were 30 Japanese oil developing companies overseas that imported into Japan.

Japan supports oil development at home and abroad in several ways. The major tool for this policy has been Japan National Oil Corporation (JNOC). JNOC is a governmental organisation that was established over thirty years ago to provide Japanese oil companies with the means to secure international oil supplies as well as providing financial and technical assistance to promote oil and gas exploration and development activities in their ventures overseas and offshore Japan. Other key functions of JNOC include implementation of Japan's stockpile programmes and research into new oil industry technology. By the end of March 2002, JNOC had supported 300 oil and gas exploration and production companies. In addition, JNOC acts as a bridge between the oil-producing countries and Japanese oil companies to promote oil and gas exploration projects. JNOC has provided funds for corporation in the private sector for petroleum stockpiling and carried out the national oil stockpile programme. JNOC will be dissolved by the end of FY2004 and its activities taken over by a new organisation. The objectives of this reorganisation are to make the activities carried out by JNOC more cost-effective and to establish a well-defined oil supply strategy.

Some streamlining of support activities has taken place because of concerns over the low cost-benefit of exploration abroad:

- **Pre-exploration stage:** The geological features of prospective, unexplored areas abroad are investigated by JNOC and basic investigations of domestic oil resources are carried out on a government commission basis.

- **Exploration stage:** Exploration investment (equity) is provided by JNOC for up to 50% of exploration costs abroad and offshore Japan (down from 70% in the past for overseas exploration and 80% for exploration offshore Japan). JNOC can also acquire direct rights in a mining area for a period of up to one year.

- **Development and production stages:** Long-term low-interest rate financing is provided by the Development Bank of Japan. The loan covers up to 50% of the investment (down from 60% in the past). The Japan Bank for International Co-operation, whose loans covered up to 80% of investments, has ceased financing oil development and production. In some cases JNOC may make investments (equity) related to asset purchases up to 50% of the investment. JNOC's debt guarantees are also possible up to 50% of loans, at a charge of 0.4 to 1.5% per year.

- **Taxes related to exploration and development:** A number of tax incentives are provided. The Overseas Investment Reserve Funds for Losses allows writing off 100% of the investment and loans in the exploration stage, and 30% in the development stage. A Depletion Allowance permits laying aside 12% of the mining revenue as exploration reserve funds or 50% of the mining net income, whichever is smaller, and tax deductions for mining revenue used for exploration of new deposits within three years.

PRICES

The pre-tax price for gasoline and diesel are among the highest within the OECD but the low taxes bring prices under the OECD average (see Figures 13 and 14). Gasoline and diesel prices decreased in 1998-1999 after the initial market opening. They then increased in 2000-2001, together with world oil market prices, and declined again in 2002. Taxation of oil products is discussed in Chapter 3.

DEMAND AND SUPPLY

Oil demand grew by only 1.2% between 1990-2001 reaching 256.1 Mtoe. The share of oil in total primary energy supply (TPES) decreased between 1973 and 1990 from 77.9% to 58%, and reached 49.2% in 2001. The government foresees in its *Long-Term Energy Supply and Demand Outlook* that oil demand will decrease by 11% between 2000 and 2010 in the Base Case, and by 13% in the Policy Case. The recent closure of the TEPCO nuclear power plants for safety inspections has a short-term upward impact on oil demand, at least for the 2002-2003 period.

From 1990 to 2001, total final consumption (TFC) of oil increased to 218.5 Mtoe, *i.e.* by 16% (see Figure 16). Because of stagnant economic growth, oil

Japanese Oil Projects Abroad

Japan's Arabian Oil Company's (AOC) drilling rights in the Saudi Arabian portion of the Neutral Zone (which produced 280 000 b/d) expired at the end of February 2000. Efforts to negotiate an extension with Saudi authorities failed owing to differences over terms and Saudi Aramco took over operation of the former AOC fields. AOC's concession in the Kuwaiti portion of the Neutral Zone expired in January 2003 but has been renewed. The new agreement gives AOC the right to buy oil from Kuwait over a 20-year period. AOC will also provide technical services to Kuwait for an initial five years, which can be rolled over. Under the new terms, Kuwait will sell AOC no less than 100 000 b/d from the zone's production at prevailing market prices, while AOC will extend soft loans to finance some zone operations at lending rates below international market levels.

Japan has been trying to make up for the loss of the Saudi concession by increasing its investment in Iran. In November 2000, Iran announced that it would begin exclusive negotiations with Japan Petroleum Exploration Corporation (Japex) and Indonesia Petroleum (Inpex), both of which are majority-owned by JNOC, for development rights to the onshore Azadegan oilfield which has been estimated to contain 6 billion barrels of recoverable reserves and is expected to reach peak production of around 400 000 b/d. The consortium submitted a preliminary development plan for Azadegan in mid-2001, but final agreement is yet to be reached. The Japanese consortium has concluded an agreement to work with Shell on the project once a final contract is signed with Iran.

Japan has also been seeking equity stakes in the Caspian Sea region. In 1996, Itochu joined Azerbaijan's offshore ACG field. JNOC has financially supported Itochu in the development of this field including a pipeline project for crude oil export to Ceyhan, Turkey (BTC pipeline project). In 1998, Japanese companies joined three projects: Azerbaijan's offshore Kur Dashi Contract Area (Mitsui), Atashgyakh-Mugandeniz-Yanan Tava Contract Area (Inpex, Japex, Teikoku Oil and Itochu) and Kazakhstan's offshore Kashagan's field (Inpex). JNOC has also supported these Japanese companies financially. JNOC's most significant financial support in 2002 was for Inpex, which purchased a 10% stake in Azerbaijan's offshore ACG field.

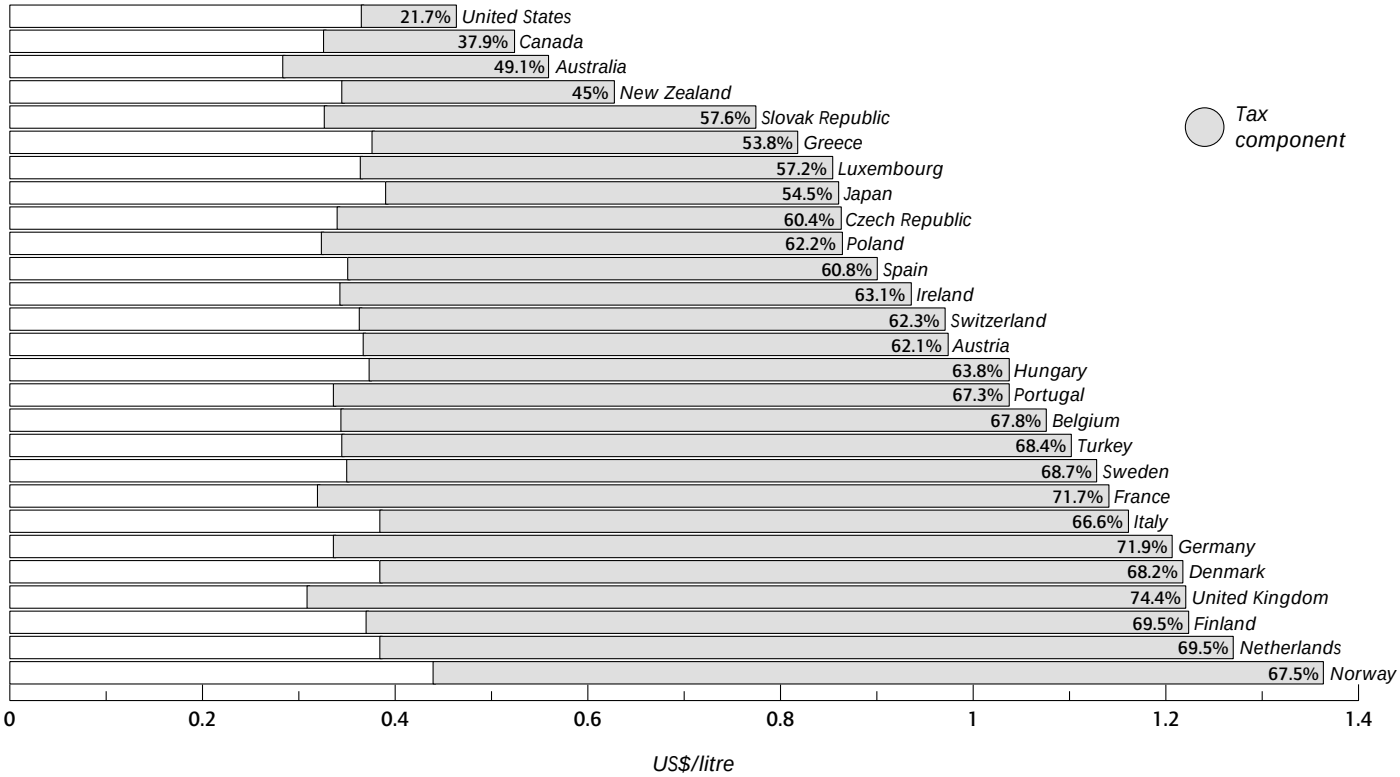
Source: *Japan Country Analysis Brief*. Energy Information Administration EIA. April 2002.

consumption ceased to increase, and a downward trend emerged. The transport sector is the largest oil user (43%), followed by industry (31%), and household and other sectors (26%). Kerosene is the most typical heating oil used in Japan.

In 2001, the share of gasoline in the consumption of transport fuels was 49% and that of diesel 34%. The rest included aviation and other fuels such as LPG.

Figure 13

OECD Unleaded Gasoline Prices and Taxes, First Quarter 2003

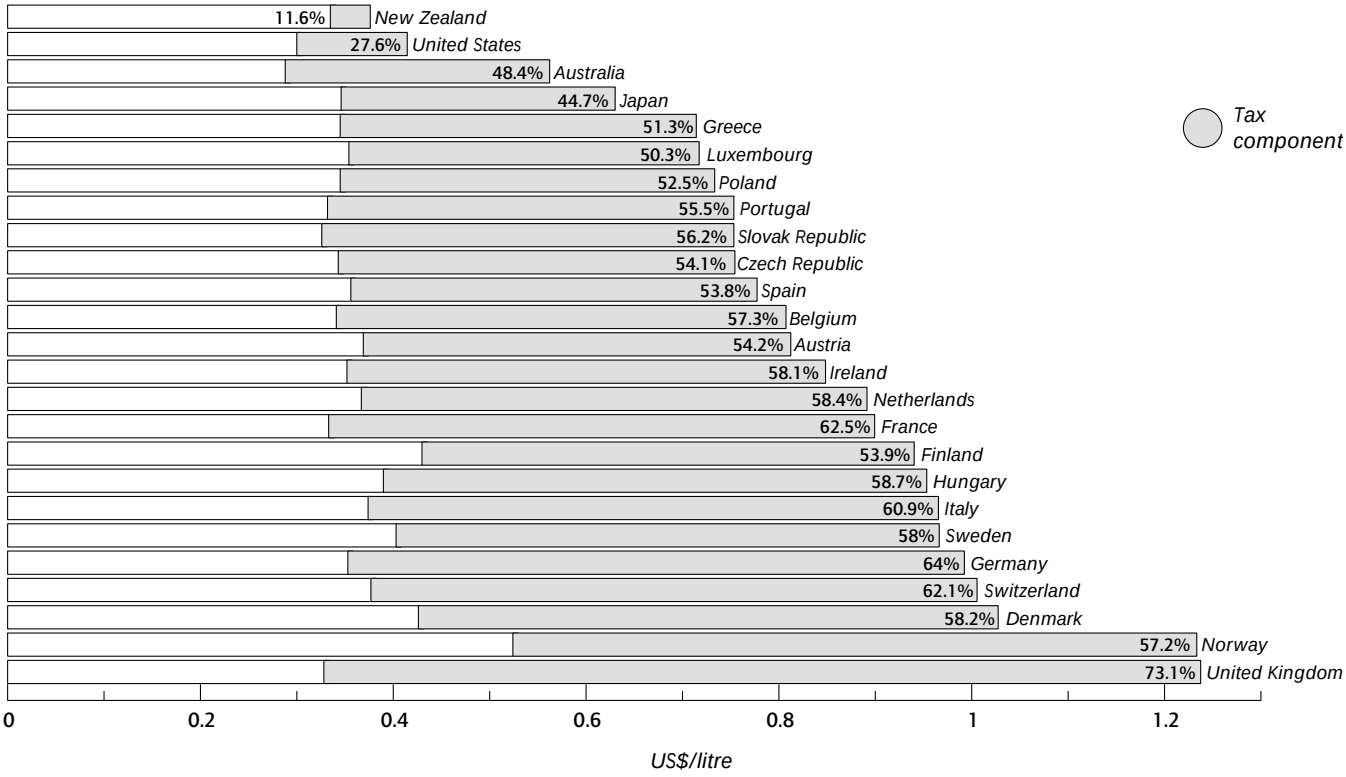


Note: Data not available for Korea and Mexico.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 14

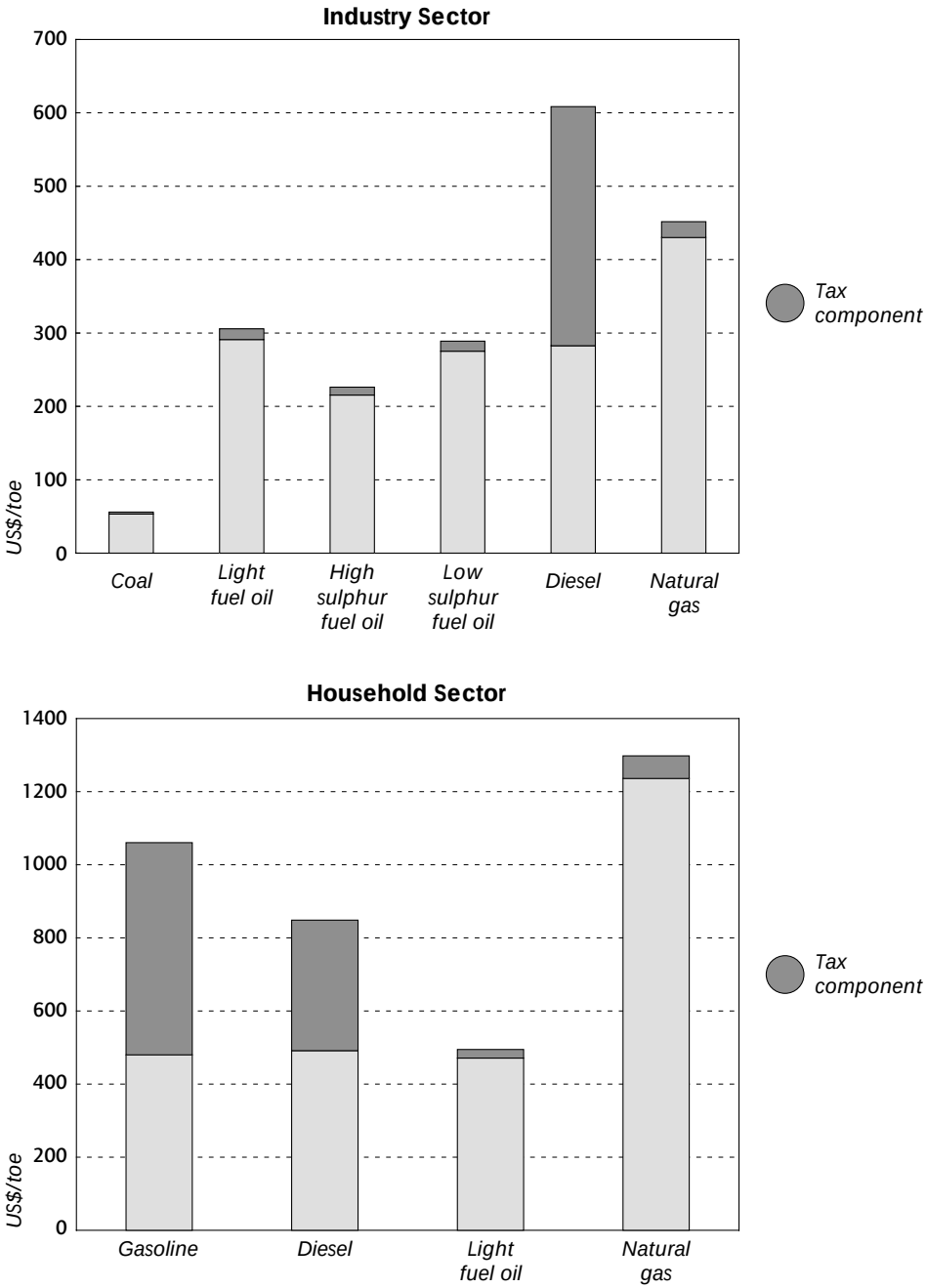
OECD Automotive Diesel Prices and Taxes, First Quarter 2003



Note: Data not available for Canada, Korea, Mexico and Turkey.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 15

Fuel Prices, 2001

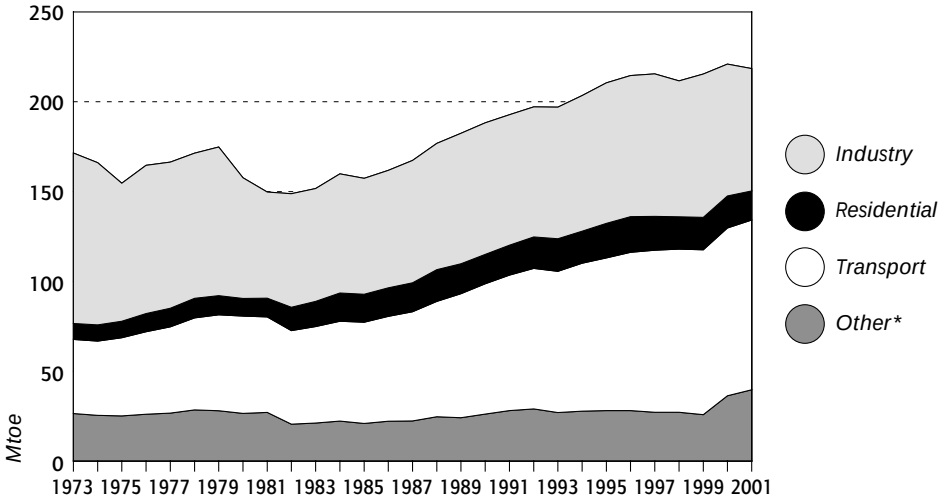


Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Japan is the second largest LPG consumer within the OECD at 18 Mtoe in 2001; 56% of LPG is used by the residential and service sectors, 35% by industry and 9% by transport.

Figure 16

Final Consumption of Oil by Sector, 1973 to 2001



* includes commercial, public service and agricultural sectors.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

Almost all oil is imported. In 2001, crude oil imports were 205 million metric tonnes. The sources were Saudi Arabia (25%), United Arab Emirates (24%), Iran (12%), Qatar (11%), Kuwait (10%), Oman (6%), Indonesia (4%) and several other sources (8%). The share of Middle East oil grew over the past decade reaching 88% in 2001, after a decline from 78% in 1974 to 68% in 1988. This concentration of supplies from one area is a serious concern for the government from the viewpoint of energy security. To diversify supply sources, for example, one long-term project being discussed is importing oil from the Russian Far East via a pipeline.

Imports of oil products were 46.7 million metric tonnes in 2001 and the breakdown of these consisted of naphtha (44%), LPG (31%), petroleum coke (9%), kerosene (8%) and other products (8%). Oil products are imported from the Middle East (43%), Korea (20%), Indonesia (6%), Australia (3%) and other diversified sources (28%). Oil product exports, about half to other OECD countries and half to other areas, were 4.7 Mt in 2001 and comprised diesel (35%), residual fuel oil (24%), kerosene (16%) and other products (26%).

INDUSTRY STRUCTURE

The Japanese oil industry has faced some restructuring following the liberalisation of oil product imports in 1996 and exports in 1997. As a response to competitive pressure, some refineries have closed, a number of filling stations slowly declined and many oil refining and wholesale companies are reorganising their operations through mergers and partnerships.

The oil refining market is dominated by four major corporate groups, namely Nippon Oil, Japan Energy, ExxonMobil Group and Idemitsu Kosan. Nippon Oil and Mitsubishi Oil merged in early 1999, forming Nippon Mitsubishi Oil and now Nippon Oil. In September 1999, it acquired Koa Oil from Caltex and in February 2002 merged Koa Oil with another subsidiary, Tohoku Oil. In October 1999, Nippon Oil announced a strategic alliance with another independent Japanese refiner, Cosmo Oil. In January 1999, Showa Shell (Royal Dutch Shell's Japanese subsidiary, in which it owns a 50% stake), announced a strategic alliance in petroleum product distribution and crude oil procurement. The third large player in the refining sector is ExxonMobil, through its Japanese subsidiary, Tonen General Sekiyu, which resulted from the merger of two ExxonMobil subsidiaries in February 2000. Finally, in December 2002, Idemitsu Kosan announced a strategic alliance with Nippon Oil in petroleum product distribution.

Following the liberalisation of oil imports, concern grew in the oil industry that there were more petroleum refining facilities than necessary. For example, in 2000, the average utilisation ratio of refining facilities was 90% in the United States, 90.7% in Europe and 78.3% in Japan. At the same time, oil consumption decreased because of the economic slow-down. Over the past three years, around 0.4 mb/d of atmospheric distillation facilities have been shut down. At the end of March 2001, the capacity in use was 4.97 mb/d (see Table 10). It is estimated that some 0.5 mb/d of refining capacity will be closed down during the next few years owing to low competitiveness and new environmental standards for petroleum products[14]. Investments in the refining sector – most of them likely to have been made to upgrade existing facilities – dropped from ¥300-400 million per year in the early and mid-1990s to about ¥50-60 million per year for 2000-2001. In 2002, investments increased to about ¥90 million.

At the end of March 2003, the total number of filling stations was 52 592. After peaking in 1994 (at 60 421) the total number has been slowly but continuously declining. Filling stations in Japan are characterised by many small and medium-sized enterprises, a large number of dealers compared to the number of filling stations and the low number of self-service stations. After self-service stations were permitted in 1998, their number reached

14. All diesel sold in Japan must have a sulphur content of less than 50 ppm (parts per million) by the end of 2004, but the government intends to lower the limit to 10 ppm.

Table 10

Refining Capacity

Fiscal year	*Capacity b/d*	*Average utilisation ratio (%)*	*Number of toppers*	*Number of refineries*
1985	4 972 000	62.3	68	46
1995	5 221 000	79.4	53	40
1996	5 269 000	79.2	53	40
1997	5 353 000	81.2	53	40
1998	5 379 000	77.8	53	40
1999	5 383 000	77.2	49	37
2000	5 274 000	78.3	49	36
2001	4 967 000	81.0	47	35

Source: Petroleum Association of Japan.

1 943 in September 2002. The average fuel sales per filling station are 1.1 million litres per year, whereas according to the European Commission, average sales per filling station at the end of 1999 were 3.1 million litres in Germany, 2.8 million litres in the United Kingdom, 2.5 million litres in France and 1.4 million litres in Italy.

REGULATORY REFORM

In the past, the government heavily regulated the refining industry for energy security reasons. The fundamental basis was the 1962 Petroleum Industry Law empowering the government to "co-ordinate supply and demand". Under this law, the change of refining facilities (such as expansion or reduction of refining capacity) was subject to approval by METI, which formulated the Petroleum Supply Programme for a period of five years based on demand forecasts. Because of the need to enhance efficiency and reduce price levels through competition, the government launched the liberalisation process in the late 1980s. Over the years, various regulations on refining facilities and imports of petroleum products have been eliminated. This process was finalised in January 2002 by the abolition of the 1962 Petroleum Industry Law.

Since 1977, the Gasoline Sales and Distribution Business Law has been the main legislation governing the gasoline retail market in Japan. It set many restrictions to competition, including the need for dealers to have a supply certificate issued by wholesale distributors, and restrictions on new stations in

designated areas. In addition, between 1979 and 1990, METI froze the number of service stations per distributor. Liberalisation of the retail market started in 1996 which led to full liberalisation as imports are only subject to environmental and stockpiling regulation, exports are free, designated areas for distributors have been abolished, gasoline dealers can enter the market only subject to registration and self-service stations can be built.

EMERGENCY RESPONSE MEASURES

Given the continuing high rate of dependence on oil imported from the Middle East as well as high import dependence on all energies, lack of oil substitutes in the transport sector and limited economic substitutes for peak electricity demand, Japan is highly vulnerable to an oil supply disruption. This situation is reflected in the high priority of oil emergency response measures. The government has wide-ranging legal authority to implement emergency response measures and facilitate close co-operation with the industry.

The basic legal framework to secure adequate oil supplies in an emergency consists of:

- The Petroleum Stockpiling Law (amended in July 2002).
- The Japan National Oil Corporation Law (a new law on an organisation for oil, natural gas and mineral sources will be introduced in 2004 and the National Oil Corporation Law will be abolished by March 2005).
- The Petroleum Supply and Demand Optimisation Law. This law provides for the following actions to secure adequate supply, subject to a Cabinet decision and proclamation to implement an emergency measure under the law:
  - The METI prescribes and issues the target for oil supply.
  - Each oil refiner, oil importer or oil marketer prepares and reports to METI its plan for oil production, import and sale.
  - The METI, when it is necessary to achieve the oil supply target, will instruct the oil refiner or marketer to revise its plan for oil production or sale.

In the case of an oil supply disruption, the Agency for Natural Resources and Energy (ANRE) would be responsible for the implementation and co-ordination of the domestic emergency response measures. Japan's National Emergency Sharing Organisation would be established in ANRE.

Japan maintains a high level of emergency oil stocks. The government maintains its own emergency reserves under the Japan National Oil Corporation Law and

imposes stockpiling obligations on industry (primary distributors, refiners and importers), in accordance with the Petroleum Stockpiling Law.

Government stocks, currently held by JNOC, are all crude oil. While the government directly possesses oil stocks, management of its stocks and stock facilities will be commissioned to a new independent administrative agency which will be established by February 2004 in accordance with a newly enacted law on the organisation for oil, natural gas and mineral resources.

The 50 million kl target of government stocks was achieved in February 1998. Together with the private stocks, Japan's stock level stands at 120 days of net imports (according to IEA definitions) and the government carefully monitors the emergency reserves.

In accordance with the new Petroleum Stockpiling Law, government stocks can be drawn down on instructions given by the Minister of Economy, Trade and Industry. Regarding the draw-down of private stocks, the minister is empowered to reduce stockholding obligations, taking into account individual companies' oil availability as well as the general oil supply situation. During the Gulf war, the government lowered stockholding obligations by four days for compulsory stocks held by companies to meet Japan's commitment as part of the IEA Contingency Plan.

Under the Petroleum Stockpiling Law, LPG stocks are held by private companies. In addition to this private sector stockpiling, the government plans to establish a national LPG stockpiling system to build up a reserve volume of 1.5 Mt by FY2010. The aim is to secure a steady supply of LPG in the event of a major oil disruption. There is no requirement to stockpile LNG.

The Petroleum Supply and Demand Optimisation Law and the Electric Utilities Industry Law provide the government with legal authority to implement compulsory demand restraint measures. These laws would be activated in a severe crisis if energy conservation measures and moderate demand restraint measures are not sufficient. The Cabinet Committee for the Promotion of Comprehensive Energy Measures and the Committee for the Promotion of Energy and Resources Conservation Measures (vice-ministerial level) will be convened to determine the appropriate measures.

The government is empowered to take initiatives to introduce demand restraint measures aimed at persuading the public and industry to make greater efforts to conserve energy and provide them with necessary information on the emergency situation. Measures to be taken would be decided on an *ad hoc* basis and would reflect the nature of any crisis.

In case of an emergency, the minister has authority to make a recommendation to modify the supply plan or issue a supply order to electric power companies in accordance with the Electric Utilities Industry Law. This will secure adequate

capacity for electric power supply and shift the electricity supply to non-oil energy sources.

COAL

DEMAND AND SUPPLY

Since 1990, all domestic production is steam coal. Following the restructuring of the coal industry owing to its low competitiveness, domestic production decreased by over 60% in the last decade, reaching 3 Mt (1.6 Mtoe) in 2001 and accounting for 1.6% of domestic demand. Following the closure of Ikeshima and the reorganisation of the Taiheiyo mine in 2001, the amount was further reduced to 0.7 Mt in 2002. At present, Taiheiyo continues to operate, but at a reduced scale, under the name Kushiro, and is the only coal mine in operation.

Coal demand increased from 74 Mtoe in 1990 to 100.2 Mtoe in 2001, *i.e.* by 35%. The demand for different types of coal has developed differently. Whereas consumption of steam coal increased by 111% between 1990 and 2001 mainly led by increasing demand for electricity generation, consumption of coking coal decreased by 6% as a result of economic slow-down and declining demand for steel. In 2001, 76% of steam coal was used for power generation and most of the remainder was used by the non-metallic minerals industry. All coking coal is used by the steel industry. The government's *Long-Term Energy Supply and Demand Outlook* forecasts an increase in coal demand of 26% between 2000 and 2010 in the Base Case and of 9% in the Policy Case. Final consumption of coal has remained quite steady in the 1990s; it decreased from 22.5 Mtoe in 1990 to 20.8 Mtoe in 2001.

Japan is the world's largest importer of steam coal for power generation and of coking coal for steel making. It accounts for about 23% of the world's total hard coal trade. In 2001, steam coal was imported mainly from Australia (58%), China (17%) and Indonesia (11%), and coking coal[15] mainly from Australia (61%), China (15%), Indonesia (11%) and Canada (7%). Imports from Australia have been at approximately the same level for several years, whereas imports from China and Indonesia are increasing and those from Canada are decreasing. Increased imports from China can be seen as part of the expanding trend of Chinese trade into the Asian markets, including Japan.

Coal imports have been free from government intervention since 1992 and coal supply sources and contracts are negotiated by individual importing companies: 50% of steam coal imports are based on long-term contracts

15. For Japan, the IEA classifies coal used in pulverised coal injection into blast furnaces as coking coal, although its physical qualities are those of steam coal.

Table 11

Coal Imports to Japan by Country, 1980 to 2001

(thousand metric tonnes)

FY	*Australia*	*Canada*	*United States*	*China*	*Indonesia*	*South Africa*	*Russia*	*Others*	*Total*
1980	31 027	11 838	21 410	2 231	9	3 491	2 282	844	73 132
1985	44 157	17 834	13 928	3 719	315	8 627	4 529	827	93 936
1990	56 236	18 337	11 965	5 337	1 085	4 991	8 397	1 285	107 633
1995	65 311	18 169	10 826	10 093	9 515	5 688	5 021	2 470	127 093
1996	66 544	18 344	9 601	12 078	9 734	5 914	5 021	2 773	130 009
1997	73 717	18 496	7 404	12 491	11 889	4 808	4 541	2 506	135 852
1998	70 320	16 747	6 516	13 045	12 847	3 072	3 813	2 659	129 019
1999	80 575	14 731	5 067	13 547	13 475	2 894	5 079	2 755	138 123
2000	90 101	13 631	3 662	19 295	14 630	1 552	5 410	2 418	150 699
2001	91 476	10 168	2 241	25 172	16 805	1 097	5 641	2 098	154 698

Source: METI.

(3-5 years), 30% on one-year contracts and 20% are purchased from spot markets; 20% of coking coal imports are based on longer-term contracts and 80% on one-year contracts.

CLEAN COAL TECHNOLOGIES

Japan has been promoting clean coal technologies for several reasons. While Japan needs to continue using coal to ensure a balanced generation mix, it has ambitious emissions reduction targets under the Kyoto Protocol and improved efficiency in coal use would reduce emissions. The industry has accepted the need to improve coal's environmental performance to compete with gas and nuclear. Also, the local governments' role in siting coal power plants and establishing environmental regulations – the right given to them under the Anti Air Pollution Act of 1968 – has sometimes led to strict local emission limits which may impact on the use of technologies with lower emissions. Several power plants using pressurised fluidised bed combustion and ultra-supercritical technologies have been operating for many years (see Table 12). Some of them have been developed by J Power with investment support from the government.

Japan produced 8.4 Mt of coal ash in FY2000 and this is expected to continue to increase. Coal ash is used in the production of cement which is decreasing in Japan and therefore has reached its upper limit unless other applications are found. Also, finding new landfill sites for coal ash has become increasingly difficult and new technologies need to be developed for its treatment and use.

Table 12

Power Stations Using Clean Coal Technologies

Plant	*Type*[1]	*Gross capacity, MW*	*Efficiency*	*Commissioned*
Osaki 1	PFBC	250 gross	38.1%	2000
Karita Shin 1	PFBC	360 gross	38.7%	2001
Tomatoatsuma 3	PFBC	85 gross	39.5%	1998
Misumi	USC	1 000 gross	42.1%	1998
Matsuura 2	USC	1 000 gross	41.4%	1997
Tachibanawan 1, 2	USC	2 × 1 050 gross	41.9%	2000
Reihoku	USC	700 gross	39.8%	1995
Haramachi 1, 2	USC	2 × 1 000 gross	42.2%	1997/1998

1. PFBC = Pressurised Fluidised Bed Combustion, USC = Ultra-supercritical.

Source: METI.

COAL POLICY

Until recently, Japan maintained a small but heavily subsidised coal production industry mainly on the grounds of security of supply. The main form of subsidy was directed at coal consumption by the electric utilities, where coal producers received subsidies to cover the differences between the market prices and those established under domestic agreements. This cost premium (about ¥39 billion in 1999-2000) was paid by all electric utilities in Japan even though only three utilities actually used domestic coal. The power industry voluntarily bought the domestic coal.

In FY1992 to FY2001, Japan followed a restructuring programme – sometimes referred to as the "post eighth coal policy". The programme addressed mining damages and provided support to structural adjustment (*e.g.* business diversification), former miners, land restoration and the development of mining areas. When the programme expired in FY2001, public subsidies ceased. During the final programme year, the subsidy was ¥12 110 per tonne sold totalling ¥32.4 billion for current production. The only remaining coal mine, Kushiro, will supply coal to the electric utilities until 2006 without any public subsidies, regardless of the higher cost compared to market prices.

NATURAL GAS

INDUSTRY STRUCTURE

The Japanese city gas industry is fragmented into many vertically integrated regional companies. As of March 2002, 234 utilities operated in city gas distribution, of which 172 were privately owned and 62 publicly owned.

Whereas the electric utilities import most of the LNG, the city gas market is dominated by the three largest companies, namely Tokyo Gas, Osaka Gas and Toho Gas (see Table 13) which account for 75% of the city gas market. Most gas utilities produce or import their own gas but some of the smaller ones buy gas from the larger ones. They had exclusive supply areas which were protected from competition by government regulation, and are subject to public service obligations in their own supply area. Following the partial gas market liberalisation some power companies, for example TEPCO, and other energy suppliers have entered the gas distribution market.

Gas industry productivity has improved during the last decade. The number of employees was 6.6% lower in 2001 than in 1990 and the gas sold per employee increased by 59.2%.

Table 13

Major Gas Companies

Company	*Gas sales volume FY2001*		*Gas sales turnover 2001*		*Number of customers FY2001*	
	Bcm	*Share*	*Billion ¥*	*Share*	*Million*	*Share*
Tokyo Gas	8.27	35.7%	743	32.8%	9.0	34.3%
Osaka Gas	7.21	31.2%	594	26.2%	6.5	24.6%
Toho Gas	1.92	8.3%	193	8.5%	1.7	6.5%
Subtotal	***17.37***	***75.2%***	***1 530***	***67.5%***	***17.3***	***65.4%***
Other utilities	5.73	24.8	736	32.5%	9.1	34.8%
Total	**23.11**	**100.0%**	**2 266**	**100.0%**	**26.3**	**100.0%**

Source: METI.

DOMESTIC PRODUCTION AND EXPLORATION

Domestic natural gas production amounts to 2.5 bcm and accounts for 3.3% of demand. Proven domestic reserves are 40 bcm and they will be depleted in 16 years with the current rate of use.

Like oil, exploration and development of natural gas at home and abroad are mainly subsidised by JNOC – and its successor – and carried out by private companies. To promote and facilitate development, JNOC provides funds and debt guarantees for the development and liquefaction stages of the natural gas supply chain. In 2000, the Petroleum Council, a consultative organ to the METI, carried out an assessment of these activities and recommended that they continue.

The specific support forms in the pre-exploration, exploration, development and production stages, as well as in terms of taxes related to these phases, are

the same for natural gas as for oil (see section on oil above). There is no import tax on LNG. The Development Bank of Japan provides low-interest loans, and a special repayment system (or tax deductions) for the construction of LNG terminals and transmission pipelines as well as for promoting the use of natural gas by those local gas companies that rely on LPG.

Sonar surveys suggest that large amounts of methane hydrates[16] lie off the Pacific coast in the middle of the Japanese archipelago. According to some rough expert estimates, reserves near Japan could provide 7 400 bcm of methane which is enough to support Japan's natural gas use for a century. The plan to develop methane hydrates took off in 1994, following a report from the Petroleum Council. The report recommended that a basic survey be carried out to investigate the reserves and their future commercial potential. Under the plan, the ANRE and JNOC began test production in 1999 at a point 50 km off the coast of Shizuoka Prefecture, at a depth of 945 metres. The government aims to start commercial production from 2016. There are important obstacles to commercialisation because no country has the technology and production experience, the main problem being the effective and safe extraction of methane gas from the solid. To address these obstacles, the government has formed a consortium involving industry, academia and JNOC, and promoted technology co-operation with the United States, Canada and Germany.

GAS DEMAND

Japan is the seventh biggest gas consumer in the world. Natural gas demand reached 64.8 Mtoe (80 bcm) in 2001 which is 50% higher than in 1990. The share of gas in TPES increased from 9.9% to 12.4% over the same period. The government, in its *Long-Term Energy Supply and Demand Outlook*, expects natural gas demand to increase by 4% between 2000 and 2010 in the Base Case and by 5% in the Policy Case. Uncertainties in the future of the nuclear programme may, however, further increase gas demand in the coming years.

Some 44.4 Mtoe (69%) of natural gas is used for power generation. TFC of gas has grown by 39% since 1990 reaching 20.4 Mtoe in 2001 (see Figure 17). The industry accounts for 41% of TFC of gas and the rest is used in the household, services and other sectors. Despite its rapid growth, natural gas is still available only in about 5% of the whole country and 21% in city areas. The number of gas users has been gradually increasing from 22 million in 1990 to over 26 million (about 55% of all households) in 2001. Natural gas use in

16. Methane is formed by the decomposition of vegetable matter. When the temperature is low and the pressure high, methane combines with water to form methane hydrate which looks like dry ice. When brought to normal air pressure, the crystalline substance will provide about 170 times its original volume in gaseous methane.

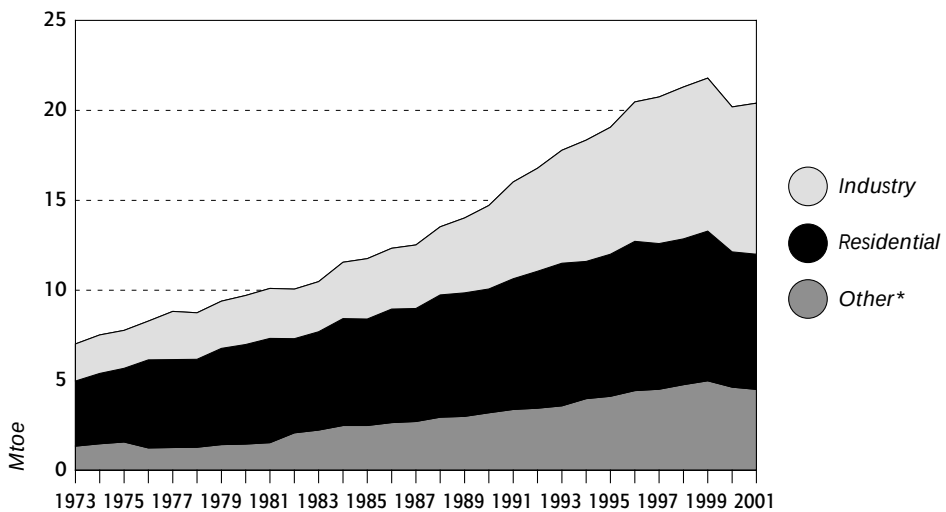
the transport sector is still limited but growing fast. In 2001, the number of natural gas vehicles exceeded 12 000 and the number of filling stations was about 180. However, little change is expected in the sectoral breakdown of gas demand by 2010.

The issue of seasonality of demand is less pronounced in Japan than in most other OECD countries as the ratio between gas sales in the peak and the lowest consuming months was 1.4 to 1 in 2000, whereas in most other countries the ratio is 2 or 3 to 1. There are two demand peaks in Japan: one in the winter for heating purposes and one in the summer for air-conditioning. The use of gas for air-conditioning has reduced the seasonality of gas demand. The number of gas air-conditioning units has increased from 36 000 in 1991 to 108 500 in 2000.

In addition to natural gas, other types of gas (coal-type gas and LPG) are distributed via the networks by the gas utilities. In the past, the share of other gases was larger but since the end of the 1970s, natural gas has had the major share. Today, about 88% of all city gas is natural gas whereas the share of LPG is 11% and the share of gas derived from coal is 1%; 57 utilities distribute only LNG, 15 both LNG and indigenous natural gas and the rest distribute only LPG or coal-type gas.

Figure 17

Final Consumption of Natural Gas by Sector, 1973 to 2001



* includes commercial, public service and agricultural sectors.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

NATURAL GAS SUPPLY

Most natural gas consumed in Japan is imported as LNG. Japan initiated LNG trade in the Asia-Pacific region in 1969 with its first imports coming from Alaska. The country has since become the world's largest LNG importer.

Because of its high import dependence, Japan has been seeking a secure and diverse supply. LNG comes from ten liquefaction plants in eight countries. LNG tanks at the regasification terminals provide relatively ample storage capacity. Although there are five underground gas storages in Japan, they are not connected to these LNG tanks. Some 40% of Japan's gas-fired power plants are multi-fired and can switch to other fuels, most commonly crude or fuel oil. Security of gas supply is discussed in more detail in Chapter 3.

Natural gas comes from diverse sources. In 2001, the import sources were Indonesia (30%), Malaysia (21%), Australia (14%), Qatar (12%), Brunei (11%), the United Arab Emirates (9%) and Alaska in the United States (2%). When the ExxonMobil's LNG plant in Arun in Sumatra (Indonesia) was closed for seven months in 2000 owing to political unrest, the second Indonesian LNG plant (Bontang) and the other East Asian suppliers made up for the deficit.

Natural gas imports are based on long-term take-or-pay contracts signed by gas and electricity industries. The role of spot LNG cargoes in gas supply has so far been very small, but an increasing, though not extensive, number is expected in the future. Supply contracts are typically for 20 to 25 years (see Table 14) and many of the existing contracts will have to be renegotiated in 2007-2011. The gas and electricity industries now consider long-term contracts too risky. Market liberalisation has had little impact on total gas demand but it has made it more difficult for each utility to forecast its own gas demand and market share because the future landscape of Japan's deregulated market is as yet unclear. Therefore, the utilities have been seeking more flexible and shorter contracts. Renewal of old contracts have often been for 10 to 15 years, whereas completely new ones are still mainly long-term contracts of 20 years. The trend for shorter contracts is expected to continue because many current LNG exporters to Japan have amortised their investments and are not required by the financial institutions to have rigid 20 to 25-year contracts.

Japan is looking into possibilities for importing natural gas from the Russian Far East. The two projects under consideration are the Sakhalin I Project importing pipeline gas, and the Sakhalin II Project importing LNG. Technical and economic studies of the Sakhalin I Project show that the pipeline gas project would be feasible. METI considers that imports from Russia will improve energy security through diversification of supply sources. The result of the feasibility of the Sakhalin pipeline project would exert downward pressure on LNG prices. The volume of gas carried by the pipeline project would be equivalent to 6 Mt of natural gas, which is about 11% of current national gas demand. Furthermore, prerequisites for the implementation of

Table 14

Long-term LNG Contracts

Supply source	*Import started (y/m)*	*Duration of contract*	*Contracted amount (thousand tonnes)*	*Importers*
Alaska	1969/11	1989–2004 (15 a)	1 300	TEPCO Tokyo Gas
Brunei	1972/12	1993–2013 (20 a)	6 010	TEPCO Tokyo Gas, Osaka Gas
Abu Dhabi	1977/5	1994–2019 (25 a)	4 300	TEPCO
Indonesia (Bontang)	1977/8	2000–2010 (11 a)	8 450	Chubu, Kansai and Kyushu Electric Power Companies, Toho Gas, Osaka Gas, Nippon Steel Corporation
Indonesia (Bontang)	1983/9	1983–2003 (20 a)	3 520	Chubu and Kansai Electric Power Companies
		2003–2011 (20 a)		Toho Gas, Osaka Gas
Indonesia (Arun)	1984/1	1984–2004 (21 a) 2005-2009 (5 a)	3 510 960	TEPCO, Tohoku Electric Power Company
Indonesia (Bontang)	1994/1	1994–2013 (20 a)	2 310	Tokyo Gas, Toho Gas, Osaka Gas
Indonesia (Bontang)	1996/3	1996–2015 (20 a)	390	Osaka Gas, Hiroshima Gas, Nihon Gas
Malaysia I	1983/2	1983–2003 (20 a) 2003–2018 (15 a)	7 600	TEPCO, Tokyo Gas
		1993–2013 (20 a)		Saibu Gas
Malaysia II	1995/6	1995–2015 (20 a)	3 360	Kansai Electric Power Company, Tokyo Gas, Toho Gas, Osaka Gas
		1996–2016 (20 a)		Tohoku Electric Power, Shizuoka Gas
		1997–2017 (20 a)		City of Sendai (Gas Bureau)
		1993–2013 (20 a)		Saibu Gas
Australia	1989/8	1989–2009 (20 a)	7 330	TEPCO, Chubu, Kansai, Chugoku and Kyushu Electric Power Companies, Tokyo Gas, Toho Gas, Osaka Gas
Qatar	1997/1	1997–2021 (25 a)	6 000	Chubu Electric Power Company
		1998–2021 (24 a)		Tokyo Gas, Toho Gas, Osaka Gas
		1999–2021 (23 a)		TEPCO, Tohoku, Kansai and Chugoku Electric Power Companies
Oman	2000/4	2000–2025 (25 a)	660	Osaka Gas
Total			**55 700**	

Source: METI.

Sakhalin I are enough volume of gas demand and improvement of the domestic pipeline network. The volume of Sakhalin II would be 4.8 to 9.6 Mt of LNG. Some gas and electric companies are reported to be planning to purchase LNG from Sakhalin II and exports could start by 2007.

Large LNG buyers aim to start using their own vessels for transportation to reduce supply costs through transparency of freight and to enable them to resell their own LNG rather than leaving that option solely to the discretion of the supplier. TEPCO is the largest LNG importer accounting for over 33% of Japan's total imports and is expected to have the first vessel operational in October 2003. By the end of 2006 TEPCO will have two vessels, Osaka Gas three vessels and Tokyo Gas will probably have four vessels.

SUPPLY SECURITY MEASURES

Japan has developed a series of measures providing insurance against supply interruptions in the gas sector:

- *Supply diversity:* Eight countries supply LNG to Japan. Individual Japanese companies generally have more than one supplier. Osaka Gas, for example, has six suppliers, under nine separate contracts.

- *Long-term contracts:* Suppliers and customers are interdependent and have a common interest in security of supply. They are linked by long-term contracts that have proved a stable basis for managing business in the past.

- *Modular supply systems:* Production and liquefaction plants include a number of separate units; several tankers are involved in each contract; most importing companies have more than one terminal; terminals have more than one jetty.

- *Supply flexibility.* Most supply contracts have from 5% to 10% flexibility either written into the contract or on a "best endeavours" basis.

- *Gas supply sharing:* Although there are few pipeline connections, a number of terminals are shared between gas and electricity companies. Furthermore, there is a high degree of standardisation of shipping capacity: extra supply available from a particular source can usually be transferred to another company that might be facing difficulties.

- *Fuel-switching:* 40% of gas-fired power generating capacity is dual-fired, with crude or fuel oil as the main alternative. Fuel-switching would pose few logistical problems as the sites are all coastal and have storage and handling capacity. This flexibility will decline somewhat in the future as new gas-fired generation will be mainly single-fired combined cycle gas turbine (CCGT) plants. For city gas contracts there is less flexibility. There are no

interruptible contracts as such. Only about 20% of larger city gas consumers – accounting for a small proportion of total demand – have dual-firing, and that proportion is declining.

- *SNG manufacture:* The capacity for manufacturing synthesised natural gas (SNG) from naphtha is around 1.4 Mt annually for city gas companies as a whole.

- *Storage:* Although Japan has little underground storage capacity, it has a large above-ground capacity (7.3 bcm) designed to cope with fluctuations in supply.

GAS INFRASTRUCTURE

The total length of the pipeline network is 215 800 km of which 0.7% are high-pressure pipelines (1 MPa or higher), 12.8% are medium-pressure pipelines and the remaining 86.5% are low-pressure pipelines (less than 0.1 MPa). The network consists of several local networks which have not been interconnected (see Figure 18) and most of the LNG is consumed close to the terminals.

The low and medium-pressure gas pipelines were extended by 34 000 km in 1990-2000 but the high-pressure networks only by about 420 km over the same period. The mountainous terrain and seismic instability make building pipelines expensive in Japan; the construction cost is ¥0.2 to 0.3 billion per km, which is 3-4 times more expensive than in most other countries.

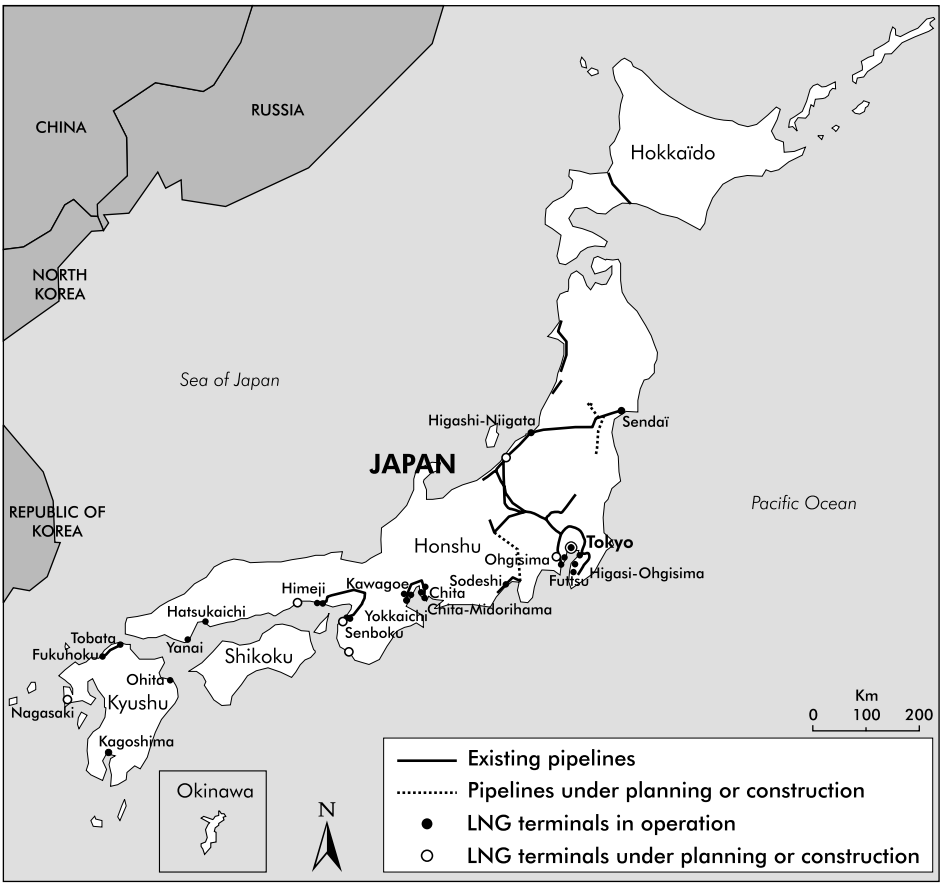
Japan has 24 regasification terminals for a total capacity of 614.2 mcm/day (224 bcm/year), which gives the country significant flexibility (see Table 15). Seven new terminals with a total capacity of 3.96 mcm are under construction or planned. Storage capacity is 12.2 mcm of LNG (equivalent to 7.3 bcm of gas), which is enormous in comparison to other LNG-importing countries, but this is the major means to store gas in Japan as there is no underground gas storage facilities. Many terminals serve specific power plants but some are shared between power and gas companies: 25% of terminal capacity is owned by gas utilities, 24% by power utilities, 32% jointly by gas and power utilities and 19% by other users.

PRICES

Japanese gas sales prices are by far the highest within IEA member countries for all consumer types (see Figure 19). One factor is the higher cost of LNG supply as compared to the cost of pipeline gas which most other countries are able to use. Another factor is the high cost of construction of natural gas infrastructures, which is partly explained by the country's terrain and seismic instability. Furthermore, the Japanese gas industry was not subject to

Figure 18

Natural Gas Infrastructure



Sources: *Natural Gas Information 2002*, IEA/OECD Paris, 2002; and METI.

competitive pressure in the past, which would have forced it to reduce prices by seeking possibilities to increase efficiency.

As most LNG supply contract prices are linked to the prices of crude oil imported into Japan, the user prices closely follow oil prices. Gas prices peaked in 1995, but declined thereafter together with world oil market prices and started to climb again in 1998 (see Figure 20). Price growth reached its peak again in 2000 and prices declined thereafter.

REGULATORY REFORM

The main legislation governing the gas sector is the Gas Utility Law. Initial steps towards competition have been gradually taken since March 1995 when

Table 15

LNG Import Terminals

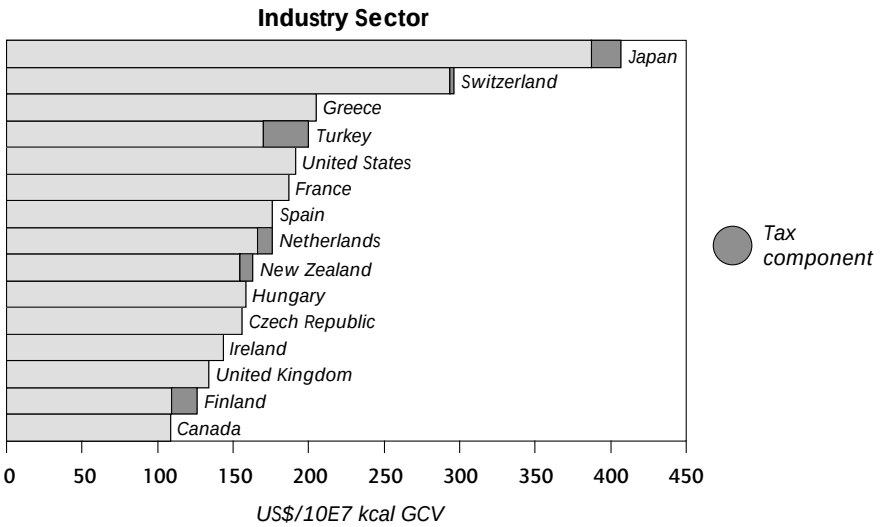
Terminal (ownership)s	*Storage tanks (1 000 cm of LNG)*	*Nominal capacity mcm/day*	*Start-up date*
Negishi (Gas and Electricity)	1 180	40.8	1969
Senboku I (Gas)	180	8.4	1972
Sodegaura (Gas and Electricity)	2 660	103.2	1973
Senboku II (Gas)	1 585	43.8	1977
Tobata (Electricity, etc.)	480	24.0	1977
Chita I (Gas and Electricity)	300	26.5	1977
Himeji I (Electricity)	520	30.6	1979
Chita II (Electricity and Gas)	640	40.6	1983
Higashi-Niigata (Electricity, etc.)	720	31.8	1984
Himeji II (Gas)	560	18.0	1984
Higashi-Ohgishima (Electricity)	540	62.9	1984
Futtsu (Electricity)	610	69.3	1985
Yokkaichi (Electricity)	320	27.7	1987
Yanai (Electricity)	480	8.2	1990
Oita (Electricity, etc.)	320	17.2	1990
Yokkaichi (Gas)	160	2.5	1991
Fukuoka (Gas)	70	2.2	1993
Hatsukaichi (Gas)	85	1.3	1996
Sodeshi (Gas, etc.)	177	3.0	1996
Kagoshima (Gas)	36	0.5	1996
Shin-Minato (Gas)	80	0.9	1997
Kawagoe (Electricity)	480	18.4	1997
Ohgishima I (Gas)	400	18.0	1998
Chita III (Gas)	200	14.3	2002
Total	**12 783**	**614.2**	

Source: METI (based on utility reports).

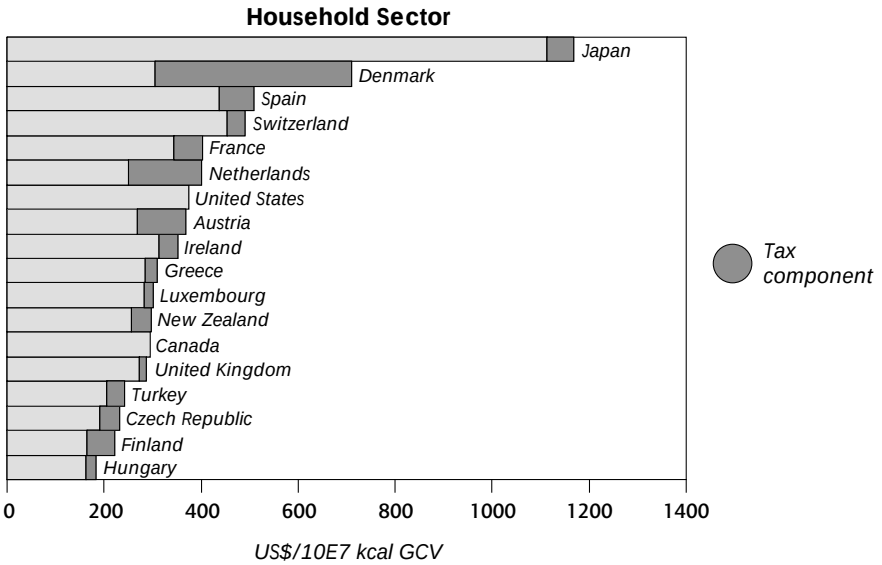
retail activities were partly liberalised after a revision of the law. At the time, consumers with at least 2 mcm annual gas demand were allowed to choose their supplier and freely negotiate the rates. In May 1999, the law was amended again to expand liberalisation to consumers with an annual demand of at least 1 mcm and to mandate third-party access (TPA) for retail purposes to the pipelines owned by the four largest gas utilities, namely Tokyo Gas, Osaka Gas, Toho Gas and Saibu Gas. Each of them is required by law to publish their terms, conditions and access rates on their Internet pages after

Figure 19

Gas Prices in IEA Countries, 2001



Note: Tax information is not available for Canada and the United States. Data not available for Australia, Austria, Belgium, Denmark, Germany, Italy, Korea, Luxembourg, Norway, Portugal and Sweden.

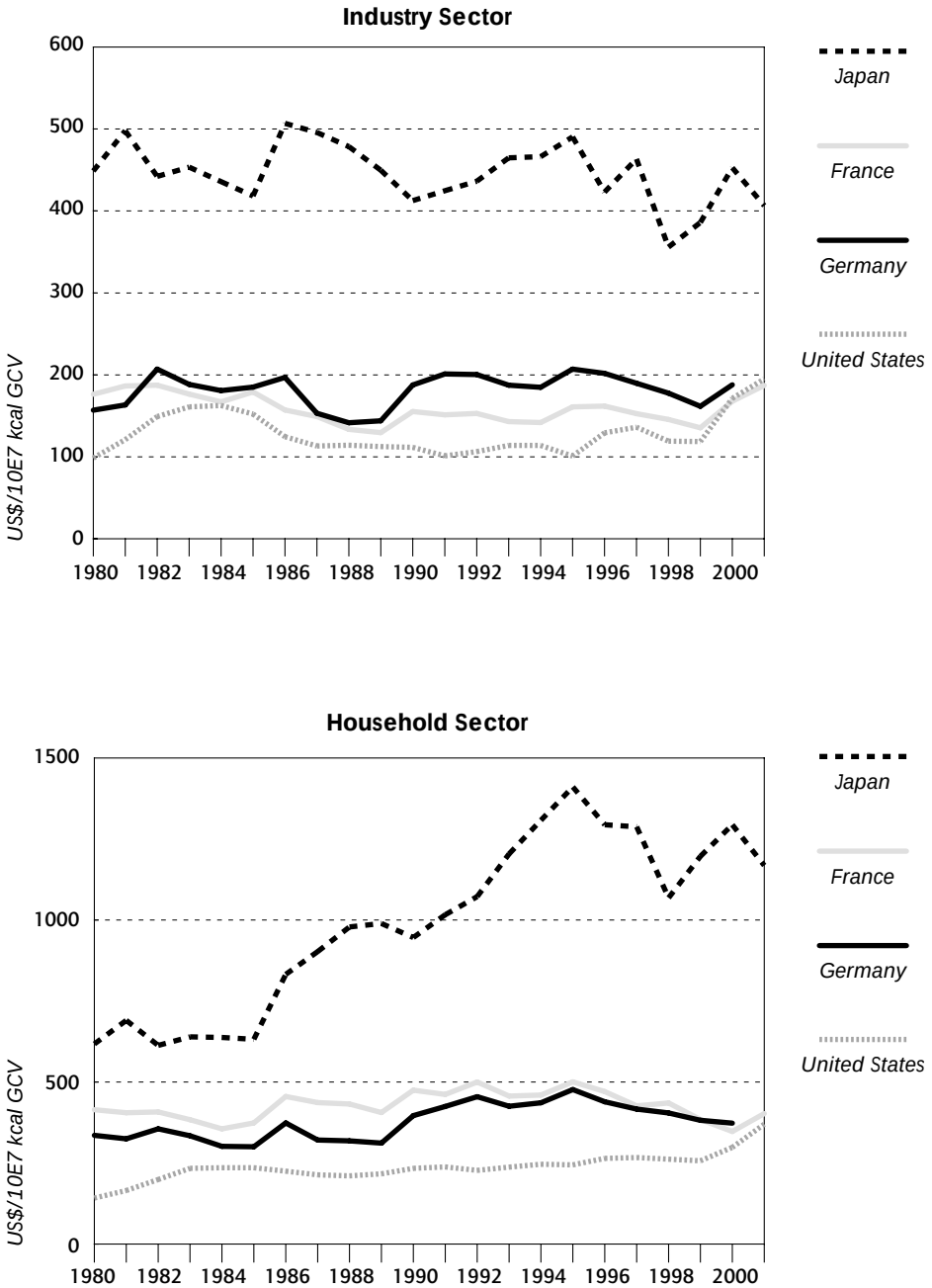


Note: Tax information is not available for Canada and the United States. Data not available for Australia, Belgium, Germany, Italy, Korea, Norway, Portugal and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 20

Gas Prices in Japan and in Other Selected IEA Countries, 1980 to 2001



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

notification to the METI. The revision, which came into force in March 2000, increased the market opening to 37% of the total gas market in FY2000. METI has the role of regulatory authority in the gas market.

As a result of partial liberalisation, 11 new companies have entered the gas market, including TEPCO, Nippon Steel Corporation, Teikoku Oil and Mitsubishi Corporation. The volume of gas supplied by the new entrants accounted for 2% of total gas supplies to the liberalised market. As of May 2003, there was a total of 16 TPA cases. Liberalisation has also led to some price reductions by the incumbents to their captive consumers. For example, Tokyo Gas has lowered its prices by 5.2% since November 1999 and Osaka Gas by 8.7% since January 1999. Furthermore, in addition to "gas-to-gas" competition, new forms of competition, for example between gas and electricity and gas and petroleum, have developed in the commercial and industry sectors.

The unofficial Study Group on Gas Market Reform was established by METI in January 2001 to consider the direction of further regulatory reforms of the gas sector. The April 2002 report of the Study Group recommended that mandatory TPA should be expanded to all pipelines, negotiated TPA to LNG terminals should be promoted and market access should be expanded to smaller gas users.

After the Study Group findings, the government established the Urban Heat Energy Subcommittee in September 2002 to examine and make concrete recommendations for a future regulatory framework for gas. The subcommittee consisted of 20 members representing academia, consumers and the gas industry, including new entrants. The subcommittee recommendations, published on 20 February 2003, addressed the need to develop an efficient infrastructure for gas supplies and to promote its effective use as well as extending market liberalisation to smaller consumers.

The proposed regulation stipulates regulated TPA to all gas pipelines. It also promotes negotiated TPA to LNG terminals but will not establish a TPA obligation. Pipeline owners will be obliged to prepare standard TPA contracts and notify the conditions to METI. Also, general guidelines for negotiated TPA to LNG terminals have to be published by the terminal owners. Account unbundling of transmission and distribution operations from other activities will be required and abusive behaviour forbidden. Non-gas utilities will have equal possibilities and conditions for constructing gas pipelines as gas utilities. To provide incentives to construct new pipelines, the subcommittee proposed to exempt owners of new pipelines from notification and publication of terms, rates, and conditions for TPA and to accept higher rates of return in setting TPA tariffs for a certain period of time.

The subcommittee recommended the market access threshold to be lowered to 0.5 mcm in 2004 (equivalent to 44% market opening) and to 0.1 mcm in

2007 (equivalent to 50% market opening). Market opening for all consumers would be determined after an evaluation of the success in market liberalisation for larger consumers, the prevailing gas supply situation, the status of market reform in other energy sectors and international experience in gas market liberalisation. TPA regulation would also cover network access for wholesale purposes, whereas now it is limited only for retail purposes. Under existing legislation, gas companies are required to obtain approval from the METI if they want to acquire a client from the supply area of another gas company but the subcommittee's recommendation is to move from the *ex ante* permission process to the *ex post* notification obligation. However, the METI reserves the possibility to give an administrative order after the notification if it considers that the transaction has a significant impact on prices for the captive consumers. On the basis of the subcommittee's proposal and its public consultation, the METI has recently presented the Diet an amendment of the Gas Utility Law to implement some parts of the proposal, and parts not included in the law will be implemented by government or METI ordinances or by guidelines issued by METI.

CRITIQUE

SECURITY OF FOSSIL FUELS SUPPLY

Because of its heavy dependence on imported fuels, Japan has always placed a great importance on measures to enhance the security of fuel supply. Though market operators are free to choose their supply sources and negotiate their contracts, the government has had an important role in creating favourable conditions to support the development and procurement of oil and natural gas, and, more recently, procurement of coal from new sources. Coal and gas are purchased from well-diversified sources. However, a new challenge following market liberalisation will be to ensure adequate diversification of gas sources. It is of grave concern that the dependence on Middle East oil has been increasing since the mid-1980s and has reached 89% – much higher than the level at the time of the first oil crisis. However, diversification of oil supply sources is not an easy task. The development of oil supplies via a pipeline from Russia – a long-term strategic project discussed between the Japanese and Russian governments – could help to reduce dependence on the Middle East. As dependence on the Middle East cannot be reduced in the short term, it is essential to enhance relations with Middle East producer countries and promote a producer-consumer dialogue. In this context, Japan's initiative to host the 8th International Energy Forum in 2002 is commendable.

JNOC has played an active role in implementing policies to address security of supply. As effective stockpile management is a necessity in ensuring energy security, a smooth transition should be ensured when JNOC is dissolved and its successor established. The Japanese policy to support overseas exploration

of gas and oil by Japanese companies has made some contribution to energy security as crude oil supplies from these sources account for 11.5% of the total. Therefore, exploration activities, and associated R&D efforts, should not be jeopardised by the dissolution of JNOC. In addition, cost-effectiveness of such activities should be maximised.

OIL

The downside of Japan's oil exploration policies has been their high cost. Output volumes of oil from Japanese overseas projects are considerable but comprise less than half of the targets set for 2000. Over the years, JNOC has given numerous loans to Japanese exploration firms. However, some of them have proved to be bad ones owing to poorer-than-expected results. Generous subsidies for exploration may have discouraged exploration firms from seeking high rates of return for their investments. In this context, it is positive that the government has taken the initiative to evaluate and streamline its various support schemes with a view to maximising their cost-effectiveness. This should become a continuous process. To ensure compatibility with energy market liberalisation, JNOC's successor should be structured along conventional corporate lines with no government intervention in its management. The government should also concentrate all financing for exploration to this company and avoid direct involvement in investment decisions or other operations.

Although the companies receiving government assistance are assumed to supply Japan, there is no formal obligation to do so. This is sensible under a normal supply situation because strict requirements could lead to high supply costs, for example for logistic reasons. However, the government should consider what measures it could take to ensure that oil found abroad is supplied to Japan during emergency periods.

It is commendable that oil markets have been fully liberalised. As a consequence, competition has started to develop as reflected in the changes in industry structure and in some oil product price reductions. However, there is still considerable room to increase the efficiency of the oil sector through competition both at the wholesale and retail levels. The relatively lower operational ratio of refining capacities, low sales volume per service station and the low number of self-service stations are examples.

The government should encourage the refining industry to further rationalise its operations as compared to the development of demand. The tightening environmental regulations will also affect industry's decision as to which facilities are to be closed, and which facilities are to be upgraded with necessary investments. At the moment, the government is considering the establishment of tighter environmental requirements for transport fuels. Given the investments needed to implement these, and the reorganisation process in

the refining industry, the government should establish these requirements with adequate lead times to avoid regulatory uncertainty.

Competitive pressure in the oil sector has led to the formation of four major alliance groups in the refining industry. Furthermore, in recent years, alliances between companies belonging to different groups are also emerging. While this is a movement aimed at developing stronger oil industries which can compete in the international market, care should be taken that this would not hamper effective competition, or result in excessive market power, in the Japanese market.

There has been a reduction in the number of filling stations, but experience in other countries suggests that a further reduction in the number of retail outlets can be expected. The recent increase in self-service facilities will intensify competition, which will lead to a further reduction in the number of retail outlets. It is commendable that the self-service facilities have been allowed to enter into the market as a mean to broaden consumer choice. They can exert downward pressure on the prices in the distribution market thanks to a favourable cost structure. Intensified competition and diverse demand from consumers have led to further business diversification in this sector by incorporating and improving other concepts and business tools such as car maintenance facilities, convenience stores and the introduction of sophisticated point-of-sale systems.

COAL

The development of the Japanese coal market has been quite different from that in Europe. Whereas coal demand in Europe has been decreasing for more than a decade, it has been increasing in Japan, particularly for power generation because of its relatively lower price. Coal is also seen to contribute to the diversification of the energy mix. Japan is highly dependent on imported energies and coal should therefore be part of a balanced energy mix. Since there is some uncertainty over the extent to which generation from nuclear power can be increased, the role of other fuels in power generation may grow. The high cost of LNG and the uncertainties with respect to pipeline supply of gas (see the section on natural gas) may expand the use of coal in the liberalised power market.

In the course of market liberalisation, power plant developers have shown significant interest in increasing the use of coal in power generation. While coal has advantages in terms of cost and security of supply, these need to be balanced with environmental objectives, such as addressing climate change concerns and pollutant emissions.

Coal makes a significant contribution to Japanese energy supply. It accounted for 18% of TPES in 2000. A sizeable proportion of Japan's energy needs for

the foreseeable future – well beyond 2010 – will be met by coal. Therefore, a widespread introduction of clean coal technologies (CCTs) would be necessary to achieve energy efficiency savings, to avoid air pollution problems caused by conventional coal plants and even to contribute to the GHG emissions target. Japan has been in the forefront of the development of CCTs over the past decade and should be well placed to implement their commercial introduction. The cost of CCTs is higher than that of conventional alternatives. Therefore, measures may be needed to encourage the market deployment of this technology. This could be addressed by similar market-based incentives such as those given to the development and commercialisation of renewable energy technologies, *i.e.* accelerated depreciation or tax rebates. Long-term investment in CCTs also requires stability in the environmental and other regulatory framework.

Coal is one of the few indigenous energy sources in Japan. However, its high production cost prevents it from competing with imported coal. Japan should be highly commended for its success in phasing out its uneconomic domestic coal industry without major social consequences. This has been possible thanks to considerable restructuring and business diversification efforts by the government. The phase-out should also not raise any security of supply concerns as the international market in hard coal is well established and offers secure and reliable sources of fuel at prices that Japanese national production cannot match.

The electricity market liberalisation is also changing the nature of coal trade because generators need to reduce fuel costs to remain competitive. The share of China as a supply source has been increasing rapidly owing to its competitive prices resulting from low production and transportation costs. In comparison, imports from Australia have been stabilising and from Canada declining. The need to reduce fuel costs can also increase spot purchases of coal.

NATURAL GAS

The Japanese gas market is unique compared with other IEA countries. It can be seen as a developing market which has not reached full maturity in some of its segments. Most of the gas used is imported LNG and there are no natural gas import pipelines. The gas networks are not interconnected and they cover only a fraction of the urban areas. Also the large, though decreasing, share of LPG in total gas supply is unique within IEA member countries. Another exceptional feature is the extremely high gas prices, explained in part by the high supply cost of LNG and high costs of building pipelines due to geographical and safety considerations.

The government expects natural gas to play a greater role in the future energy mix for three reasons. First, natural gas can contribute to energy security

because there are abundant natural gas reserves in the Asia-Pacific and Russian Far East. Expansion of gas imports from these regions could contribute to a reduction of Japan's dependence on Middle East supplies. Second, it can contribute to environmental protection goals because of its lower emissions of CO_2, NO_x and SO_x compared to other fuels. Third, natural gas can be used in new technologies such as micro-gas turbines and fuel cells, which would substantially expand the scope of natural gas usage and also contribute to energy security and environmental protection.

However, there are many challenges in expanding natural gas use. The first is the very high price of natural gas. One factor is the price link to crude oil prices which is a characteristic of Asian countries, including Japan. While long-term take-or-pay contracts of LNG imports have been contributing to security of supply, they reduce the liquidity and possibilities to seek cheaper gas sources (*e.g.* purchases from spot markets), should they emerge. Gas and electricity utilities are finding it more difficult to enter into rigid long-term take-or-pay contracts partly because of the uncertainty of future gas demand and, therefore, future contracts are likely to be more flexible and somewhat shorter. However, in order to reduce natural gas prices, Japan will need to have more bargaining power. Reduction of construction and maintenance costs of natural gas infrastructures is also essential to ensure competitive prices.

The Sakhalin projects present an interesting opportunity to diversify gas sources in the long term. However, uncertainties exist about the cost of pipeline gas and the future development of gas demand. Some of the expiring long-term contracts have already been renewed while others are in the process of being renewed. Nearly all regional LNG suppliers have unused export capacity or expansion plans and they have better possibilities to enter into shorter contracts owing to depreciation of their assets. Under these circumstances it is not certain that there will be adequate demand for the new pipeline gas. On the other hand, uncertainties in the implementation of the nuclear programme could have an impact on gas demand for power generation in the future.

The second challenge is the development of the gas infrastructure, in particular pipeline networks. Pipeline infrastructure has been developed only around LNG power plants close to import bases and urban areas, thus limiting the use of gas. A domestic gas trunk network is also essential to link the widespread existing and potential new consumers to create aggregate demand necessary for the introduction of pipeline gas. An interconnected network could also enhance security of supply by providing more flexibility and help competition to develop. While the construction and management of a natural gas pipeline is primarily the responsibility of the private sector, the government could also play a role in improving the investment climate to reduce business risks, *i.e.* uncertain demand in the early stages of pipeline construction. Prudently, it is considering measures to create incentives for the development of gas networks. The proposed measures, such as granting an

exception for notification and publication of terms, rates and conditions for TPA or allowing higher profits for TPA for a certain amount of time, can have a positive impact on the willingness to invest. Reducing construction costs, which are several times higher than in Europe and North America, is also essential. While securing safety, the government also needs to re-examine the current safety regulation and standards, taking into account international experience and standards. In order to expand natural gas use in the transport sector, further expansion of natural gas filling stations should be promoted in locations where natural gas vehicles would bring environmental benefits compared with more traditional technologies.

Liberalisation of the natural gas market started in 1995 to lower prices for final consumers through greater competition. However, since then, little competition has developed, though some price reductions can be observed during the last few years. It is difficult to judge to what extent price reductions are the result of competition, and to what extent they have been caused by other factors such as the developments in oil prices and lower interest rates available in the financial markets. The government has recognised the need for further action and is proposing changes to the Gas Utility Law. The proposal addresses some shortcomings in the existing regulatory framework.

Effective unbundling can help to avoid situations where a vertically integrated transport company discriminates in favour of its own gas supply business. Unbundling also aims to ensure that costs are correctly allocated to the gas company's different activities, which is fundamental for efficient, cost-reflective pricing. Unbundling can take different forms. In ascending order, these are: accounting separation, functional separation, operational separation and divestiture. The choice is a matter of striking a balance between achieving greater competition and other energy policy objectives. For import-dependent countries with an underdeveloped gas network like Japan, a modest form of unbundling may be preferable in order to secure the conditions for investment and diversification. In this regard, the government proposal for account unbundling in the draft Gas Utility Law is a good starting point for fair and transparent market access while taking into account gas network development needs.

The market players are required to have advance approval by METI when they wish to acquire customers in the franchised areas of the incumbent gas utilities. The government justifies this by the need to protect the interests of the captive consumers. This involves investigating the impact of such transactions on the prices for captive consumers. This is a very heavy-handed approach with the potential to form a significant regulatory barrier. Therefore, the proposal to abolish the *ex ante* permission process is a positive step because it will accelerate market access procedures and reduce regulation costs. However, the *ex post* notification obligation also presents potential problems. The possibility for a government intervention by an administrative

order to stop or change new entrants' supply plans after a transaction has already taken place creates significant regulatory uncertainty. No other IEA country has implemented such an approach. Instead, countries often require that distributors acquire licences which are based on transparent and equal conditions for all players.

The government proposal is to promote negotiation between owners of LNG terminals and third-party users. In the absence of TPA obligations, it is not clear if terminal owners will have enough incentives to allow access to their terminals. As no cases have yet occurred, the government should closely observe the situation in TPA negotiation and effectiveness of the arrangement and not preclude further regulatory measures should access problems emerge.

The electricity and gas industries are becoming increasingly linked with each other because of diversification of businesses; for example, electric utilities have started gas distribution, and gas use for power generation is increasing. General competition law applies to both electricity and gas sectors excepting only those elements which have sector-specific rules. Consequently, it is essential to have effective communication between the competition authorities and gas and electricity regulators with clear demarcation of their functions. There is also typically some migration of regulatory knowledge from the electricity sector towards the gas sector. At present the METI plays the role of regulator of both sectors. Keeping the regulatory functions of the two sectors together brings some synergies and simplifies the communication processes and, hence, reduces the cost of regulation. Should electricity regulation be moved outside the METI in the future, this should also be implemented for gas regulation (see Chapter 9).

RECOMMENDATIONS

The government of Japan should:

- *Continue addressing security of fossil fuel supply by encouraging the procurement of fuels from diverse sources and creating favourable international relations.*
- *Ensure consistency with the energy security goals in setting up the new entity replacing Japan National Oil Corporation.*
- *Evaluate the cost-effectiveness of Japan National Oil Corporation's operations and take this into account in establishing its successor which should also function consistently with the competitive energy markets.*
- *Ensure real competition in the petroleum market and see to it that consolidation and mergers will not hamper it.*

- *Facilitate further restructuring of the refining and retailing sectors to improve efficiency.*
- *Encourage the commercial demonstration and deployment of advanced coal power plants that have higher efficiency and lower GHG emissions.*
- *Stimulate the development of trunk pipelines for natural gas.*
- *Introduce account unbundling between pipeline transmission/distribution of gas and other activities of gas companies.*
- *Reduce regulatory barriers for new entrants to acquire customers in franchised areas.*
- *Follow closely the effectiveness of efforts to promote third-party access to LNG terminals. If the measures are not adequate to ensure effective competition, consider implementing TPA obligation.*

NEW AND RENEWABLE ENERGY SOURCES

The Japanese government considers hydropower and geothermal energy as mature technologies. It calls other renewable energy sources and fuel cells "new energy". Fuel cells are discussed in Chapter 10.

SUPPLY

In 2001, energy from new and renewable sources (including large-scale hydro) amounted to 16.3 Mtoe and accounted for 3.2% of TPES. Some 7.2 Mtoe came from hydropower, 5.2 Mtoe from combustible renewables and wastes, 3 Mtoe from geothermal energy and 0.9 Mtoe from solar and wind power. Use of renewables increased by about 20% in absolute terms but their share in TPES remained at roughly the 1990 level.

Electricity generation from renewables declined by 6.6% in 1990-2001, the main reason being an annual variation in hydropower generation. Gross electricity generation (excluding pumped storage) from renewables totalled 101 TWh in 2001, accounting for 10% of total generation. Hydropower is by far the most common source, with 84% share of total generation from renewables, followed by solid biomass (7%), municipal solid waste (5%), geothermal energy (3%), industrial waste (0.3%) and wind power and photovoltaics (PV) (0.3%).

At the end of 2001, the total hydropower generation capacity was 46 400 MW (of which pumped storage accounted for 24 300 MW). The generating capacity from solid biomass was 1 600 MW, municipal solid waste 1 500 MW, geothermal 533 MW, PV 452 MW and wind 175 MW.

Some 7.5 GW of hydropower capacity is under construction and 5.9 GW is in the planning stage. Most of these plants are pumped storage plants and only 1 GW is conventional hydropower over numerous small sites. Japan has nearly exhausted sites for construction of conventional large-scale hydropower plants. In recent years, special emphasis has been placed on the development of large-scale pumped storage systems to handle peak load, improving the stability of the nation's electric power supply. TEPCO's Kazunogawa plant, which began operation in June 2000, has the highest effective head (714 m) of any pumped storage hydroelectric plant in the world.

Japan produced 52 Mt of municipal solid waste and 406 Mt of industrial solid waste in FY2000; 77% of municipal solid waste and 3.4% of industrial solid waste was incinerated; 93% (incineration capacity base) of the incineration

facilities for municipal solid waste have heat recovery and power generation capability. Low-temperature combustion during waste incineration is the cause of over 90% of all dioxin emissions. The government is addressing this issue by developing high-temperature combustion incineration plants.

The total capacity of Japan's 15 geothermal power plants was 533 MW at the end of FY2000. A number of electric power companies (EPCos) operate 12 plants with a total capacity of 497 MW. The capacity factor of geothermal power plants was 72% in FY2000.

Wind power plants have been developed in over 100 locations. Low wind speeds in many easily accessible areas limit the possibilities to expand the use of wind power. The seasonal variation in wind speed is counter-cyclical with peak demand. The strongest winds are in winter while peak demand is in summer. The seabed generally shelves quite steeply, limiting the possibilities for offshore wind power. Onshore wind power generation is limited for a variety of reasons, including intermittency, high cost and difficulties in achieving planning permission because of visual intrusion. However, the Ministry of Environment has recently announced plans to permit construction of wind power facilities in national parks. Power distribution grids, into which wind capacity needs to be supplied, are in many cases not strong, particularly on the north island of Hokkaido which has the greatest potential for wind applications. Weaker grids are limited in their ability to accept the intermittence of wind energy because of its impact on the fluctuation of voltage and frequency. Therefore, the Hokkaido Electric Power Company has announced that it will limit the access of wind power to its networks at 250 MW and the Tohoku Electric Power Company at 470 MW[17].

Japan is the second-largest producer of solar power in the world and the largest of PV power. Situated between latitudes of 24°N and 46°N, Japan has a moderate to good solar resource. For power generation, the peak supply from PV correlates with peak demand. In 2002, Japan's manufacturing capacity for PV systems was 250 MW. Major house builders are working closely with PV manufacturers to better integrate PV systems into building designs. At the end of FY2001, about 81 000 homes had solar cell panels installed and the number was expected to increase to 100 000 by the end of FY2002. The use of solar heat soared in the 1980s following the second oil crisis.

COST-COMPETITIVENESS

High cost is the most fundamental impediment for wider penetration of new and renewable forms of energy. Those closer to market deployment – because of their

17. For comparison, total generating capacity of the Hokkaido EPCo was 5 936 MW and the Tohoku EPCo was 15 221 MW in March 2001.

relatively lower cost – are municipal solid waste, agricultural waste and wind power.

Increased installed capacity has resulted in a significant decline in the cost of electricity generated by PV from ¥260 per kWh in 1993 to ¥66 per kWh in 1999. Nevertheless, PV for residential use still cost three times compared with electricity tariffs charged by utilities. The METI projects a price reduction for domestic PV systems from around ¥0.8 million per kW in 2000 down to ¥0.3 to 0.4 million per kW by the second half of this decade, yielding electric power at ¥25 to 30 per kWh. This price is comparable with the present power retail prices for households. The cost of solar heaters is ¥0.3 million and the price of house PV systems (including 6 m^2 of panels) is ¥0.9 to 1 million.

While wind power is relatively competitive compared with solar energy, the cost of installed wind capacity in Japan is about 1.5 times the cost in Europe and the United States (US$ 1 million/MW). The cost of generation, ¥10 to 14 per kWh (US$ 0.10), is considerably higher than the US$ 0.04 to 0.06 which is average for comparable sites in Europe. The reasons for this are difficulties with site access, high cost of labour and civil work in Japan and the cost of land. Low wind speeds and more expensive maintenance (remote from manufacturers' bases) add to the cost. At present, collection and transportation costs hinder the competitiveness of biomass energy.

POLICY

The government considers hydropower and geothermal energy as mature technologies which do not need government support. It has been formulating policy and legislative frameworks to support "new energies" where cost competitiveness is still low, but the promotion of which will enhance energy security and climate change mitigation.

Prior to the introduction of new legislation in June 2002, the policy and legislative framework for new and renewable energies evolved through the following stages:

- In 1994, Japan adopted the "Basic Guideline for New Energy Introduction" as a Cabinet decision, setting out the government's position on new and renewable energy for the first time. The guideline called for government-wide efforts to introduce new and renewable energy at the national level, local efforts by local governments, and co-operation by private businesses and the general public.

- In May 1997, the Cabinet adopted an "Action Plan for the Reform and Creation of Economic Structures" to initiate structural reform of the Japanese economy. The Action Plan positioned new energy as one of the new industrial sectors with future growth potential, and described programmes for encouraging development and growth in this sector.

Table 16

Power Generation Cost of New and Renewable Energy Sources

Renewable energy	*Cost of power generation or heat use*	*Ratio of renewables cost to competitive energy cost*	*Competitive energy costs*
Photovoltaics, residential use	Average 66 ¥/kWh	3 : 1	Utilities' residential rate 23.2 ¥/kWh
		16.5 : 1	Fuel cost equivalent[1] 4.0 ¥/kWh
	Top-Runner 46 ¥/kWh	2 : 1	Utilities' residential rate 23.2 ¥/kWh
		11.5 : 1	Fuel cost equivalent 4.0 ¥/kWh
Photovoltaics, non-residential use	Average 73 ¥/kWh	3.5 : 1	Utilities' commercial rate 20.0 ¥/kWh
		18.3 : 1	Fuel cost equivalent 4.0 ¥/kWh
Wind power	Large scale 10-14 ¥/kWh	1.4-2 : 1	Thermal power price 7.3 ¥/kWh
		2.5-3.5 : 1	Fuel cost equivalent 4.0 ¥/kWh
	Small to medium scale 18-24 ¥/kWh	2.5-3 : 1	Thermal power price 7.3 ¥/kWh
		4.5-6 : 1	Fuel cost equivalent 4.0 ¥/kWh
Waste	Large scale 9-11 ¥/kWh	1.2-1.5 : 1	Thermal power price 7.3 ¥/kWh
	Small to medium scale 11-12 ¥/kWh	1.5 : 1	
Fuel cell (phosphoric acid fuel cell)	22 ¥/kWh[2]	1.1 : 1	Utilities' commercial rate 20.0 ¥/kWh
Geothermal	16 ¥/kWh		
Solar thermal system	28 ¥/Mcal	1-3 : 1	9.0-27.3 ¥/Mcal[3]
"Untapped energy sources"[4]	10 ¥/MJ	1.1 : 1	Heat supply cost (using gas or kerosene) 9 ¥/MJ

1. "Fuel cost equivalent" (¥4.0 per kWh) represents the avoided cost, which utilities can save by purchasing wind and solar power. Because of the intermittent nature of solar and wind power, utilities find their value only in avoided cost.
2. This figure takes into account the cost saved by recovering and using waste heat.
3. The competitive energy costs for solar thermal systems represent the costs of hot water supply (¥9.0 per kWh), city gas (¥18.5 per kWh) and LPG (¥27.3 per kWh).
4. This includes thermal energy conversion using seawater, river water, etc., heat utilisation from waste incineration, and storing ice and snow during winter to store agricultural products during the summer or for air-conditioning.

Source: METI.

- As a consequence, the Law Concerning the Promotion of the Use of New Energies was enacted in June 1997 to provide a framework encouraging the introduction of new and renewable energy. The law clarified the role of various entities such as end-users and the government, and incorporated financial assistance measures. Under this law, such renewable energies as PV, wind power, solar heat, thermal energy conversion, waste power, waste heat were defined as "new energy". This law also covered new forms of energy utilisation such as fuel cells, natural gas vehicles and natural gas co-generation.

In June 2001, the New and Renewable Energy Subcommittee (set up under the Advisory Committee for Natural Resources and Energy) projected a potential increase in the use of renewable energy up to 2010 under two case scenarios. The Base Case assumes the continuation of the suite of policies in place in 2001, leading to an increase in the share of new energies in TPES from 1.2% in 2000 to only 1.4% in 2010. The Policy Case assumes that new aggressive policies will be put in place and the share of new energies would climb to 3% of TPES in 2010.

The most significant additional policy is the introduction of a portfolio standard for renewable generation in the electricity market. In June 2002, the Diet adopted the Law Concerning the Promotion of the Use of New Energy by Electric Power Suppliers. The law introduced a portfolio standard, *i.e.* electric power retailers are required to obtain a certain percentage of their sales from new energy sources. The law aims at promoting capital investment in new energy sources through mandatory expansion of their market with a view to climate change mitigation and fuel diversification.

According to the portfolio standard, retailers are obliged to acquire around 1.35% of their sales volume from new energy sources in 2010. The specified sources are solar power, wind power, small and medium-sized hydropower (< 1 MW and without a dam), geothermal energy using vapour recycling technologies, biomass and organic waste. The scheme is estimated to increase generation from such sources from 3.28 TWh in FY2003 to 12.2 TWh in FY2010. The government estimates that the growth of individual renewable sources will follow the estimated potentials presented under the Policy Case in Table 17. The retailers will have three options to fulfil the obligation: 1) produce from their own generation, 2) buy green electricity from other companies that generate electricity from renewables, and 3) buy a part of the obligations fulfilled by other retailers in the form of transaction of "applicable amount of New Energy Electricity". The third alternative resembles the tradable green certificate system introduced by other countries. The retailers need to conform with annual interim targets established by METI based on the starting level of each company, *i.e.* the initial percentage of renewable generation in their sales volume. Non-compliance with the interim

Table 17

New and Renewable Energy Prospects for FY2010

Energy	*FY2000*		*FY2010*				*2010/2000*
			Base Case		*Policy Case*		*increase*
	Crude oil equivalent	*Capacity MW*	*Crude oil equivalent*	*Capacity MW*	*Crude oil equivalent*	*Capacity MW*	
Photovoltaics	8.1	330	62	2 540	118	4 820	15-fold
Wind power	5.9	144	32	780	134	3 000	23-fold
Waste (power generation)	115	1 030	208	1 750	552	4 170	5-fold
Biomass (power generation)	4.7	69	13	160	34	330	7-fold
Solar thermal energy	89	..	72	..	439	..	5-fold
"Untapped energy"[1]	4.5	..	9.3	..	58	..	13-fold
Thermal use of waste	4.5	..	4.4	..	14	..	3-fold
Thermal use of biomass	..	..	..	..	67	..	..
Black liquor, wood refuse, etc.	490	..	479	..	494	..	no increase
Total, new renewables (Share of TPES)	**722 (1.2%)**	**..**	**878 (1.4%)**	**..**	**1 910 (about 3%)**	**..**	**3-fold**
Hydropower	2 100		2 000		2 000		no increase
Geothermal energy	100		100		100		no increase

1. This includes storing ice and snow during winter to store agricultural products during the summer or for air-conditioning.

.. = Not available.

Source: METI.

and final targets will be subject to fines of up to ¥1 million. The scheme was launched in April 2003.

The budget for the promotion of new energy (¥144.9 billion for FY2002) has more than doubled over the past five years. This was ¥34.3 billion greater than the previous fiscal year (see Table 18), to boost existing programmes and measures to reduce costs through the process of technology learning. In addition, fiscal measures are in place to promote investment in renewable energy. Tax deductions or special depreciation allowances apply to the acquisition cost of new energy facilities. Local property taxes are also lower for new energy projects. The government intends to continue the measures outlined in Table 18 after the portfolio standard system is implemented.

Investment subsidies for new energy are not given to hydropower and geothermal power plants because they are considered to be competitive. Other technologies,

Table 18

Measures to Promote New and Renewable Energy Sources, FY2001 to FY2002

Phase	*Content*	*Projects*	*Budget FY2002 (FY 2001)*
Technology development	Development of technologies related to important development tasks for reducing the cost of new energy technologies and improving their performance.	• PV power generation projects (¥7.3 billion) • Wind power generation projects (¥650 million) • Fuel cells projects (¥19.5 billion) • Power generation from waste projects (¥600 million)	¥38.8 billion[1] (¥38.7 billion[1])
Demonstration	Based on the results of technological developments, demonstration tests will be carried out to identify, elucidate and address the problems that may impede the said technological development from being put to practical use and marketed. The objective of the tests will be to demonstrate and confirm the effectiveness of these technologies in actual use.	• Field tests on solar power generation for industrial use (¥4.5 billion) • Subsidies for the demonstration of PV power generation systems (concentrated power grid types) (¥100 million) • Field tests on advanced waste power generation (¥270 million) • Demonstration of solid polymer-type fuel cells (¥2.5 billion)	¥10 billion (¥5.3 billion)
Promotion of introduction	*Encouraging market independence* Try to create initial-stage demand for new energies that are on the threshold of being put to practical use, to encourage their prompt market independence through mass production.	• Support for the introduction of PV systems for household use (¥23.2 billion) • Support for the introduction of systems for households that use solar heat at advanced levels (¥6 billion) • Support for the introduction of clean energy motor cars (¥17 billion)	¥96.1 billion (¥66.6 billion)
	Advanced businesses Support for enterprises and municipalities in their efforts to introduce new advanced energies and encourage the extensive use of similar projects.	• Projects such as the drawing-up of visions related to new energy in the region (¥12.7 billion)	
	Grassroots activity Provide assistance to projects that promote the introduction of new energy carried out by NGOs and other entities, to accelerate the use of new energy at the grassroots level.	• Projects to support regional activities to foster the use of new energy (¥880 million) • Projects to support regional activities related to new energy (¥140 million)	

1. Including fuel cells.
Source: METI.

such as PV and wind power, have received a significant amount of investment subsidies [18]. Investment subsidies for PV for household installations, however, will be reduced from ¥23.2 billion in FY2002 to ¥10.5 billion in FY2003. In addition to subsidies given by the government, prefectures, cities, towns and villages have implemented their own subsidy systems to complement national subsidies.

The general power utilities have been voluntarily buying electricity from renewables, such as PV and wind power at premium prices. For example, households with renewable systems that generate more electricity than they consume sell the surplus electricity to power companies at the same price as they buy electricity from the power companies. Together with government support, this voluntary purchase has made a large contribution to the penetration of renewable energies, in particular solar and wind. The government expects the introduction of the portfolio standard to encourage retailers to purchase all surplus electricity from renewables in the future.

CRITIQUE

The need to reduce greenhouse gas emissions and to increase the use of domestic energy sources has driven Japan's renewables policies for the last ten years. The indicative target to increase the use of new and renewable energies threefold between FY2000 and FY2010 is an ambitious one because under business-as-usual conditions they are estimated to increase by only 20% during this period.

Japan has put considerable effort into evaluating a wide range of potential new and renewable energy technologies to contribute to future energy supply and is now focusing its efforts, particularly R&D, on PV and fuel cells. The successful commercialisation of these technologies will depend on a wide range of efforts and incentives if they are to make a significant, rather than a token, contribution to policy objectives. Solving technological challenges related to transmission will be a prerequisite for wider use of wind power. It is necessary to explore how more renewable generation could be promoted without unduly compromising the reliability of the network system.

18. In FY2002, the subsidies paid to PV plants for residential use (output under 10 kW) were ¥0.1 million per kW which is equivalent to one-seventh of the installation cost. For larger PV plants with output above 50 kW, subsidies were one-third of the installation costs for enterprises and 50% for municipal entities. Subsidies for electricity generation from waste were 10% of the installation cost for plants with less than 15% efficiency and for more efficient plants, one-third of installation cost for enterprises and 50% for municipal entities. Subsidies paid to renewables plants such as wind and biomass were, in principle, one-third of installation cost for enterprises and 50% for municipal entities.

The most common policies to promote the use of renewable sources in IEA member countries are subsidised feed-in tariffs and portfolio standards. The portfolio standard chosen by Japan is a market-based approach which has the benefit of ensuring that a certain amount of power will be generated from renewable sources. It can also lead to lower total cost than feed-in tariffs because the projects with lowest cost will be implemented first. This generates competition between different renewable sources and projects. Its pitfall is that it maximises short-term benefits at the cost of the development of technologies and energies which may be more promising in the longer term. Therefore, the government should ensure that these potentially interesting technologies are promoted by other means. One key policy to support new technologies is enhanced R&D, including funding for demonstration. Another is the declining subsidies given to PV until its cost reaches about US$ 3 per peak watt. The IEA estimates this will happen around 2007 if promotion efforts of PV remain at the current global level. This price level would still be higher than the price of competing energies but it is also generally considered to be the price level at which PV would be a cost-efficient choice for large-scale markets. The Japanese approach of declining subsidies incorporates the lessons of technology learning and, hence, works well with the market. Nevertheless, care should be taken to avoid excessive cost burden on the taxpayers and consumers by such additional measures.

Some issues need to be considered and monitored to ensure the effectiveness of the portfolio standard. For example, consideration should be given to the appropriate level of penalties so that there is a strong incentive to comply but without leading to an unreasonable financial burden. At the moment only a few companies are subject to the portfolio standard. However, if the number of market players increases, it will be necessary to ensure that there are mechanisms in place to help retailers find renewable energy supply sources. At the moment there is relatively little practical experience internationally in the functioning and effectiveness of portfolio standards.

To date, electric power companies have purchased electricity produced from renewables at preferential tariffs to avoid regulatory measures. In heavily regulated markets they have been able to recover the additional cost. However, following partial market liberalisation, such a voluntary approach may become impossible as it is at odds with the objective of improved economic efficiency. Also the introduction of the portfolio standard may diminish motivation for voluntary action and force utilities to look for the most economical renewables. This could mean that some generators of renewable electricity, particularly small generators such as PV systems in buildings, may find it difficult to market their surplus power or that there will be downward pressure on prices.

Similar favourable treatment as given to nuclear may be necessary to encourage market uptake of renewables. Special consideration is given to nuclear power

in liberalised electricity markets, such as the planned preferential access to transmission capacity when capacity is constrained. Nuclear power also enjoys better possibilities for acquiring necessary planning permits. The opposite appears to be happening for intermittent renewables as intermittency is perceived as meaning there is no capacity value. Improvements in wind forecasting may enhance the ability to plan around the availability of intermittent wind resources. Access to day-ahead and other electricity markets based on their ability to deliver a secure supply would provide improved market opportunities for wind. Further, integration of intermittent energy sources with energy storage systems such as pumped hydro or compressed air energy storage could be explored but are expensive options.

RECOMMENDATIONS

The government of Japan should:

- *Review in due time the implementation of the renewables portfolio standard to ascertain its effectiveness and what further measures may need to be taken.*
- *Taking account of their potential energy security and GHG benefits, ensure renewables have access to the grid as envisioned for nuclear power.*

NUCLEAR ENERGY PRODUCTION

The Japanese government strongly supports nuclear energy on the basis of stability of fuel supply, zero greenhouse gas emissions, fuel prices and economic performance.

In April 2002, the country's installed gross nuclear generating capacity in commercial nuclear plants was 45.7 GW. This comprised 27 boiling water reactors (BWRs), 2 advanced boiling water reactors (ABWRs), and 23 pressurised water reactors (PWRs). Gross generation was 320 TWh in FY2001 [19], which was 31% of the total. The average plant availability was around 80% over recent years, but for 2002, availability is estimated at 72% because of closures of some units for safety inspections. The commercial water-cooled reactors are owned by 9 private utility companies and one other company, which is a producer and wholesaler of nuclear-generated electricity.

In addition, two prototype reactors, one advanced thermal reactor (ATR) and one fast breeder reactor (FBR), have been built. They are owned and operated by Japan Nuclear Fuel Cycle Development Institute (JNC). The ATR, however, terminated its operations in March 2003.

The commercial plants have mainly been supplied by Toshiba, Hitachi and GE (BWRs), and by Mitsubishi and Westinghouse (PWRs). At the end of 2002, the average age of Japanese plants was about 19 years. Plant life will be determined on an economic and safety basis taking into account the costs of maintaining safety standards. Equivalent plants in the United States are currently expected to operate for 60 years.

In recent years, nuclear power plant operations in Japan have been marred by safety-related incidents, both at generating and fuel manufacturing plant sites. The most notable of these have been:

- Since 1995, the operation of the prototype FBR (Monju) was suspended following a sodium leakage. In December 2002, the METI gave JNC permission to build installations preventing sodium leakage. However, in January 2003, the Japanese High Court overruled this decision and METI issued an appeal to the Supreme Court in March 2003.
- The death of two workers resulting from an accident at the Tokai Mura fuel facility in 1999. Other workers and many residents nearby were exposed to radiation.

19. All nuclear statistics in Japan are published for fiscal years.

Table 19

Commercial Nuclear Power Plants in Operation on 31 March 2002

Company	*Facility*	*Type*	*Gross capacity MW*
JAPC	Tokai II	BWR	1 100
	Tsuruga – 2 units	BWR, PWR	1 517
Hokkaido EPCo	Tomari – 2 units	PWR	1 158
Tohoku EPCo	Onagawa – 3 units	BWR	2 174
Tokyo EPCo	Fukushima I – 6 units	BWR	4 696
	Fukushima II – 4 units	BWR	4 400
	Kashiwazaki-Kariwa - 7 units	5 x BWR, 2 x ABWR	8 212
Chubu EPCo	Hamaoka – 4 units	BWR	3 617
Hokuriku EPCo	Shika	BWR	540
Kansai EPCo	Mihama – 3 units	PWR	1 666
	Takahama – 4 units	PWR	3 392
	Ohi – 4 units	PWR	4 710
Chugoku EPCo	Shimane – 2 units	BWR	1 280
Shikoku EPCo	Ikata – 3 units	PWR	2 022
Kyushu EPCo	Genkai – 4 units	PWR	3 478
	Sendai – 2 units	PWR	1 780
Total	**52 units**	**23 x PWR, 27 x BWR, 2 x ABWR**	**45 742**

Source: The Federation of Electric Power Companies.

- Falsification of technical records of plutonium/uranium-mixed oxide fuel (MOX) for Japan by United Kingdom's BNFL in 1999. All fuel has since been returned to BNFL. No MOX fuel has yet been loaded in Japanese reactors.

- Falsification of TEPCO's nuclear plant testing records was revealed in August 2002. The suppression of recent plant inspection records was also made public. As a consequence, significant outages of TEPCO's 17 nuclear plants took place in 2002-2003 to repeat key safety-related tests. As a result, Japanese nuclear plant availability will likely decrease in 2002-2003 (see box).

These events have undermined Japanese public confidence in nuclear energy. There is also a political sensitivity to nuclear energy, reflecting the interaction between the national government responsible for broad energy policy and safety regulations and local governments which coexist and have a veto over nuclear plant operations.

The Falsification of Plant Testing Reports

The investigation into the falsification of plant testing reports began in July 2000 when the fact was reported to METI by a TEPCO employee. In August 2002, TEPCO admitted that there was a total of 29 suspected falsification cases at 13 nuclear power units and subsequent investigations revealed 16 such cases at 9 nuclear units. The authorities initiated their investigations, but also concluded that the technical problems did not have immediate significant effects on safety.

In September 2002, the Nuclear and Industrial Safety Agency (NISA) was informed of the discovery of cracks and crack indications in the re-circulation piping of 12 units run by Chubu EPCo, Japan Atomic Power Company (JAPC), TEPCO and Tohoku EPCo. These cases are under review.

At one of TEPCO's Fukushima Daiichi units, compressed air was improperly injected into the containment vessel during a leak rate inspection conducted in 1991 and 1992. This was revealed on 25 October 2002. After examination, the NISA issued an administrative order closing down the unit for one year to permit a detailed inspection.

By mid-April 2003, TEPCO had closed all its 17 reactors to carry out pressure tests, either for periodic inspections (8 units) or for voluntary checks (9 units). Replacement power is provided by oil-fired reserve power plants as well as from increasing the use of LNG and imports from other utilities. TEPCO has also been advising consumers to save electricity. The closures have made the demand-supply situation tight as the reserve margin fell to 3% during winter. By 27 August 2003, six units had been reopened and two were to be reopened subject to public acceptance after having successfully passed inspections. However, it was not clear when TEPCO would be able to reopen other units. This will depend on the results of inspections, the implications of suspected cracks with respect to licensing conditions and ultimately on the consent of local governments to restart.

The government has taken action following the discovery of the falsification of reports. A decision has been taken to reinforce the work of NISA with an independent organisation, the Japan Nuclear Energy Safety Organisation (JNES), which will strengthen the implementation of safety regulations. In addition, the government will replace the voluntary periodical self-inspections carried out by nuclear power operators by mandatory ones. Penalties for misconduct will be increased and the operators will be required to establish quality management systems. Safety regulations will also be clarified.

Sources: *Status Report Countermeasures against Falsification Related to Inspections at Nuclear Power Stations,* NISA, 10 December 2002; and METI.

FUTURE NUCLEAR GENERATION

According to Japan's *Long-term Energy Supply and Demand Outlook* published in 2001, nuclear generation is targeted to increase by approximately 30% (*i.e.* by 97 TWh) between 2000 and 2010, requiring 10 to 13 additional units. If the load factor can be increased, fewer new units will be needed to achieve the target. One new nuclear plant was commissioned in 2002, three plants are currently under construction and nine more are planned. However, increasing capacity to meet the target is very challenging and may be delayed by the need to restore public confidence. According to the *Outline of Electric Power Supply Plan 2003*, the construction of the planned Ohma nuclear plant will be delayed for a year. In March 2003 the utilities announced delays in other nuclear projects. However, a large increase of nuclear generating capacity could also raise the prospect of the plants supplying other than base-load.

Electric utilities' managers think that the deregulation of the electricity market and the role of nuclear should be addressed simultaneously. In particular, they argue that the demarcation of responsibilities between the public and private sectors should be clarified in such fields as high-level radioactive waste disposal, MOX fuel fabrication and long-term nuclear liabilities. They believe the government should strongly announce its commitment to promoting these policies and provide appropriate support. To address such issues, the government plans to launch deliberations at its advisory council in the next two years on how to secure nuclear power generation in the liberalised electricity market.

The assessment conducted by METI in 1999 calculated the cost of a new nuclear power plant for baseload generation as ¥5.9 per kWh[20] (see Table 21). The costs of natural gas, coal and hydropower generation were ¥6.4, ¥6.5 and ¥13.6 per kWh, respectively.

GOVERNMENT RESPONSIBILITY FOR NUCLEAR ENERGY

The Atomic Energy Commission (AEC) is a statutory body under the Atomic Energy Basic Law (1955). It was set up by the Prime Minister's Office in January 1956 with the purpose of the democratic execution of national policy on research, development and use of nuclear energy. The AEC is authorised to plan, discuss and decide on a nationwide nuclear policy and development programme. This Long-Term Plan is renewed every five years. The Nuclear

20. Here a 3% discount rate is used, which is lower than the 10% discount rate used by other countries with liberalised markets (except for Finland, which applies a 5% discount rate). The accounting costs for utilities are somewhat higher (¥7-8 per kWh) reflecting, for example, capital investment amortisation rate.

Table 20

Nuclear Power Plants under Construction or Planning

Power plant	*Operator*	*Location*	*Capacity MW*	*Type*
Under construction				
Higashi-Dori No. 1	Tohoku EPCo	Aomori	1 100	BWR
Hamaoka No. 5	Chubu EPCo	Shizuoka	1 380	BWR
Shika No. 2	Hokuriku EPCo	Ishikawa	1 358	BWR
Under planning[1]				
Tomari No. 3	Hokkaido EPCo	Hokkaido	912	PWR
Ohma[2]	J Power	Aomori	1 383	BWR
Tsuruga No. 3&4	Japan Atomic Power Co.	Fukui	2 x 1 538	BWR
Shimane No. 3	Chugoku EPCo	Shimane	1 373	BWR
Kaminoseki No. 1&2	Chugoku EPCo	Yamaguchi	2 x 1 373	BWR
Others[3]				
Higashi-Dori No. 2	Tohoku EPCo	Aomori	1 325	BWR
Fukushima-Daiichi No. 7&8	TEPCO	Fukushima	2 x 1 380	BWR
Higashi-Dori No. 1&2	TEPCO	Aomori	2 x 1 380	BWR
Namie-Kodaka	Tohoku EPCo	Fukushima	825	BWR
Maki No. 1	Tohoku EPCo	Niigata	825	BWR
Suzu No. 1&2	Hokuriku EPCo	Ishikawa	2 x 1 350	BWR

1. "Under planning" means that the plants have been authorised under the National Programme.
2. Planned to use MOX in its full core.
3. "Others" means that the plants are planned by electric companies but have not yet been authorised.

Source: METI, March 2003.

Table 21

Cost of New Nuclear Power Units

Capital cost, including	2.3 ¥/kWh
– decommissioning costs	0.07 ¥/kWh
Operation and maintenance	1.9 ¥/kWh
Fuel, including	1.65 ¥/kWh
– fuel acquisition	0.74 ¥/kWh
– reprocessing	0.63 ¥/kWh
– interim storage and waste management	0.29 ¥/kWh
Total	**5.9 ¥/kWh**

Source: METI.

Safety Commission (NSC), established through an amendment of the basic law in 1978, offers specific policy advice to the Cabinet Office on safety regulations. Government responsibility for nuclear energy promotion policy rests with the METI, and, more specifically, ANRE's Electricity and Gas Utility Department.

Up to the end of 2000, nuclear safety issues were under the responsibility of the former Public Utility Department of ANRE and the Nuclear Safety Bureau of the Science and Technology Agency (STA). As a consequence of a re-organisation of the ministries and agencies and following the Tokai Mura accident, their responsibilities were merged into the Nuclear and Industrial Safety Agency (NISA) which was established within ANRE/METI in January 2001. While METI takes responsibility for the use of nuclear power as an energy source (see below), the Cabinet Office takes responsibility, with advice from AEC and NSC, on the planning and co-ordination of the broader use of nuclear in the fields of science and technology, energy, transport, international co-operation, medicine, agriculture and so forth.

Nuclear safety regulations are effectively separated from the nuclear promotion policy in line with the Nuclear Safety Convention. While NISA is established within ANRE, it began reporting directly to the METI minister in 2002 to enhance its independence.

Following TEPCO's data falsification, in order to complement the work of NISA, a decision was taken to strengthen the implementation of safety regulations by establishing JNES. The number of people involved in nuclear safety within NISA has been increased from 260 to 300. The number of staff within JNES, which will be formally established in October 2003, will be 460.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has responsibility for the scientific and technical aspects of nuclear energy policy-making, in line with AEC's recommendations. It also oversees the development of advanced nuclear fission and fusion technologies carried out by institutes like Japan Atomic Energy Research Institute (JAERI) and Japan Nuclear Fuel Cycle Development Institute (JNC).

THE FUEL CYCLE, WASTE MANAGEMENT AND PLANT DECOMMISSIONING

The supply of uranium ore and hex conversion services are procured by Japanese utilities from the international market. Enrichment services are similarly procured from international markets to supplement the supplies produced by the utility-owned plant, through the Japanese Nuclear Fuel Company Limited (JNFL), a joint utility-owned company at Rokkasho Mura.

Fuel fabrication is mainly provided from domestic sources. The operation of Japanese plants has evolved less than in other parts of the world and thus the increased technical demands placed on fuel elsewhere, *i.e.* irradiation, uprating, cycle length, have been minimal in Japan.

The Tokai Reprocessing Plant of JNC has been in operation since 1977 but Japan is also a major customer for French and British reprocessing services. It is also constructing a reprocessing plant at Rokkasho Mura which is currently at an early stage of commissioning. Full commercial operation is planned for 2005.

One of the intentions of Japan's nuclear energy policy is for the separated plutonium resulting from reprocessing to be loaded into its reactors as MOX fuel. However, its practical implementation has been suspended at present because of public resistance. For example, following the results of a referendum held at Kariwa village in May 2001, the use of MOX in a nuclear power plant in Niigata Prefecture has been delayed, or possibly abandoned. These results were followed by a resolution in September 2002 by the municipal assembly of Kashiwazaki asking TEPCO and the government to terminate the plans to use MOX in the area. Another example is Fukushima Prefecture where the local government halted progress of a nuclear recycling project in February 2001.

Some low-level radioactive waste is disposed at the Rokkasho Mura site in shallow, engineered facilities. High-level radioactive waste returned from reprocessing in vitrified form is currently stored at the same site pending the availability of a deep geological repository. The Specified Radioactive Waste Final Disposal Act of 2000 stipulates the funding methods, implementing body and siting procedures for the disposal of high-level radioactive waste. The act established the Nuclear Waste Management Organisation of Japan (NUMO). NUMO is responsible for planning and conducting site selection followed by site characterisation at the disposal site and relevant licensing application for repository construction operation and closure. The site selection schedule is planned as follows:

- By 2007 Selection of preliminary investigation areas.
- 2008-2012 Selection of areas for detailed investigation.
- 2023-2027 Selection of site for construction of a final disposal repository.
- 2033-2037 Start of final disposal.

Funds to meet the costs of long-term nuclear liabilities are amalgamated with the utilities' finances. Provisions are recorded within the companies' accounts.

NUCLEAR THIRD-PARTY LIABILITY

Japan has established a national regime dealing with compensation for nuclear damage resulting from accidents. It is not a party to either the Paris or Vienna International Conventions on Civil Liability but its four national laws incorporate a number of the principles embodied within them. Essentially the laws require financial security to be primarily provided by operators and liabilities to be at a prescribed level. The government is responsible for meeting compensation claims beyond this level. The utilities pay a fee to the government for this arrangement.

CRITIQUE

Japan has clear medium- and long-term objectives to support nuclear energy. It has successfully and progressively pursued the construction of nuclear power plants over several decades in response to its lack of domestic energy resources. More recently, Japan has regarded the use of nuclear energy as a central measure in achieving its very challenging Kyoto target. In the *Long-Term Energy Supply and Demand Outlook*, nuclear power generation is expected to increase by 30% between 2000 and 2010 to simultaneously address energy security and climate change mitigation. However, the government and electric utilities are facing significant, fundamental challenges in meeting this ambitious target.

The most significant challenge is improving the level of public acceptance. Nuclear power operations in Japan have been marred by safety-related incidents in recent years, either at generating plant sites or at fuel manufacturing plants. In particular, the recent data falsification by TEPCO has seriously undermined public confidence in nuclear energy. Public opinion has a serious impact on the political processes involved in the establishment, operation and decommissioning of nuclear plants by different constituents of local governments. While the national government is more oriented towards national strategic objectives, quite naturally decisions by local governments need to consider the people who live close to nuclear facilities. Therefore, even though the safety of the suspended nuclear power plants is confirmed by NISA, the relevant local governments have to give their consent to restart operations. Low public confidence in nuclear may make it extremely challenging to develop several nuclear plants, which would be necessary to increase nuclear power generation by 30%. This can particularly affect projects in their planning stage (see Table 20). The government should make the utmost effort to restore public confidence in nuclear energy, in particular by addressing political tensions between national and local governments.

Sound safety measures are one of the fundamental prerequisites to restore public confidence in nuclear energy. The Japanese government's response to

safety-related incidents is authoritative and has a very significant profile in national affairs. However, the value of a 190% increase of resources and the introduction of a second nuclear safety regulatory organisation are yet to be proven. Particularly critical will be the interface between the NISA and the JNES.

While not compromising the highest safety levels, nuclear safety regulations should also be optimised. It is not evident that more stringent regulatory procedures and additional institutions would solve the underlying problems. Rather, the regulations themselves need to be clear without risk of misinterpretation. In this respect, the government's intention to clarify the rules is positive. Recent safety concerns highlighted the need for the utilities and the regulator to operate and interact in a credible manner. For example, a time frame should be established for the regulator to initiate inspections and make decisions. The government's proposal to strengthen penalties for misconduct can also help. However, it is important that such punitive actions take the form of fines rather than plant closures as the latter have an impact on energy security – unless closures are necessary for nuclear security reasons.

While nuclear power plant performance improved in the period to 2001, Japanese power plant availability did not approach the world's best levels. In 2002, it fell again after the closure of 13 nuclear power plants. In particular, the availability of the BWR tranche was disappointing as it has the potential to increase availability by 10%. A 10% improvement in 20 plants would be the equivalent of constructing and operating two completely new plants. Given that the development of 10-13 additional plants is challenging, more attention should be given to increasing the load factor of the existing units by shortening the statutory and other outage periods and reducing their frequency.

Ensuring the competitiveness of nuclear power in a liberalised electricity market is a challenge. This issue has not been addressed in the recent debate on directions for electricity market reform. While METI's cost assessment in 1999 shows that nuclear power is more competitive than any other energy source in Japan, most other countries find combined cycle gas turbines the most attractive alternative given their low capital cost, high efficiency and short construction period. Noting the critical role of nuclear in terms of energy security and climate change mitigation, the government should promptly clarify the role of nuclear power in liberalised markets as well as demarcation of responsibilities between the public and private sectors in high-level radioactive waste disposal, MOX fuel fabrication and long-term nuclear liabilities.

Currently, competition in the supply of nuclear fuel fabrication services to Japanese plants is minimal. The fuel is another factor that could improve the economics of plant operations similar to other measures such as increased irradiation levels, increased plant rating and extended plant operating cycles.

More attention to international fuel fabrication markets could reduce prices and further improve the cost-competitiveness of nuclear energy.

The disposal of high-level radioactive waste is an issue with serious implications for public acceptance of nuclear energy itself and on NUMO's programme of site identification and technical development. Japan has implemented plans to dispose of low-level radioactive waste and to manage its high-level radioactive waste in dedicated stores. Since its plants are relatively young, decommissioning wastes will not become an issue for many decades. However, concerns exist about the ultimate fate of all radioactive material, and proactive planning to cope with these issues would reassure concerned stakeholders.

The existence of funds to meet the costs of discharging long-term nuclear liabilities is recognised. However, as the nature of the utility companies which hold them may change with market deregulation, consideration should be given to the introduction of a more secure system to guarantee the funds will be available when required, for example through segregated funds as exist in some other OECD countries.

RECOMMENDATIONS

The government of Japan should:

- *Address safety-related shortcomings, paying particular attention to ensure the effective working of the Nuclear and Industrial Safety Agency and the new organisation, Japan Nuclear Energy Safety Organisation.*
- *Work to restore public confidence in nuclear energy, especially by addressing the political tensions between national and local governments.*
- *Maintain efforts to improve nuclear plant availability, particularly of the boiling water reactor tranche.*
- *Clarify the role of nuclear power in the liberalised market and the respective responsibilities of government and industry in meeting its back-end costs.*
- *Pursue the ultimate disposal of high-level radioactive waste, seeking appropriate sites through enhancing acceptance of its nuclear policy.*

INDUSTRY STRUCTURE

Japan's electric power industry comprises five types of companies (Figure 21):

- General electric utilities which are referred to as electric power companies (EPCos) (10 companies).
- Wholesale electric utilities (2 companies).
- Wholesale suppliers (34 municipal utilities, 20 joint-venture companies and numerous independent power producers).
- Special electric utilities (2 companies).
- Autonomous generators (numerous).

The ten EPCos are Hokkaido, Tohoku, Tokyo (TEPCO), Chubu, Hokuriku, Kansai, Chugoku, Shikoku, Kyushu and Okinawa (see Table 22). These are private companies with integrated generation, transmission and distribution capacities. Each of them supplies a designated area where they have public service obligations (see Figure 22). In FY2001, they generated 72.3% of all electricity in Japan. There are, however, large differences in size, the three largest ones being Tokyo, Kansai and Chubu EPCos.

Table 22

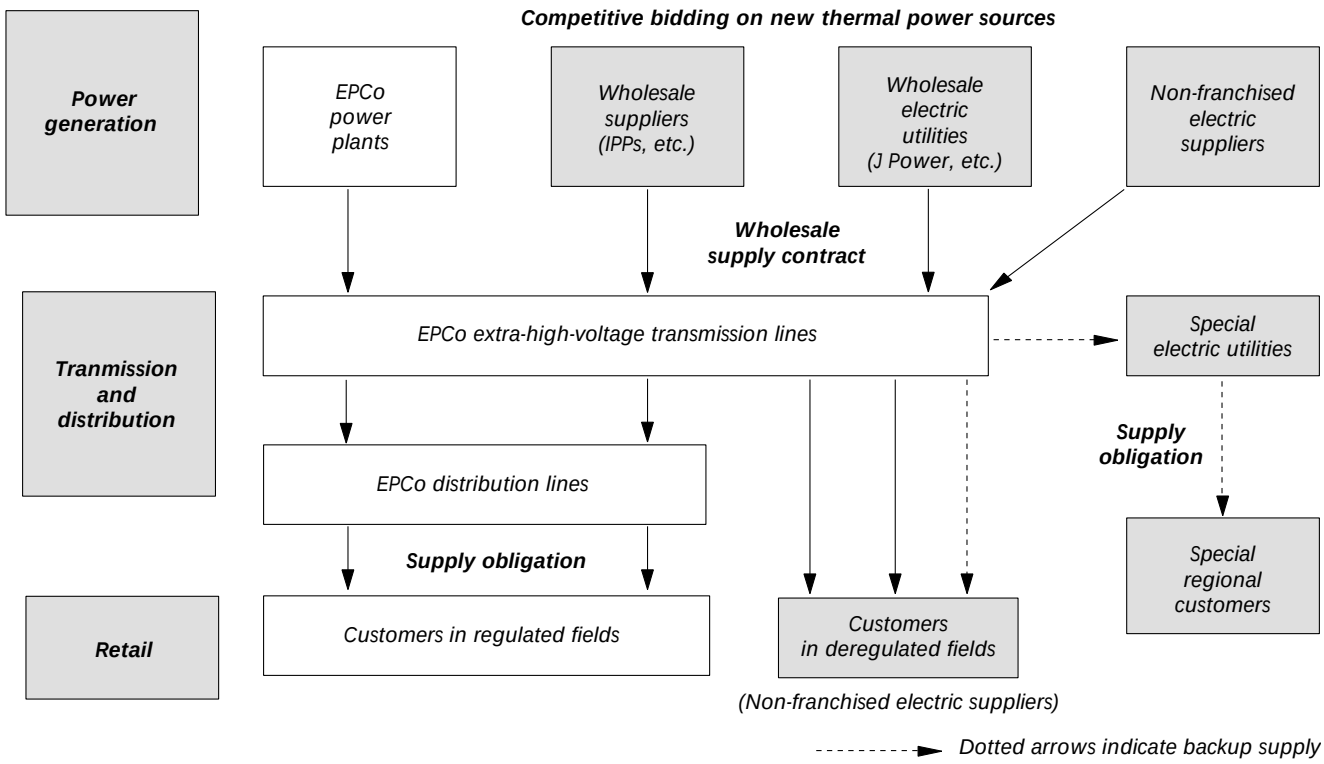
General Electric Utilities, FY2001

Company	*Generating capacity MW*	*Electricity sales TWh*	*Revenues billion ¥*	*Number of customers million*	*Number of employees*
Hokkaido	5 904	28.8	520	3.8	6 275
Tohoku	16 076	72.5	1 557	7.6	13 242
Tokyo	60 375	275.5	5 130	27.0	40 624
Chubu	32 231	120.9	2 148	10.1	18 301
Hokuriku	6 759	25.0	482	2.0	5 439
Kansai	35 585	139.8	2 518	12.9	25 563
Chugoku	12 179	53.6	973	5.1	11 052
Shikoku	6 877	25.8	553	2.9	6 625
Kyushu	19 336	75.3	1 385	8.1	14 186
Okinawa	1 676	6.9	139	0.8	1 550
Total	**196 999**	**824.1**	**15 403**	**80.2**	**142 857**

Source: The Federation of Electric Power Companies in Japan.

Figure 21

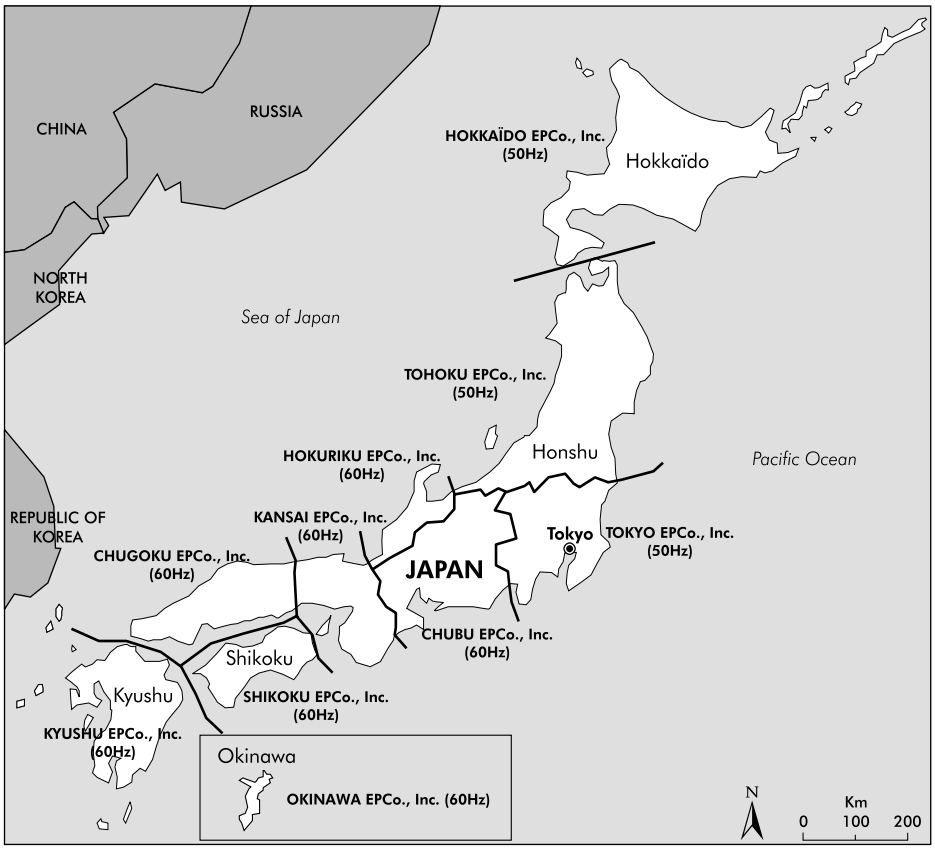
Electricity Market Structure



Source: Japan Electric Power Information Center.

Figure 22

Supply Areas of General Electric Utilities



Source: METI.

The two wholesale electric utilities are the Electric Power Development Company (operating under the trade name J Power) and the Japan Atomic Power Company (JAPC), which both sell electricity to the ten EPCos on a wholesale basis. J Power operates 16 000 MW of large hydropower and coal-fired power plants but also geothermal power plants and associated transmission assets.

J Power is owned by the government (66.7%), TEPCO (10%), Kansai EPCo (7.3%), Chubu EPCo (6.3%) and the other seven EPCos (9.7%). Full privatisation is expected by the end of FY2003. JAPC was established by the EPCos to commercialise nuclear power in Japan. It has, however, only three plants with a total capacity of 2 617 MW. In FY2001, J Power and JAPC generated 6.9% of Japan's electricity. Although J Power does not currently hold any nuclear power assets, it has decided to build a nuclear power plant using MOX fuel at Ohma.

Wholesale suppliers usually operate thermal power plants that sell electricity to EPCos through a bidding system (*i.e.* under contract – the bidding system is for awarding the long-term supply contract) or directly to final consumers in the liberalised market segment. They are municipal generating companies, joint ventures or independent power producers (IPPs). In FY2001, wholesale suppliers generated 6.5% of Japan's electricity.

The two special electric utilities operate in generation, transmission and distribution in their own small designated supply areas where they have a public service obligation. In addition to their smaller size, their difference, compared to the EPCos, is that they supply a defined set of customers rather than the general public. Their share of the total generation is negligible.

Typical autoproducers are steel makers, chemical companies, oil refiners, cement producers and pulp and paper companies. In FY2001, they generated 14.3% of all electricity in Japan. However, their share in industrial demand is larger; the Federation of Electric Power Companies (FEPC) estimates that about 34% of electricity consumption in the manufacturing industry is taken care of by on-site generation. Many of these large industrial plants generate electricity with coal. Approximately one-sixth of this industrial power generation is supplied by co-generation.

After partial market liberalisation, trading companies have also emerged in the electricity markets. Typically, they buy electricity from autoproducers and sell it forward.

DEMAND AND SUPPLY

DEMAND

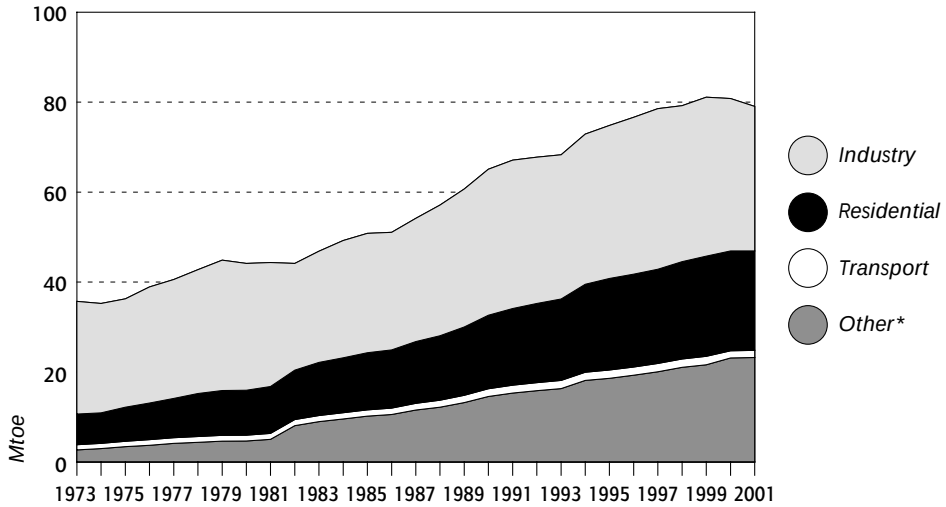
Electricity consumption in Japan was 919 TWh in FY2001. Industry was the largest user, consuming about 41% of electricity, followed by the service sector (29%), the residential sector (28%) and the transport sector (2%). Between 1990 and 2001, electricity consumption grew by 21%, compared to GDP growth of only 14%, and the forecast puts growth in electricity consumption for the current decade at about 9%.

Power consumption in Japan varies drastically depending on the season. Because of the growing demand for air-conditioning systems, peak consumption levels in the afternoons of summer months are growing (see Figure 24). In recent years, peak demand has become sharper with record highs for electricity consumption being exceeded several times over the same summer.

The annual load factor varies significantly year by year (Figure 25) and weather plays an important role. The load factor decreased between the 1960s and mid-1990s with some increases during the years with cold summers. In the

Figure 23

Final Consumption of Electricity by Sector, 1973 to 2001



* includes commercial, public service and agricultural sectors.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

late 1990s, however, the load factor started to improve for the first time in decades but in 2001 it declined to the early 1990 levels owing to a decrease in electricity demand.

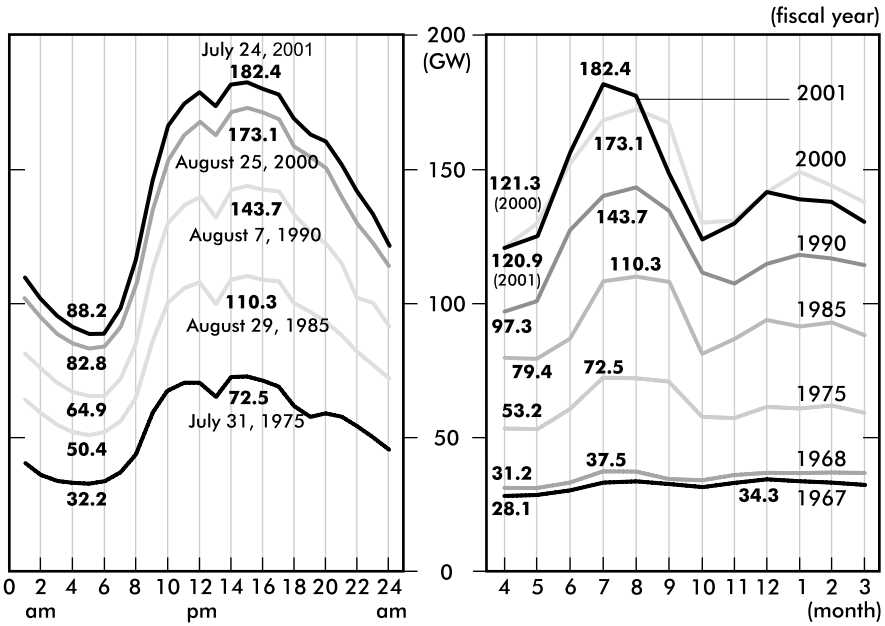
In May 2000, the government adopted an Action Plan for Economic Structural Reform, which identifies load-levelling as one of the key measures to reduce the high cost of electricity supply. The plan identifies the following areas of action:

- Dissemination and expansion of thermal storage technologies in air-conditioning.
- Enhancement of electricity tariffs which promote load-shifting.
- Intensified efforts to gain public understanding of the load-levelling issue.
- Reinforced efforts to develop new technologies for load-levelling.

The energy industry tries to address the sharpening peak by both supply- and demand-side measures. The key measure on the supply side is constructing new power plants but the normal augmentation of transmission facilities can also make a contribution. The main demand-side measures have been developing the use of new air-conditioning technologies (gas and thermal storage air-conditioning), and load-levelling through electricity rate systems, such as interruptible contracts.

Figure 24

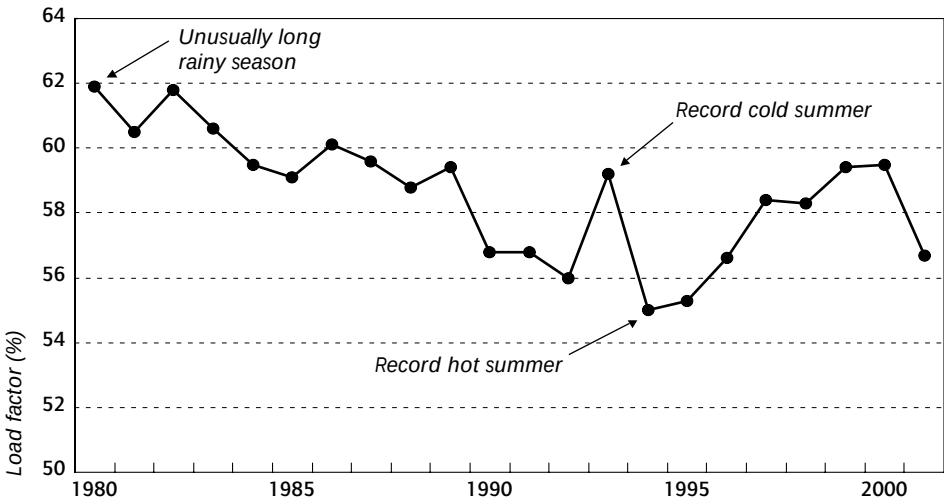
Development of Load Curves



Source: The Federation of Electric Power Companies in Japan.

Figure 25

Development of the Annual Load Factor, 1980 to 2001



Source: METI.

The EPCos are working together to disseminate and expand the use of thermal storage air-conditioning systems. At the end of FY2000, about 13 400 thermal storage systems, mostly the Eco Ice type, had been installed. The Eco Ice system uses electricity at discount rates at night to store ice in summer or hot water in winter in a storage tank for use in air-conditioning or heating during the day. Eco Ice is suitable for a wide range of building sizes. The use of gas air-conditioning in large buildings is growing rapidly and reached 9 000 systems in 2000. Although the number of thermal-storage and gas air-conditioning systems is growing, their share of the total cooling market is still very small.

Loads are also being levelled by offering a range of seasonal and time-of-use tariffs and special tariffs for thermal storage use. For example, in 2001, about 0.56 million consumers used night-time tariffs for water heating in Tokyo. Real-time pricing – where the price of electricity varies by hour reflecting the actual cost of generation – is not at present being used in Japan.

SUPPLY

The generation mix changed significantly over the last decade (see Figure 26). The share of nuclear power in total generation increased from 23.8% in FY1990 to 31% in FY2001, the share of coal increased from 14.5% to 23.1% and the share of natural gas increased from 19.4% to 24.9%. These energies replaced oil with its relative share declining sharply from 29.7% in FY1990 to 11.3% in FY2001. The shares of other fuels in FY2001 were 8.1% for hydro, 0.7% for combustible renewables and waste and 0.3% for geothermal energy. In the Base Case of the *Long-Term Energy Supply and Demand Outlook*, the government estimates the share of nuclear power to increase to 40.7% of total generation by 2010. The share of oil will decline to 3.7%. Little change is expected in the share of coal (22.8% in FY2010), gas (22.7%) and hydropower (9.4%). The government plans to increase the share of renewables (excluding large-scale hydro, traditional geothermal and non-organic waste) to 1.35% of total generation by 2010 through the use of portfolio standards.

Hydro and nuclear power are the baseload supply sources, while coal and LNG are the mid-range supply sources. Peak demand is supplied by oil and pumped storage power plants but in some cases the hydropower plants are also used to provide peak supply.

At the end of FY2001, total electricity generating capacity was 262 GW, and 12% of this capacity was installed by autoproducers. The EPCos will develop 45 GW of additional power generating capacity during the next ten years. About 26.2 GW of new power plants are under construction and 31.4 GW in the planning stage. The thermal power capacity under construction totals 14.9 GW at 22 sites, and 18.2 GW planned at 24 sites. Almost all new thermal

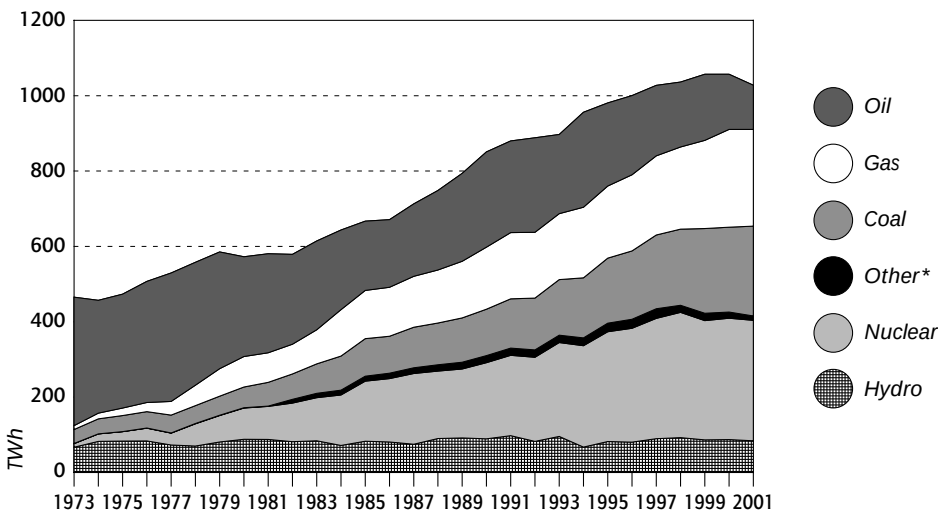
power capacity under construction is coal and natural gas, but natural gas is the most common fuel among those in the planning stage. Some 7.5 GW of hydropower capacity is under construction and 5.9 GW is planned. Most of these plants are pumped storage plants and only 0.4 GW is conventional hydropower in numerous small sites. The nuclear generating capacity under construction is 3.8 GW and planned capacity totals 9.5 GW (see Chapter 8).

The average time to develop a nuclear power project is 20 years or more and 10 years or more for a coal-fired power plant. Time frames in other countries are typically 10-12 years for nuclear power at a greenfield site, 8-10 years for coal and 3-5 years for gas power plants. There are many factors which make this a long process. For example, purchasing the land needed is time-consuming, acquiring all the environmental permits (at the national, prefectural and municipal levels) requires at least three years, and negotiating the property rights for fishing adds to the time and cost. It has been possible to obtain all environmental permits required by the Electric Utilities Industry Law from the national government, but other local permits are still required.

The average thermal efficiency in thermal power plants was stagnant for two decades but increased from 38.9% in 1995 to 40.6% by 2000. The major reasons for this have been the increased use of natural gas in combined cycle gas turbines with efficiencies up to 50-55%, from an already efficient level, and the installation of new coal plants which have efficiencies above 40%.

Figure 26

Electricity Generation by Source, 1973 to 2001



* includes solar, wind, combustible renewables and wastes.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

ELECTRICITY TRANSMISSION

Japan's four main islands are interconnected but Okinawa is not connected to the main grid. The EPCos serving the northern part of Japan (Hokkaido, Tohoku and Tokyo) deliver electricity at a frequency of 50 Hz, and western Japan uses 60 Hz. Frequency converter stations are operated by J Power at Sakuma and by TEPCO at Shin Shinano, but the total interconnection capacity between the two frequency areas is limited to 900 MW. Japan has no electricity interconnections with neighbouring countries and there are no plans to build any.

In the past, all EPCos were required to be self-sufficient in their electricity supply either through their own generation or by buying electricity from other generators. Therefore, interconnections between the regions have been built for security of supply reasons only and the need for third-party access has not been taken into account in transmission planning. As a result, interconnections between some regions are weak, even in the same frequency area. Figure 27 shows both the total transmission capacities between the different regions and those transmission capacities which have been reserved by the EPCos for their own use. The unreserved transmission capacity is typically very low and, in some cases, non-existent. In future, supervision of the interconnections will be undertaken by the planned "neutral organisation" (see next section on Regulatory Reform and Competition).

The government required EPCos to publish annually Long-Term Electric Power Facilities Development Plans which cover their investment plans for the next ten years, which is the time needed for developing new high-voltage transmission lines. The most recent plans covering the period 2001-2011 announce the commissioning of one frequency converter station at Higashi Shimizu (300 MW) and construction of an associated high-voltage transmission line. However, they do not envisage any additional interconnections among the regions. The mountainous terrain and the elongated shape of Japan restrict opportunities for enhancing the networks through parallel transmission lines.

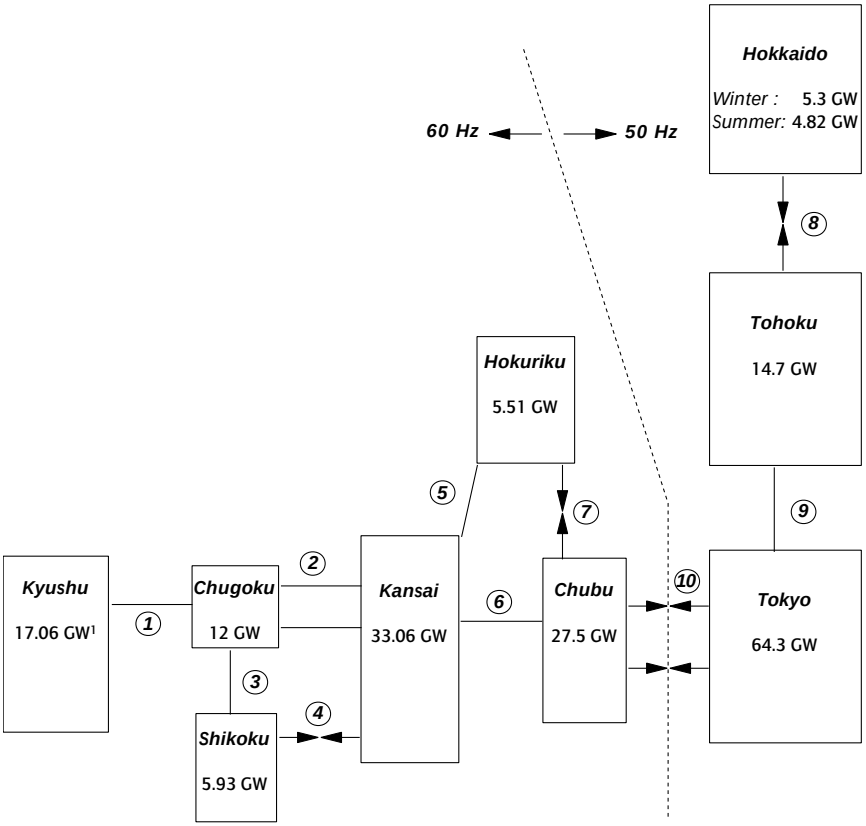
Transmission and distribution losses have been significantly reduced in the 1990s, from 5.7% in 1990 to 5.1% in 2000. The major reason is the significant investment in new transmission technology, although efforts to improve the load factor may also have made some contribution.

PRICES AND TARIFFS

The EPCos establish the tariffs as well as supply terms and conditions for the captive consumers but any price increases are subject to authorisation by the METI. The METI procedures for approving any price increase include the use

Figure 27

Transmission Interconnection Capacities



	Rating of interconnection equipment (e.g. thermal limits)[2] MW	Total transfer capacity[2] MW	Available transfer capacity[2] MW
1	5 570	2 800 to east; 300 to west	600 to east; over 300 to west
2	16 660	4 000 to east; 600 to west	600 to east; over 600 to west
3	2 400	1 200	200
4	1 400	1 400	50 to east; 200 to west
5	5 570	600 to east; 1 300 to west	200 to east; 200 to west
6	5 570	2 500 to east; 1 000 to west	500 to east; over 500 to west
7	300	300	0 to south; 200 to north
8	600	600	100 to south; 0 to north
9	6 000	1 300 to north; 5 000 to south	700 to south; over 700 to north
10	900	900	0

1. The data in the frames are the gross peak load in FY 2001.
2. In FY 2002.

Source: METI.

of the "yardstick formula"[21] and public hearings. A notification approach was applied to price reductions in March 2000. Until then, price reductions were subject to the "yardstick formula" assessment. EPCos are permitted to offer optional tariffs to contribute to the efficient use of facilities (*e.g.* interruptible contracts for large consumers and time-of-use and seasonal tariffs) without the need for authorisation.

Prices can be freely negotiated between the liberalised consumers and suppliers. The EPCos publish a list of tariff alternatives for eligible consumers. Options vary from EPCo to EPCo, but some major alternatives are "load-factor contracts" that offer discounts to customers who help to improve the load factor and "holiday full-operation contracts" that offer discounts to customers who increase their consumption on weekends and holidays.

In 1996, the EPCos introduced a fuel cost adjustment system which employs a sliding scale for electricity rates that allows rapid adjustment in response to fluctuations in fuel costs. Each company's electricity rates are adjusted every three months on the basis of average fuel prices calculated from averaging customs clearance statistics. If the three-month average price shows an increase of more than 5%, the rates are adjusted to reflect this. A ceiling of 50% on fuel cost increases prevents the EPCos from passing the entire cost increase on to their customers, should fuel prices increase sharply.

Japanese electricity prices have been significantly reduced from their peak levels (Figure 29). However, they remain most expensive among IEA countries for all consumer types if exchange rates are used[22] (Figure 28). The difference is even more striking for households when pre-tax prices are compared. Since the partial electricity market liberalisation in March 2000, prices for captive consumers have been reduced twice. For example, TEPCO reduced its prices on average by 5.32% in October 2000 and by 7.02% in April 2002. Though part of the reduction was due to falling financial costs, it was also an attempt to transfer streamlining of management and efficiency gains from market liberalisation to consumers who are not free to choose their suppliers.

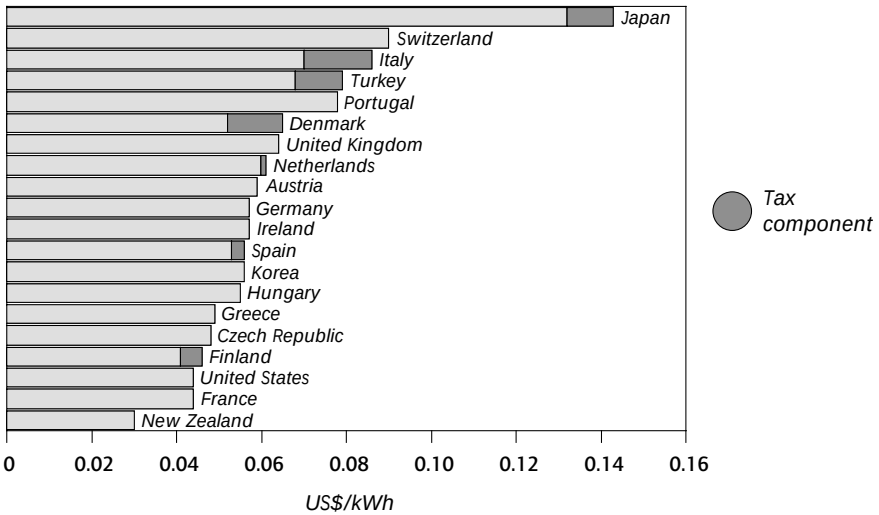
---

21. The yardstick assessment involves comparing the EPCo to its own and other EPCos' past performance on the basis of three categories (generation; transmission, transformation and distribution; and general administration) where the costs compared are those over which the EPCo is considered to have control. For each category, the range of costs is calculated and the costs for each EPCo determine whether it is in the bottom, middle or upper third of the range. Those EPCos in the bottom third (*i.e.* among the most efficient or most improved) are allowed to receive revenues equal to the value of their costs in that category. Those in the middle and top third (*i.e.* among the least efficient or least improved) are allowed to receive revenues equal to 99% or 98%, respectively, of the value of their costs in that category. Rankings are published.
22. If purchasing power parities are used, Japanese electricity prices for household consumers are 35% lower than in Germany and 27% lower than in the United States. If measured in local currency, the average sales price of the ten EPCos was highest in 1985, ¥23.74 per kWh. By FY2001, it declined to ¥17.72 per kWh.

Figure 28

Electricity Prices in IEA Countries

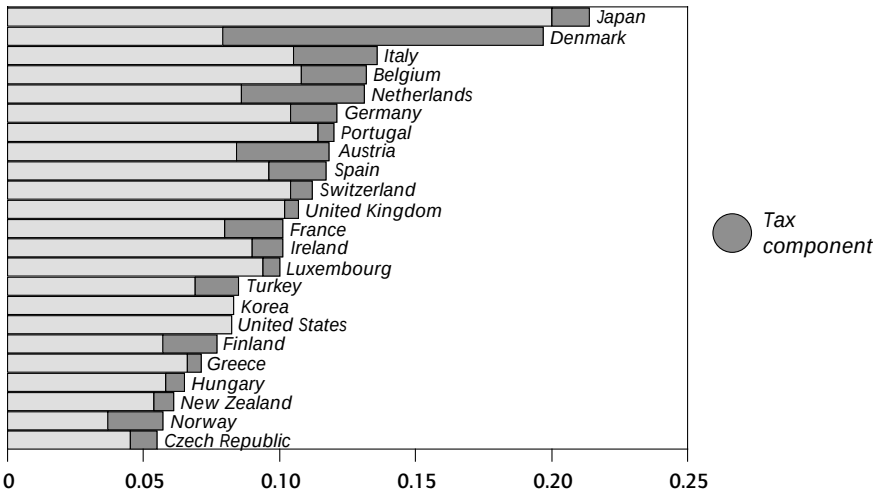
Industry Sector, 1999*



** The market liberalisation process has made it difficult to collect price data from industries, so it is therefore not possible to make comprehensive comparisons after 1999.*

Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Belgium, Canada, Luxembourg, Norway and Sweden.

Household Sector, 2000

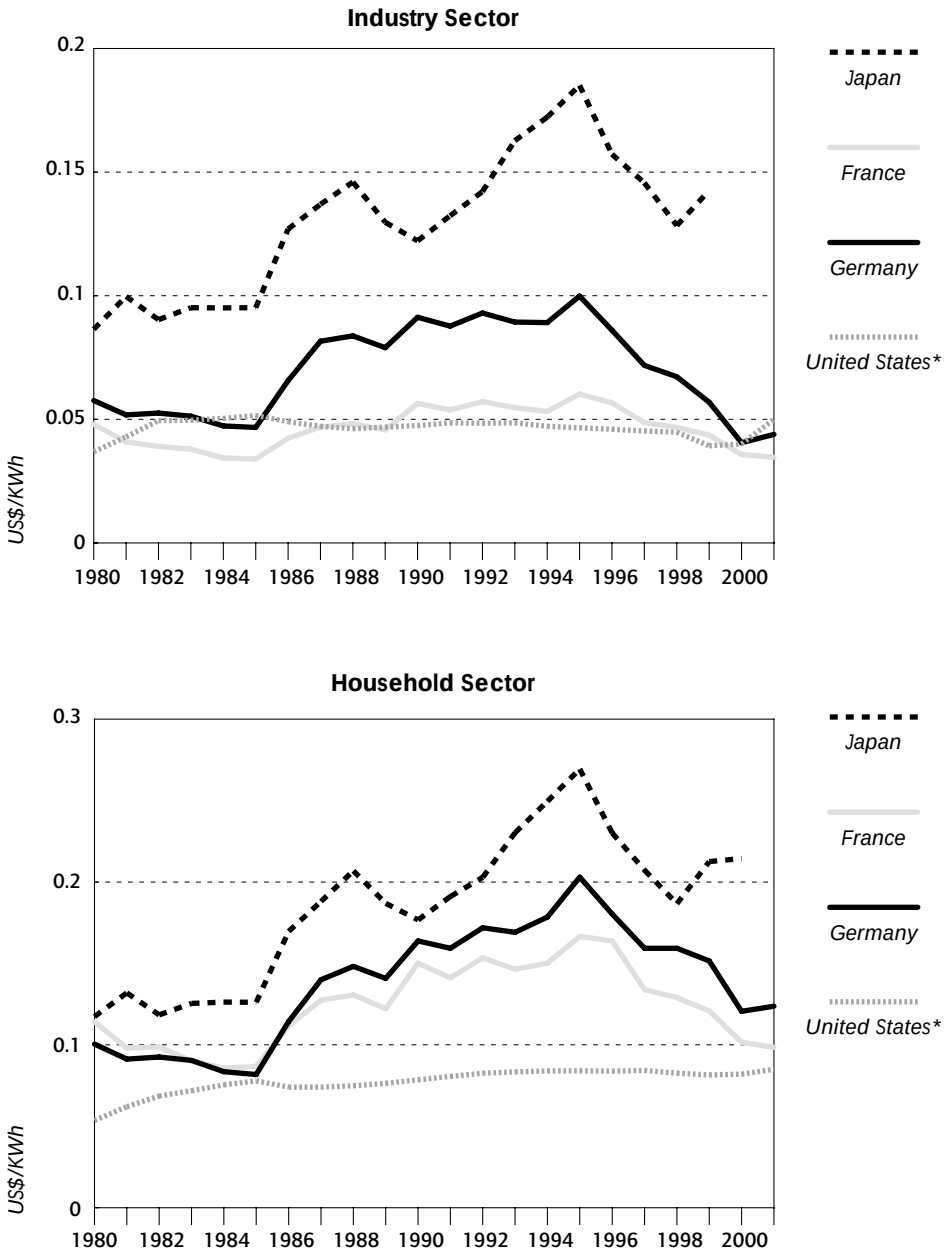


Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Canada and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 29

Electricity Prices in Japan and in Other Selected IEA Countries, 1980 to 2001



* excluding tax.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

There are several reasons for the high prices:

- **High generation capital costs:** Japan has the highest investment costs for nuclear, gas and coal-fired power in the OECD. Expensive land, compensation payments made to local communities and high safety standards (including earthquake resistance) contribute to increased costs. EPCos have recently been actively encouraging foreign participation in their equipment procurement tenders which can put downward pressure on prices. However, very high technical standards for equipment compared with other countries force prices up and limit the number of competitors.

- **High fuel costs:** EPCos pay more for oil and natural gas than many OECD countries. Coal prices are close to the OECD average. Customs duty on oil will contribute to high oil costs until 2006. Oil costs would be even higher except that a number of Japanese oil-fired plants are capable of burning heavy sweet crude oil which is cheaper than heavy fuel oil. Natural gas costs are higher owing to a gas price link to crude oil prices, the need to use more expensive LNG over pipeline gas (available in most other OECD countries) and taxes.

- **High transmission and distribution costs:** Transmission and distribution infrastructure costs are high because of high land costs, mountainous terrain, remote siting of new power stations, very high construction standards to withstand earthquakes and typhoons, and very high operating standards.

- **Regulatory costs:** Regulations regarding maintenance of power plants are extremely strict. For example, nuclear plants are required to undergo a refuelling outage every 13 months, although longer fuel cycles have been proven to be both safe and feasible elsewhere. Government regulations also require natural gas turbines to be completely disassembled for inspection every 30 months – a requirement not duplicated in other countries and not recommended by the manufacturer. Japanese environmental regulations are also quite strict. As a result, nearly all coal-fired and most oil-fired power stations are equipped with flue gas desulphurisation and the majority of coal-fired plants have advanced NO_x removal technologies. The Air Pollution Control Law allows local government to set even stricter limits, resulting in additional cost. For example, despite flue gas desulphurisation, utilities still use coal and oil with a lower sulphur content.

- **Low load factor:** The load factor in Japan (the ratio of average electricity demand to the annual peak demand) is extremely low (59.5% in 2000) in comparison with other industrialised countries principally because of seasonal air-conditioning use. For example, in the United States the load factor was 61.2%, France 69.3% and the United Kingdom 67.4% in 2000 and in Germany 76.8% in 1998. Each 1% decrease in the load factor increases service costs by approximately 1%.

- **Specific taxes:** A special electricity power development tax, ¥0.445 per kWh, is used to finance funds paid to communities near new power plants with the objective of gaining public acceptance for nuclear projects and encouraging development and diffusion of alternative energy to oil.

- **Development of renewables:** The utilities purchase power above cost from renewable sources, although the amounts involved have been quite small. Renewable generation is planned to increase to 12.2 TWh by FY2010 with the introduction of a portfolio standard.

There has been a reduction in electricity costs per kWh since the mid-1990s (see Table 23) because of lower interest rates, reductions in fuel cost (mainly because oil use has declined), repair and maintenance costs and depreciation levels.

Table 23

Average Costs[1] per kWh Sold by the General Electric Utilities, 1990 to 2001

(¥ per kWh)

	1990	*1996*	*2000*	*2001*
Personnel	2.06	2.21	2.17	2.13
Fuel	3.83	2.58	2.40	2.32
Repair and maintenance	2.11	2.40	2.03	1.93
Interest charges	2.29	1.80	1.26	1.07
Depreciation	3.11	3.77	3.33	3.35
Taxes	1.69	1.72	1.70	1.72
Power purchases (intercompany and others)	1.86	2.18	2.15	2.24
Other	2.59	2.75	3.02	3.28
Total	**19.55**	**19.41**	**18.05**	**18.05**

1. In nominal terms.

Source: Japan Electric Power Information Center.

REGULATORY REFORM AND COMPETITION

REGULATORY REFORM

The government has amended the Electric Utilities Industry Law three times to reduce electricity prices through competition. In 1995, the government introduced a bidding system to promote the entry of independent power producers (IPPs) into the power generation sector. Under this system, the EPCos determine the thermal power needed and are obliged to organise tenders where IPPs are allowed to bid. In FY1996-1999, the EPCos received

numerous bids of which about one-fourth were accepted. As a result, about 7 000 MW of IPP capacity entered the wholesale market generating electricity at prices 10 to 40% below the "upper limit prices" calculated by the EPCos. The minimum contract length required is 10 years. The first amendment only allowed thermal power sources with short development periods (lead time of seven years) to bid, but in March 2000 mandatory tendering was expanded from thermal power sources with short development periods to all thermal power sources.

The second amendment took place in March 2000. Under the new legislation, METI grants approval to new entrants in the electric power services sector according to whether they plan to enter the general, wholesale, special or "special scale electric utility"[23] supply business. Where IPPs wish to function as wholesale suppliers to the EPCos, the latter are responsible to continue conducting tenders and setting "upper limit prices" for bids.

The high-voltage customers (20 kV or higher), and with at least 2 MW of connected load, are now allowed to choose their supplier. This corresponds to about 30% of the total retail electricity market, and the number of eligible consumers is about 9 000. As the public supply obligation is only applied to EPCos, they serve as the last resort for customers who fail to sign a supply contract.

Third-party access to transmission networks is open to all suppliers by using so-called "wheeling tariffs" which are established by the transmission network owners following METI guidelines. The tariffs and access conditions, as well as information on how the tariffs are calculated, are notified to the METI (although not to the public). In this respect, the wheeling tariffs and the process of establishing them resemble the regulated third-party access (TPA) tariffs used in some European countries. The difference between the wheeling tariffs and the regulated TPA tariffs is that whereas it is the electricity consumer who pays the regulated TPA rate, it is the power supplier who pays the wheeling rate to network owners. Under the current system, the power supplier is also obliged to pay wheeling tariffs to all the network owners on the way from its power plant to the final consumer (so-called "pancaking"). According to an estimate made by the Ennet Corporation, an electricity retail company, the wheeling rate[24] is 31% of the retail price for industrial consumers and 24% for commercial consumers. The government estimate is somewhat lower, on average 23% of the electricity prices of liberalised consumers.

23. "Special scale electric utilities" supply large consumers. They include companies with their own generating capacity as well as traders. IPPs do not need to receive prior government approval to function as special scale electric utilities.
24. The assumptions for the calculation of the wheeling rate are: 45% load factor, rate of generator's maximum capacity 50%, "accident" frequency once a year, and TEPCO's tariffs.

Japanese legislation does not require the vertically integrated EPCos to implement account unbundling for the generation, transmission and distribution/retailing of electricity. The government has expected transparency to be adequately secured by voluntary disclosure of the balances (revenue and expenditure of wheeling services) of the general electric utilities for government auditing. Table 24 summarises the unbundling arrangements in IEA countries.

Table 24

Unbundling of Transmission System Operators in IEA Countries[1]

Ownership unbundling	*Legal unbundling*	*Management or account unbundling*	*Not liberalised*
Australia, England, Finland, Norway, Sweden, Spain[2], Wales	Main parts of Austria, Belgium, Czech Republic, Denmark, Ireland, Italy, Korea, the Netherlands, New Zealand, Northern Ireland, Portugal	Grid of Tiwag and Illwerke in Austria, Canada[1], France, Germany[3], Greece, Hungary, Scotland, Turkey, United States[1]	Switzerland

1. Varying methods of unbundling can be found in Canada and the United States, depending on state. Luxembourg does not have significant transmission networks.
2. Ownership unbundling is being gradually introduced.
3. Some TSOs have voluntarily implemented legal unbundling.

Sources: The country submissions and the European Commission.

The 2000 amendment of the Electric Utilities Industry Law assigns the METI the following regulatory responsibilities:

- Developing, implementing and enforcing administrative rules pertaining to utilities' calculation of transmission charges, and open and fair access to transmission networks in accordance with the Electric Utilities Industry Law.
- Monitoring utilities' transmission rates with respect to third-party users and issuing change orders in the event that such rates do not conform with METI rules.
- Administering environmental, technical and safety standards for power generation facilities.
- Formulating competition policy guidelines jointly with the Fair Trade Commission (FTC).
- Settling disputes (in conjunction with the FTC).

In January 2001, the METI separated its policy-making and regulatory activities pertaining to the electric power sector into two newly established divisions – the Policy Planning Division (in charge of all policy planning) and the Electricity

Market Division (in charge of all industry regulation). Table 25 summarises the regulatory institutions in Japan and other IEA countries.

Generally the METI has jurisdiction over disputes that concern the Electric Utility Industry Law, while the FTC has jurisdiction over cases that involve the Antimonopoly Law. The FTC investigates both filed cases and issues it has identified internally. The average time needed by FTC to resolve a case is eight months. It also gives administrative counselling to both new entrants and incumbents within a response time of one month. The response time of METI to enquiries and disputes is limited to one month but there have been some delays.

Table 25

Regulatory Institutions in IEA Countries

Ministry	*Ministry and ministerial agency*	*Ministry and independent advisory and dispute settlement organisation*	*Ministry and independent regulator*
Czech Republic, Germany, Japan, New Zealand, Switzerland[1], Turkey	Hungary, the Netherlands, Norway	Belgium, Greece, Luxembourg, Spain	Australia, Austria, Canada, Denmark, Finland, France, Ireland, Portugal, Sweden, United Kingdom, United States

1. Switzerland has not implemented market reform.

Source: *Regulatory Institutions in Liberalised Electricity Markets*, IEA/OECD, Paris, 2001.

The METI and the FTC published *Guidelines for Appropriate Electric Power Trade* in December 1999, and updated them in July 2002. These guidelines cover retail supply requirements, retail price setting for eligible consumers, supply arrangements between wholesalers and new entrants, information disclosure between the transmission and other operations in the companies that own networks, as well as the handling of disputes.

The 2000 Electric Utilities Industry Law required the government to review the status of its implementation and put into effect necessary changes three years after its enactment. In November 2001, the government started to investigate possibilities to further exploit the efficiency and price benefits of market liberalisation. In February 2003, the Electricity Industry Committee, an advisory body to the METI minister, presented its proposals for changes in the regulatory regime. Consequently, a third amendment to the law was proposed by the government and approved by the Diet in May 2003. The committee recommendations not included in the law will be implemented by regulations and other measures.

The proposal of the Electricity Industry Committee includes the following provisions:

- **Ensuring fair play in competitive markets:** Regulation regarding transmission, system access and operation will be established. Legislative measures will be put in place to establish account unbundling and information firewalls from April 2005, to prohibit cross-subsidies between transmission and other functions and to prohibit discriminatory treatment. The regulatory capacities of the METI will be reinforced. A "neutral organisation" for transmission, with participation from the incumbent market players and new entrants, will be established to handle electricity transmission issues. The "neutral organisation" will be appointed and supervised by the government. Its main functions will be:
  - Preparing rules that govern, *e.g.* transmission and distribution facility development, system access, system operation and information disclosure.
  - Arbitration and dispute settlements between system users and the transmission and distribution divisions of electric power companies.
  - Operating network information systems that record, *e.g.* transmission line capacities.
  - Acting as a load dispatching liaison.
  - Providing a forum for the industry to discuss regional interconnection line improvements.
  - Assessing supply reliability.
  - Preparing and disseminating statistical data.
  - Conducting research on power systems.
- **Promotion of nationwide transmission of electric power:** Pancaking will be abolished in transmission charges. Rules will be established for settlements among utilities to assure impartiality in cost sharing and cost recovery. Siting of power plants in remote areas will be discouraged. A nationwide power exchange, operating on a voluntary basis and including day-ahead market and forward markets, will be established.
- **Enhancing a good investment environment:** Nuclear power, hydropower and geothermal energy will enjoy priority dispatching to the network to promote investments in these technologies. The government will also plan measures to encourage the industry to invest in adequate transmission capacities. Studies to clarify the treatment of nuclear back-end costs in the liberalised power markets will be conducted by the end of 2004.
- **Providing incentives to improve efficiency by the establishment of transmission charge regulations:** The criteria which METI uses to judge whether transmission charges are excessive will be clarified. At present, transmission charge calculations include the cost of the lines between general

utilities' power plants and substations. As these lines are generally not used by new entrants, the proposal is to examine the scope of these lines' costs to be excluded from the access charge.

- **Reappraisal of rules for network use:** Balancing power rules will be relaxed by increasing the tolerance band from 3% to 10% for 30 minutes and by abolishing the imbalance charges in instances of a defined "accident"[25]. Load profiling will be introduced as an alternative to metering for smaller consumers when liberalisation is extended. Taking information security into consideration, measures will be introduced to enable new entrants to load data owned and collected by the incumbent utilities to meet balancing power rules and to make attractive offers for potential new clients.

- **Securing the diversity of power sources:** The construction of privately owned lines will be allowed, subject to notification to the METI, to promote distributed power generation.

- **Timetable for retail liberalisation:** According to the proposal, market opening will be extended to smaller consumers. The next step would be opening the markets in April 2004 to high-voltage consumers whose connected load is at least 0.5 MW, bringing market opening to 40%. In April 2005, all high-voltage consumers would gain eligibility, increasing the market opening to 63% of the total retail market. Full market opening is envisaged for April 2007 but would be subject to further consideration, such as the success in opening the markets for larger consumers and experience in electricity markets in other countries.

The proposed law amendment includes the following measures for unbundling:

- The transmission/distribution segment should prepare and publish financial statements accounting for receipts and disbursements concerning its wheeling and other services.

- The financial statements of the EPCos must include a statement of income and expenditure on an operating profit and loss basis, a statement of internal transactions, a statement of fixed assets, an imputation list of common fixed assets, a list of expenses by facilities and an imputation list of common segment expenses.

25. It is currently required that new entrants balance supply and demand every 30-minute slot. The maximum difference allowed is 3%. If there is over 3% shortfall, the utilities charge 1.5 times the normal price for providing the additional energy. If the shortfall continues for more than 2 hours, backup power charges called "accident charges" are applied. These are composed of an energy component and a fixed annual fee which depends on the capacity of the new entrant. For example with TEPCO, if the capacity is 100 MW, the fixed part of the annual "accident charge" is ¥230 million. If there is a surplus of over 3%, the EPCos can take the additional electricity without compensation.

- The EPCos' financial statements must specify revenue and expenditure concerning wheeling and other services in accordance with predetermined rules.
- The EPCos must publish all financial statements they have prepared but with consideration given to information security.
- Appropriate standards should apply requiring EPCos to prepare and publish separate accounts for fixed assets shared by the electric utility industry, known as a "main business" according to the Electric Utilities Industry Accounting Regulations, and "non-main businesses".

COMPETITION

Little direct competition has developed between the EPCos. As of January 2003, none of them had directly acquired clients from competing service areas. Recently TEPCO attempted to acquire clients from Tohoku EPCo's supply area but Tohoku EPCo countered with a more attractive proposal. The EPCos have developed subsidiaries which operate on-site generation facilities (distributed generation) in other service areas. For example, MyEnergy Corporation, a subsidiary of TEPCO, operates 83 MW of generating capacities in other EPCos' supply areas and, by January 2003, succeeded in winning 44 contracts from large customers.

As of December 2002, there were seven new entrants in the electricity market (see Table 26). The first case took place in August 2000 and a few others followed in April 2001. During the first half of FY2002, their sales totalled 0.7 TWh, equivalent only to 0.5% of the total liberalised markets. Most of the clients of the new entrants are in the commercial sector where their market share exceeds 5%. Some contracts are with local governments, equivalent to 510 MW of capacity. It has been more difficult for the new entrants to acquire industrial clients because of the high share of autogeneration in this market segment.

Table 26

New Entrants to the Power Market

	April 2001	*July 2001*	*December 2001*	*July 2002*	*December 2002*
Number of new entrants	5	6	6	7	7
Supply by new entrants (GWh)	36	66	78	140	151
Supply by EPCos, total (GWh in liberalised market segment)	17 238	19 495	17 041	19 527	17 727
Share of new entrants in the liberalised market segment	0.21%	0.34%	0.46%	0.71%	0.85%

Source: METI.

The new entrants procure their electricity either from their existing power plants or by buying from the EPCos through bilateral contracts or the Economic Power Exchange. The EPCos established the exchange before market liberalisation to enable them to optimise their generation facilities by selling surplus power in the exchange. The exchange has been open to new entrants since April 2001. In FY2000 there were only 93 transactions in the exchange and in FY2001, the number had increased to 822 representing a trading volume of 73 GWh. Some new entrants, including Nippon Steel (51 MW in April 2003), Ennet Corporation (altogether 235 MW by 2004), Osaka Gas (1 000 MW by 2008) and a consortium of Tokyo Gas and Nippon Oil (400 MW in 2008 and 500 MW in 2011) have announced plans to construct new power plants. The development of prices since the market opening is discussed in the section "Prices and Tariffs" above.

CO-GENERATION, DISTRICT HEATING AND COOLING

According to the Japan Cogeneration Center, there is about 5 486 MW of combined heat and power (CHP) production in Japan, of which 4 371 MW is industrial and 1 115 MW commercial. Industrial CHP systems generated 20.9 TWh of power in FY1999. Gas turbines and diesel engines account for over 90% of the generators. Growth in CHP systems has been steady, averaging more than 360 MW a year since the late 1980s.

Table 27

Co-generation System Capacity, end of FY2000

(MW)

Sector	*Gas turbine*	*Gas engine*	*Diesel engine*	*Other*	*Total*
Commercial	209	291	483	132	1 115
Industry	2 252	186	1 552	381	4 371
Total	**2 461**	**477**	**2 035**	**513**	**5 486**

Source: Japan Cogeneration Center.

Most CHP, classified as "gas turbine" in Table 27, uses fuels other than natural gas (*e.g.* fuel oil, blast furnace gas or refinery gas). Natural gas-fired CHP capacity was 1.52 GW in 1999 (excluding steam turbines). METI estimates the use of gas turbine capacity to increase to 3.44 GW by 2010. Additional measures such as support for research, development, demonstration and diffusion of the technologies should increase capacity to 4.64 GW.

A large potential market exists for natural gas CHP, particularly when combined with cooling in urban areas. Gas CHP and gas cooling account for 45% of gas sales by Tokyo Gas. They are expected to account for over half of the company's growth in gas supply over the next five years. Future technical developments aim at producing more cost-effective CHP systems for gas cooling. Microturbine systems appear promising but will not be a viable option until the capital costs of CHP systems decline further.

All co-generation in Japan benefits from investment incentives in the form of higher levels of depreciation, an initial tax credit or low-interest loans provided by the Development Bank of Japan, and government subsidies of up to 15% of the investment cost of major district heating and cooling projects.

Several regulatory barriers have been removed, in particular to encourage the development of distributed generation and CHP systems. These include adjustments to fire regulations, the repeal of a requirement for an on-site electrical engineer and reduced inspection requirements. The government also plans to eliminate requirement for an on-site boiler engineer.

According to the Japan Heat Service Utilities Association, 86 utilities provided district heating and/or cooling services in 142 districts in 1999. In energy terms, the supply of heat for space heating was 7 917 TJ, for the production of hot water 448 TJ and for cooling applications 11 606 TJ in 1998.

CRITIQUE

SUPPLY AND DEMAND

Japan has continued to successfully diversify its generation mix away from the use of oil by increasing the use of nuclear power, coal and, more recently, natural gas. Further diversification away from oil appears necessary to reduce supply dependence on the Middle East and to achieve climate change mitigation goals. To address climate change, the government has been actively promoting nuclear power and has introduced a portfolio standard to increase generation by renewables (see Chapter 7). Increase of nuclear power generating capacity, however, has become more difficult because of the series of safety and other incidents, and the utilities consider that the development of nuclear power has become more risky with the market reform (see Chapter 8).

Despite the efforts already made by the utilities, the summer demand peak is becoming sharper. This leads to additional investment in peak capacities which increases the cost of supply. The utilities also bear some risk in matching demand and supply. Technical and pricing measures have been taken to flatten the load curve but it will be important to consider an even wider range of mechanisms for demand restraint. These should include prices which reflect the high cost of generation during peak times. This could take

the form of peak tariffs which are even more differentiated than at present, or real-time pricing to encourage changes in consumption behaviour accompanied by awareness-raising activities. Linking power prices to the utility's actual cost helps the utility to avoid selling power at a loss. It also provides a price signal to customers, giving them a monetary incentive to reduce their demand when the power supply is limited.

ELECTRICITY PRICES

Electricity prices in Japan for all consumer groups are the highest within IEA countries if compared using exchange rates. Some of the cost elements – such as high construction standards to withstand earthquakes and typhoons or the significant distance from fuel-supplying countries – are difficult to avoid. However, savings could be achieved in many other areas including increasing the load factor through new pricing and tariff structures, streamlining mandatory inspections of fossil fuel plants and lifting restrictions on equipment purchase tender processes. Some price reductions have taken place for both liberalised and captive consumers over the past two years. Whereas the reasons for the reductions are partly related to reductions in fuel cost and better load management, the low interest rate is a primary factor contributing to such reductions. Price positioning with a view to future market liberalisation may have had a smaller impact. Competitive pressure will continue to be necessary to encourage the utilities to seek efficiency.

MARKET REFORM

The initiation of market liberalisation is one of Japan's major energy policy developments since the 1999 IEA in-depth review. Although the steps taken to date have been cautious, it is commendable that the government has launched the market reform process in recognition of its potential economic benefits. However, it should be recognised that price reductions do not automatically follow from partial, or even full, opening of market access to more players. An effective transition from monopolistic markets into competitive ones occurs when competition is not only introduced, but also strongly encouraged.

The 1999 review provided a set of criteria to judge whether sufficient competition has emerged. They included limited switching by liberalised customers, few new entrants and their complaints about discrimination in network services and abuse of market dominance, limited competition between the EPCos and regulatory difficulties with accounting separation. Consideration of the Japanese experience suggests that sufficient competition has not yet emerged

in the Japanese market. New entrants have raised concerns in relation to the market liberalisation approach discussed below.

Access to Supply

Possibilities for new entrants to access supply are rather limited. Building power plants takes a long time and the process is even more difficult if the new entrant or its partner does not possess a suitable site. One of the new entrants asserts that in some cases purchasing surplus power from autoproducers has been difficult because it may impact on prices of future electricity purchases from the EPCos. Furthermore, the utilities do not have any incentives – regulatory, commercial or other – to divest any of their generation assets.

It is a positive development that the EPCos have recently allowed new entrants to participate in the Economic Power Exchange. The government's proposal to institutionalise the power exchange and to develop it further can reduce new entrants' reliance on bilateral contracts for supply. However, this will depend on the actual volume of trading and prices. The new power exchange should be operated by a neutral organisation with a clear mandate, and made secure from individual stakeholders' interests.

Power plant project developers have to undergo three layers of environmental approval – national, prefectural and municipal – which causes delays in the process and increases cost. Though some simplification in procedures has taken place, further streamlining could be particularly helpful for new entrants without previous experience in dealing with the complex administrative structures.

Distributed generation is already exerting some competitive pressure and this appears to be one reason why utilities have recently cut prices. There are, however, some regulatory barriers to distributed generation. Selling excess distributed generation to another electricity customer through self power lines is generally not allowed, even though the ability to do so would improve the cost-effectiveness of a number of projects. The requirements for electrical protection equipment, which add at least 10% to the total cost of the facility, could also be simplified without sacrificing safety. Another factor is the behaviour of utilities in the partly liberalised market. Although METI guidelines clearly state that EPCos should not impede the development of self-generation, suppliers of distributed generation equipment have suggested that utilities discourage customers from developing their own distributed generation by selectively cutting their electricity rates.

Third-party Access Rules and Tariffs

At present, the TPA tariffs (wheeling tariffs) are high compared to those found in other countries. Pancaking, where each utility adds its own transmission

charges when electricity crosses its area, increases the transmission charge paid by network users. The government's proposal to abolish this pricing mechanism may contribute to encouraging inter-area electricity transactions.

Topography and seismic instability increase construction costs, and lead to higher transmission costs than in many other countries as do the high reliability requirements established by the utilities. A balance should, therefore, be sought between reliability and cost.

The EPCos require third-party users of their transmission networks to enter one-year wheeling contracts where new entrants must pay a fixed annual fee even if they do not use these networks during that year. In some cases the EPCos have also charged penalties for early termination of wheeling contracts. These practices increase TPA tariffs and reduce liquidity in the market. Rules for good conduct should be set by the regulatory authority.

Unbundling and Transmission System Operation

Cost transparency is a key to establishing competitive end-use tariffs as well as TPA charges and should reduce the possibilities for cross-subsidies between different consumer groups. Effective unbundling is also necessary to separate the potentially competitive businesses from those with monopolistic characters. To address these needs, the government decided in 1999 to introduce account unbundling. However, it is a concern that only voluntary disclosure of the balances (revenue and expenditure of wheeling services) by the EPCos has been implemented. Therefore, it is a positive step that the government intends to make it obligatory by amending the Electric Utilities Industry Law. In this regard, measures mentioned in the section on "Regulatory Reform" are indicated. This amendment also involves functional separation by establishing "information firewalls", *i.e.* ensuring that the generators have the same information on transmission systems as their clients when buying and selling power, and separating employees involved in transmission from those involved in power sales. It should be carefully monitored whether "information firewalls" are effective in ensuring information symmetry for the utilities' generation businesses *vis-à-vis* other players. More than half of IEA member countries (see Table 24) have gone beyond account or functional unbundling to create a level playing field for all market participants since transmission and generation businesses tend to conflict because transmission prices and profits are regulated, but those for generation are not.

It is not clear whether the new "neutral organisation" can address the possible shortcomings of account and functional unbundling mentioned above. Legal unbundling is a stronger form of unbundling which is implemented by establishing one national independent transmission system operator (TSO) or a few regional TSOs in the largest countries. If this approach is applied in Japan, it could mean establishing two independent TSOs to operate the two different frequency zones.

The utilities argue that legal or ownership separation of generation and transmission would reduce the incentives to build new transmission capacities and increase supply costs. The Central Research Institute of the Electric Power Industry estimates that legal separation would increase supply costs by 9% because of the substitutability[26] between generation and transmission property. It is true that integrated generation and transmission planning can bring some savings but the loss of any potential benefits of vertical integration should be evaluated against the potential benefits of effective competition. Since it is not sure that vertically integrated incumbents invest in electricity transmission and interconnections from the viewpoint of fair treatment, the "neutral organisation" is expected to supervise and handle this issue. Significant savings may also be achieved through effective pricing signals which encourage the construction of power plants in sites which optimise the use of existing transmission facilities instead of building new ones. Other countries, for example Canada and the United States, are trying to reduce the number of regional network operators because they consider that these will operate more efficiently and facilitate competition.

It is sometimes pointed out that an independent TSO is not suitable to Japanese circumstances where the transmission grid is the property of privately owned utilities. However, private rights of utilities have been affected during market reforms, sometimes through legislation, sometimes through negotiations resulting from government initiatives. An example of the former is Spain, where legislation stipulates the transmission network ownership be gradually transferred to the independent TSO (Red Eléctrica), including assets owned by fully private utilities. Modification to the European Directive on Electricity (in the process of approval) establishes the Transmission and Distribution System Operators as independent bodies from all other market players, but does not stipulate ownership unbundling.

Nonetheless, the government recognises the need for more formal co-ordination at national level in electricity transmission. At present, all transmission network owners fully manage and operate their networks, and co-operation between them – including transmission network planning – has not been institutionalised. The establishment of the new "neutral organisation" is a step in this direction. It can help with technical questions such as management of regional interconnections and provision of technical services needed by the power exchange operator. Though information has been disclosed on how the new body will be designed and what powers it will have, special attention needs to be given to ensuring a clear mandate and independence from market participants and other interest groups, as well as from government decision-making. In particular, it should be ensured that

26. The substitutability between power generation and transmission means savings are achieved when power generation planning is carried out together with transmission planning.

large incumbents will not have more power within the organisation than new entrants. Furthermore, it is necessary to avoid the new organisation becoming yet another consulting body to the government.

If market liberalisation is to be extended to smaller consumers, account unbundling of the retailing and distribution activities of EPCos will be necessary to avoid possibilities for cross-subsidisation and discrimination.

Regulation and the Regulatory Authority

The current international trend has been towards independent regulators either with regulatory powers or an advisory role (see Table 25). The METI has separated its policy-making and regulatory functions into two different departments, clarifying its functions in these areas. However, METI's regulatory department does not have a separate budget or autonomy in the management of human resources, which are both considered necessary to secure political independence.

The actual scope of political independence is determined not only by which of the above measures are adopted, but also by the powers of the regulatory agency. When an agency has broad powers, political independence would have significant implications for the regulatory framework and the structure of the industry.

There should be a balance between independence and accountability as well as achievement of objectives of market reform in the design of regulatory institutions. While theoretically it may be possible to achieve this by keeping the regulatory functions within METI in a separate department, it may be easier to increase the level of independence by establishing a regulator outside METI. However, IEA member countries' experience with the assessment of regulatory authorities is still very limited. As soon as more international experience as well as knowledge on the performance of METI's regulatory department is obtained, the government should assess whether the chosen institutional framework is optimal. Therefore, the establishment of an external regulator to METI should not be precluded. As an interim measure, consideration of ways to improve the political independence of the regulatory department within METI is warranted.

The regulatory process should concentrate on the elaboration of *ex ante* regulations to avoid abuse of the market position by EPCos. In some respects, this has been implemented through the guidelines prepared by METI for calculating TPA tariffs, and METI's authority to order a revision of the proposed TPA tariffs if deemed necessary. However, some details, such as new rules for implementing the TPA tariffs, are yet to be defined to ensure effective, fair and transparent TPA for all market players. These detailed rules should be set in a transparent manner as part of the regulatory process. The industry structure with vertically integrated EPCos makes it important to have

strong regulation and a strong regulatory authority. In countries with an independent transmission system operator there may be less need for such an interventionist approach.

The "neutral organisation" is planned to have a significant role in many key functions such as setting the rules for transmission network access and arbitration. It is important to ensure that such important tasks are undertaken by a body where the incumbent utilities do not have a significant influence. Therefore, much will depend on the design of the new body and its interface with the regulatory department of METI.

The role of the regulatory organisation will also be instrumental in designing the procedures for enabling smaller consumers to choose their supplier. This is planned to be discussed in 2007.

Dispute Settlement Mechanisms

The Electric Utilities Industry Law requires METI to handle complaints within a month after a case has been filed. However, in practice the response has often taken longer. It is important to solve issues promptly because this discourages the incumbents to abuse their market position and delaying access by entering into lengthy dispute settlement procedures.

Ancillary Services

Ancillary services, such as balancing power, must be accessible at tariffs that reflect costs and are non-discriminatory to ensure that new entrants can compete with the utilities. They do not know in advance exactly what the demand and load characteristics of their customers will be and yet they need to ensure that demand is covered at every moment. This continuous power balance is necessary so that they can secure contracts with final consumers. Typically, only large incumbents with a balanced generation mix can provide this service, making the new entrants dependent on them.

Current balancing power rules and associated costs have hampered new entrants in the power market because the rules have been stricter than those found in other countries. Therefore, the government proposal to relax this regulation may promote market entry without compromising reliability.

Regulatory Uncertainty

The government is gradually opening the electricity market. Many other countries have followed a similar step-by-step approach. Japan has not, however, defined steps towards further market opening at the outset of the process, but instead has taken the approach of evaluating the impact of each step before taking new ones. This is a very cautious approach reflecting Japan's concerns over energy security and environmental protection. On the

other hand, it should be noted that such regulatory uncertainty will make it difficult for the market players to adequately carry out long-term strategic planning and take investment decisions.

Conclusion about Market Reform

Significant effort is needed to achieve the potential benefits of market reform. The government proposal for further reform can help to a degree. In particular, proposals to remove pancaking of transmission tariffs may help to reduce costs of inter-area electricity transactions, and relaxation of the balancing power rules may also lower costs. It is also positive that clear criteria will be developed to evaluate whether TPA tariffs are at appropriate levels. The proposal, however, does little to address the fact that the incumbents are very large companies with significant market power compared to new entrants. Given the slow entry rate, competition between the incumbents is the solution. This may entail a risk of consolidation and mergers as seen in some European electricity markets, and due consideration should be given to maintaining adequate consumer choice. Also the number of players in the market is small and the pressure for the EPCos to reduce their prices may remain limited. The effectiveness of the planned unbundling arrangements, the "neutral organisation" and the regulatory institutions are paramount. The government should continuously monitor the effectiveness of these regulatory arrangements and not exclude taking stronger measures – such as establishing an independent transmission system operator – if competition does not develop within a reasonable time frame.

ELECTRICITY TRANSMISSION AND REGIONAL INTERCONNECTIONS

Japan's transmission grid, which has been developed on the basis of each supply region's self-sufficiency and weak interconnections between some regions, is facing new challenges. However, more bottlenecks will inevitably emerge as market liberalisation increases the need for trade across the country, as more renewables are connected to parts of the system and as electricity demand grows. The existing links and network management cannot accommodate these new trade patterns. Limited access to interconnections is also increasing electricity supply costs since power from low-cost generation sources may be unavailable where it is needed. The recent need to increase imports to the Tokyo region because of the closure of TEPCO's nuclear power plants demonstrates the benefits of strong interconnections for security of supply in such emergencies.

Strengthening the transmission networks and interconnection capacities is not an easy task owing to Japan's geography, siting issues and environmental criteria. Concerns over increased competition in their service areas can reduce

the willingness of the EPCos to invest in interconnections. Specific policy actions can improve the outlook for transmission development. Legal, administrative and regulatory processes should be streamlined to avoid unnecessary delays and uncertainty in the licensing of new installations. The roles of the various players involved in transmission – namely the "neutral organisation", incumbent utilities and the regulatory authority – must be clearly and consistently defined. A centralised system operation could facilitate interconnection, with associated benefits of increased reliability and lower costs. Transmission prices must allow adequate returns to investors and provide sufficient incentives to attract investment where needed. Pressures to reduce costs should not prevent adequate investment in grid maintenance and enlargement.

If Japan wishes to develop national electricity markets with active competition, the transmission issues, particularly interconnection issues, have to be resolved. For example, if all six utilities in the 60 Hz frequency zone of Japan were in a single electricity-trading region, no utility would have more than 35% share of generation capacity. These potential benefits must be weighed against the high cost of expanding transmission lines in Japan. The issue needs to be approached from regulatory, administrative as well as technical viewpoints. Open access to interconnections is a prerequisite for effective market integration. The current trend in Europe is to make transmission capacity available to all users through a capacity auctioning mechanism. To ensure effective use of transmission assets, it is usually required that, if a company does not use its reserved capacity, it has to release it to other users. Establishing such a mechanism would enhance the economic use of transmission assets and ensure fair and transparent access.

RECOMMENDATIONS

The government of Japan should:

- *Promote pricing mechanisms and other demand measures which help moderate peak loads.*
- *Ensure an effective level of unbundling to facilitate fair and effective competition. As a first step, immediately implement the account unbundling and "information firewalls" for separation of transmission from generation and retail activities to level the playing field between incumbents and new entrants. If fair and effective competition does not emerge, the government should not preclude establishing a single independent transmission system operator to manage the national network.*
- *Strengthen the regulatory framework with emphasis on an* ex ante *basis. Ensure the independence of the regulatory authority from industry and the*

industry development activities of METI, and as a second step, assess the benefits of creating a regulator completely independent from METI.

- *Foster the strengthening of an inter-regional transmission grid in a cost-effective way, particularly between the two frequency areas, to improve security of supply and facilitate effective competition. Improve the possibilities for access to interconnections by measures such as auctioning the capacities.*

RESEARCH AND DEVELOPMENT

POLICY OBJECTIVES

The Japanese government's Science and Technology Basic Plan for 2001-2005 identifies environmental R&D as one of a few priority R&D areas. Energy R&D is included into the environmental R&D because energy-related CO_2 emissions account for about 90% of Japan's GHG emissions. The Advisory Committee for Natural Resources and Energy points out that the development of energy-related technologies will play a central role in trying to simultaneously fulfil the "3 Es" (energy security, economic development and environmental sustainability).

Energy R&D is expected to play a significant role in achieving the following energy policy objectives as well as meeting the 6% GHG emissions reduction commitment under the Kyoto Protocol and, therefore, emphasis is on the following near-term objectives:

- Achievement of the energy conservation target of 53 Mtoe by 2010, compared to a business-as-usual scenario.
- Increasing the use of "new energies" to about 3% of TPES by 2010.
- Reducing the environmental burden imposed by fossil fuels.
- Increasing the volume of nuclear power generation by 30% between 2000 and 2010.

To achieve these objectives, the Science and Technology Basic Plan identifies the following R&D areas: promoting energy efficiency; reducing energy supply, transformation, distribution and use costs while enhancing convenience and performance; expanding the use of new gas technologies including gas-to-liquid (GTL) and dimethyl ether (DME); and nuclear fuel cycle.

INSTITUTIONS

The ministries responsible for energy R&D are:

- The Ministry of Economy, Trade and Industry: renewable energy, energy efficiency, and technologies relating to climate change.
- The Ministry of Education, Culture, Sports, Science and Technology (MEXT): fission and fusion research and development and basic research carried out in universities and institutes.

- The Ministry of Environment, the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Land, Infrastructure and Transport, all have very small energy-related R&D programmes.

The National Institute of Advanced Industrial Science and Technology (AIST) operates under METI and superintends 15 research institutes. AIST is responsible for nuclear power development (principally through the Japan Atomic Energy Research Institute) and basic research on climate change. It also conducts R&D on environment-friendly production process technologies, pollution and chemical substance risk management and reduction technologies, energy diversification and development of integrated assessment of environmental and energy systems.

The New Energy and Industrial Technology Development Organisation (NEDO) was established in 1980 as a semi-governmental organisation under METI. NEDO's activities include development and promotion of new energy and energy conservation technologies, management of industrial technology R&D projects, restoration of damaged coal-mining areas and international co-operation involving joint R&D and information exchange.

The Japan Nuclear Fuel Cycle Development Institute (JNC) has developed the key technology of the fast breeder reactor (FBR) cycle, which includes uranium enrichment technology, FBR technology, plutonium and MOX fabrication technology, reprocessing technology and high-level radioactive waste disposal technology.

ENERGY R&D BUDGETS

Japan has the largest energy R&D budget within IEA member countries. If measured in proportion to GDP, Japanese energy R&D expenditure is the largest among IEA member countries and third-largest for non-nuclear energy R&D. However, because of differences in definitions and classification as compared to those used by the IEA, and consequent discrepancies, the budget information below is indicative.

In 2001, out of the total energy R&D budget, the share of nuclear fission and fusion technologies was 70%. The non-nuclear energy R&D budget increased in the first half of the 1990s and has remained steady. Accordingly, its share in the total energy R&D budget has also increased from 19% in 1990 to 30% in 2001. In 2001, energy efficiency received 56% of the total non-nuclear energy R&D budget followed by power and storage technology (17%), renewables (13%), fossil fuels (7%) and other areas (8%).

86% of the R&D budget for energy efficiency is spent on industrial energy efficiency projects. In 2001, the total government budget for renewables was mainly used for photovoltaics (62%), geothermal energy (15%) and biomass (12%), and the rest for wind and ocean energy. However, much more is used

for the promotion of renewables rather than for R&D, and in FY2002 this budget totalled ¥96 billion; 56% of the budget for R&D on fossil fuels is used for coal technologies and the remaining for oil and natural gas technologies. The budget for fuel cells was ¥22.0 billion in FY2002, of which ¥2.5 billion was used for demonstration.

The budget for nuclear fission R&D increased in the early 1990s and has remained at about ¥280 billion. It covers a wide range of R&D activities including radiation, accelerator and nuclear safety research. The level is approximately equivalent to the capital cost of one nuclear power plant. Expenditure on R&D on nuclear fusion peaked in the early 1980s owing to the construction of one main facility, stabilised for ten years and peaked again in the mid-1990s with another major project. Since then, expenditure declined but is now kept at a certain level.

Table 28

Government Energy R&D Budget[1]

(billion ¥)

Sector	*1990*	*1995*	*1998*	*1999*	*2000*	*2001*
Non-nuclear	70	111	129	124	128	129
• *Energy efficiency*	*0.4*	*30.0*	*53.6*	*64.3*	*68.7*	*72.0*
• *Fossil fuels*	*41.6*	*45.2*	*32.4*	*19.5*	*12.8*	*9.0*
• *Renewables*	*14.0*	*13.1*	*14.6*	*15.3*	*18.1*	*16.2*
• *Power & storage technology*	*11.2*	*8.5*	*15.6*	*16.0*	*19.5*	*22.1*
• *Other*	*2.5*	*14.4*	*13.0*	*8.4*	*8.9*	*9.8*
Nuclear fission	266	298	282	280	281	281
Nuclear fusion	31	36	30	30	28	24
Total	**368**	**446**	**442**	**433**	**436**	**434**

1. The table has been prepared trying to exclude budgets for promotion of technologies but it is not certain that these are always excluded. It also appears that the R&D budget for fuel cells is mainly under "Energy efficiency" but may have been partly reported under "Renewables" and "Other".

Source: Country submission.

MAJOR R&D PROGRAMMES

ENERGY EFFICIENCY

In 2002, individual R&D projects in energy efficiency were grouped under a research programme called "Innovative Technologies that Cope with Global Warming". This comprises R&D projects for technologies that reduce CO_2 emissions by drastically diminishing energy consumption.

The vast majority (86%) of publicly funded R&D on energy efficiency is used for projects improving energy efficiency in industry, particularly to support the implementation of the Voluntary Action Plan by industries (See Chapter 4). Activities cover super-conductivity, hybrid construction machinery, next-generation scientific process technologies and more efficient motors. In the process industry, particular attention is paid to improving the operational energy efficiency of industrial establishments as a whole rather than developing technologies for individual stages. Other R&D areas are thermal storage systems and heat/power exchangers for industrial complexes. Attention is also given to the spillover of technologies; new energy-saving technologies are first adopted in industry and then spread into individual households to improve the cost-effectiveness of R&D.

The Home Energy Management System is an example of publicly funded R&D activities in the buildings sector. R&D on the Business Energy Management Systems is financed by the private sector. Other publicly funded efforts include technologies for more efficient use of heat (heating, air-conditioning and hot water systems using, for example, micro co-generation), electric and electronic appliances and lighting as well as improving the thermal performance of buildings under renovation.

In 2002, a programme was launched to develop next-generation low-pollution vehicles. Efforts on hybrid vehicles concentrate on better adaptation to the customer needs and cost reductions. R&D is carried out to support commercialisation of two- and four-tonne natural gas-fuelled trucks with highly efficient low-pollution engines. In March 2001, the number of hybrid vehicles was 37 300, natural gas vehicles 5 300, and electric vehicles 2 400.

FOSSIL FUELS

This area concentrates on technologies for oil production, mainly benefiting Japanese companies overseas, and on cleaner use of oil and gas. Most of the R&D is carried out by the Japan National Oil Corporation (JNOC) both in Japan and internationally (*e.g.* announcement of international research on prospecting results and joint R&D with oil-producing nations). Technology development concentrates on low-permeability, non-homogeneous carbonate stratum, high-precision imaging, methane hydrates, gas-to-liquids technology and drilling.

In 1994-2000, activities in the area of methane hydrates included basic R&D and two research wells, the Mallik Gas Hydrate Production Research Well (Mackenzie Delta, North-West Territories, Canada) and METI's exploitation test well "Nankai". After these activities were completed, the "National Methane Hydrate Exploitation Programme" was established in July 2001 for a period of 16 years. The programme is implemented by the Research Consortium

for Methane Hydrate Resources in Japan (MH21 Research Consortium), established in March 2002, with wide representation from the industry and research community. The consortium collaborates with partners from Canada and the United States.

To further reduce the environmental burden of fossil fuels, technologies are developed for the transport sector, such as new catalysts for desulphurisation. At the same time, R&D, including demonstration, is conducted to promote the use of dimethyl ether, which can be produced from natural gas, coal and other fossil fuels, and is drawing increasing attention as a potential clean fuel.

RENEWABLES

The major emphasis in R&D on renewable energy sources is on photovoltaics (PV). The objective is to reduce costs and improve performance. R&D areas include silicon crystal thin-film solar batteries, compound solar batteries, and technologies for recycling, re-using and disposal of batteries. NEDO finances four R&D programmes for PV:

- Advanced Solar Cells and Modules (2001-2005).
- Photovoltaic System Technology for Mass Deployment (2001-2005).
- Innovative Photovoltaic Technology (2001-2005).
- Advanced Manufacturing Technology for PV Power Generation Systems (2000-2004).

R&D on biomass concentrates on improvements in conversion efficiency and developing technologies which do not result in net increases in carbon dioxide emissions. Research is being conducted on the production of liquid and gaseous fuels, such as alcohol and methane, from forest and agricultural biomass.

R&D on windmill technology has been terminated. Priority areas in wind energy R&D are site selection, control technologies, system reliability and the establishment of large-scale wind power generation systems, as well as transmission network stabilisation.

POWER & STORAGE TECHNOLOGY

At present, integrated gasification combined cycle (IGCC) technology for coal is on course for demonstration tests while integrated gasification fuel cell (IGFC) has been undergoing a pilot test. When they come into practical application, IGCC is expected to achieve 46-48% and IGFC 55% net efficiency. IGFC is also estimated to produce 30% less CO_2 emissions compared to existing

pulverised coal-fired power generation systems. The Centre for Coal Utilisation of Japan forecasts practical use of IGFC to begin around 2020 with commercial use of 600 MW class units. Other areas of R&D are advanced pressurised fluidised bed combustion (A-PFBC), increasing the efficiency of ultra super critical (USC) technologies, advanced coal-to-coke conversion (SCOPE 21), ash-free coal for direct firing (Hyper Coal), hydrogen production from coal with CO_2 recovery (Hyper Ring), flue gas treatment and coal ash use.

Japan has the largest and longest-running carbon capture and sequestration technologies research programme among the IEA countries. The Research Institute of Innovative Technology for the Earth (RITE) was established by the METI in 1990 as a non-profit organisation to focus on the development of innovative environmental technologies and the broadening of the range of CO_2 sinks. With a budget of ¥9.9 billion RITE has been conducting R&D and research investigations as well as providing information to the public regarding advanced technologies and research. The different projects under way are:

- Biological CO_2 fixation and utilisation.
- Chemical CO_2 fixation and utilisation.
- Biological CO_2 fixation in desert areas.
- Study on environmental assessment for CO_2 ocean sequestration for mitigation of climate change.

OTHER NON-NUCLEAR ENERGY R&D (FUEL CELLS)

In 2001, individual R&D projects in fuel cells were grouped under a programme called "Polymer Electrolyte Fuel Cell and Hydrogen Energy Utilisation Technology".

The Japanese government has a keen interest in developing fuel cell technology. However, the use of fuel cells is subject to several major challenges such as performance in terms of durability and economical efficiency, building of infrastructures (such as fuelling stations), codes and standards, development of legal systems including standards and regulations, and overcoming the resource constraints such as platinum – all in harmony with social acceptability. A great deal of R&D is being implemented to address these challenges, including development of component technologies for solid polymer membranes and platinum catalysts, manufacturing and reforming technologies for fuels used in fuel cells, improvement of manufacturing, transport and storage technologies for hydrogen fuel. While publicly funded R&D on fuel cells covers both technology and infrastructure (meaning H_2 production, transportation and storage), the government also focuses on infrastructure, demonstration projects as well as development and improvement of standards and regulation.

The objectives of demonstrations include improvement of public acceptance as well as obtaining data on, for example, energy efficiency, cost and emissions.

At present, Japan is demonstrating the use of fuel cells in cars and stationary applications. A few filling stations have been opened. The government has a target of 50 000 fuel-cell vehicles in use by 2010 and 5 million in 2020. Although fuel-cell vehicle prices are currently high, the government is working with industry to make them competitive compared to conventional vehicles. Other challenges include hydrogen production, transportation and storage.

METI started demonstration projects for stationary fuel cells in 2002. Governmental targets for stationary fuel-cell applications are 2.1 GW in 2010 and 10 GW in 2020.

NUCLEAR FISSION AND FUEL CYCLES

Japan has a large nuclear R&D programme. Areas include uranium enrichment, advanced reactor technologies, and fuel cycle technologies such as MOX fuel processing and disposal of high-level radioactive waste. Since the Japanese nuclear R&D programme covers a wide range of activities including radiation, accelerator and nuclear safety research, only a few examples of key activities in these areas are given below.

Japan is actively engaged in developing advanced nuclear reactors and related fuel cycle technologies in order to seek a wide range of future technologies. Both MEXT and METI operate researcher-oriented technology promotion programmes to support various research and development activities among manufacturers, universities and research institutes. Japan has also been actively participating in the GIF (Generation IV International Forum) activities to develop advanced nuclear systems. Under these frameworks, advanced nuclear systems including light-water reactors, gas-cooled reactors, sodium-cooled fast reactors, advanced reprocessing facilities and other fuel cycle technologies are being developed. Major domestic developers are JNC, Japan Atomic Energy Research Institute (JAERI), JNFL, the Central Research Institute of Electric Power Industry, manufacturers and universities.

In July 1999, JNC started the "Feasibility Study on Commercialised Fast Reactor (FR) Cycle Systems" (in co-operation with electric power companies and other related institutes), which proposes the FBR system. This has the advantage of an effective use of resources, reduction of the environmental burden, proliferation resistance and economic competitiveness with the LWR system. Phase I, in which the highly feasible candidate concepts for FR Cycle System had been identified, was completed and, subsequently, activities were shifted to Phase II (lasting approximately five years). During Phase II, consistency of the entire FR cycle will be pursued, based on engineering

experiments, and candidate concepts, screened in Phase I, will be narrowed down.

JNC's Uranium Enrichment Demonstration Plant at Ningyotoge, operating since 1988, was terminated in March 2001. Expertise acquired by JNC through the operation of the uranium enrichment plant was transferred to JNFL. JNFL's uranium enrichment facilities started operation in 1992. In FY2000, it initiated a development project for new centrifugal separators with the highest level of performance and cost-efficiency. The national subsidy programme started in FY2002 with the target of drawing up basic specifications by the end of FY2003 with final specifications by the end of FY2005, testing the cascades in 2006-2009 and installing equipment in the Rokkasho Uranium Enrichment Plant around 2010.

Domestic power companies plan to start using MOX fuel in 16-18 commercial LWRs by 2010. JNC's Tokai Reprocessing Plant started operation in 1977. The first commercial-scale reprocessing plant is planned to open by 2009. Tests have been carried out since FY1999 to confirm the adaptability of the various technologies for the plant, including their operational performance, stability and ease of maintenance, with particular emphasis on reliability. Investigation of the testing method and equipment was carried out by FY2000 and a series of verification tests were performed in FY2002.

In November 2000, AEC specified the R&D framework on final disposal of spent nuclear fuel. NUMO is responsible for conducting focused R&D for safe implementation of the repository. The government and relevant organisations carry out R&D for establishing safety regulation. JNC is required to ensure the reliability of repository technology. Therefore, it has established safety assessment methodology, based partly on experience from the underground research projects in Mizunami (research on crystalline rock), Horonobe (research on sedimentary rock) and the QUALITY facility in Tokai. A surface-based investigation on the Mizunami project started in 1996 and in Horonobe in 2001. Shaft sinking in Mizunami will start in 2003 and in Horonobe in 2005. The main research excavation in both facilities is estimated to be completed by the end of this decade. In 2000, JNC selected the site for constructing an underground facility in Horonobe.

NUCLEAR FUSION

ITER (International Thermonuclear Experimental Reactor) is a major international collaborative scientific and technological project with the goal of fusion development. Negotiations began in November 2001 towards the joint implementation of the project with the participation of Canada, the EU, Japan and the Russian Federation. In June 2002, Japan proposed Rokkasho

village in Aomori Prefecture as the Japanese ITER candidate site. In January 2003, the United States and China joined the negotiations. The final site selection is scheduled for the autumn of 2003.

At the same time, the Japanese fusion R&D programme has made progress. In 2001, it was discovered in a large Tokamak device JT-60 at the Japan Atomic Energy Research Institute that a hot currentless plasma core can be kept stable. In 2001, the National Institute for Fusion Science achieved an electron temperature of 100 million degrees Celsius in the Large Helical Device (LHD). Osaka University succeeded in a proof-of-principle experiment of fast ignition in laser inertial fusion.

In January 2003, the Working Group on Fusion Research, set up under the Council for Science and Technology, issued a report "The Future of Fusion Research in Japan". The report suggests that public efforts should concentrate on the following technologies: Tokamak, helical, inertial fusion and nuclear technology of fusion reactors. In addition, it recommends that inter-university and inter-institutional research be strengthened and a plan prepared for the development of human resources.

EVALUATION

The Guidelines for Technology Evaluation were established in 1997. They were updated in April 2002 by the issuing of the Government Policy Evaluation Act. The basic objective of the guidelines is to maintain transparency, neutrality, continuity and a high level of effectiveness of evaluations. This means that evaluation results will be made public, outside experts are used, evaluation is conducted repeatedly and that R&D budgets and activities will reflect evaluation results appropriately.

Most evaluations of governmental energy R&D programmes and projects are done by METI but outside experts are also used. Preliminary evaluations by METI are made by the department in charge of projects. In other stages – such as interim evaluation, post-evaluation and follow-up evaluation which occurs several years after completion of the project – METI's Technology Review and Evaluation Division may assist the department concerned. The METI plans to allocate future energy R&D budgets based on the evaluation results.

NON-GOVERNMENTAL R&D

The government has introduced incentives to stimulate the private sector to perform energy technology research, development and demonstration. Tax incentives are given for private companies' R&D activities. Tax credits of 6%

are given for certain research expenses such as efficient use of energy and use of recycled resources; 5% of the value of acquired assets is deductible from corporate income tax only when they are considered by the Ministry of Finance to be useful for R&D on key technologies. Special depreciation and other privileges are applied with regard to the taxable income of the Research Association for Mining & Manufacturing Technology when such income constitutes a payment from its members to acquire equipment and materials for research purposes.

The AIST makes an effort to collaborate with the industry by disseminating the publicly financed results to the industry which can, in some cases, also apply public subsidies for implementing these technologies. The AIST, in co-operation with NEDO, also tries to create R&D co-operation between businesses, academic professionals and government bodies through organising research consortiums where technologies invented by national laboratories and universities are made available. The objective of such collaboration is to create new industry.

The Federation of Electric Power Companies and the Central Electric Power Council plan R&D for the electricity sector on behalf of all companies. In FY2002, the Japanese electricity industry, as reported by the Central Electric Power Council, spent ¥154 billion on research and development, down from the peak of about ¥200 billion in the mid-1990s: 33% of the FY2002 budget was used for R&D on nuclear power, 34% on "strengthening competitiveness" (construction and operation of facilities, user applications, information technology, superconductivity, etc.), 11% on networks and storage, 7% on environmental projects and 16% on other applications.

INTERNATIONAL COLLABORATION

Japan participates in most of the IEA Implementing Agreements[27]. A bilateral energy R&D collaboration agreement was signed with the United States in 1979. Collaboration with Australia in coal technologies R&D started in 1990. The main areas of international co-operation with less developed Asian countries are renewables (Malaysia, Mongolia, Nepal and Thailand), clean

27 Japan participates in the following IEA Implementing Agreements: Advanced Fuel Cells; Advanced Materials for Transportation; Advanced Motor Fuels; Bioenergy; Buildings and Community Systems; Clean Coal Centre; Clean Coal Science; Demand Side Management; Energy Conservation and Emissions Reduction in Combustion; Energy Storage; Energy and Environmental Technology Information Centres (EETIC); Energy Technology Data Exchange (ETDE); Energy Technology Systems Analysis Programme (ETSAP); Enhanced Recovery of Oil; Fluidised Bed Conversion; Geothermal Energy; Greenhouse Gas R&D Programme; Heat Pumping Technologies; Hybrid and Electric Vehicles; Hydrogen; Hydropower; Ocean Energy Systems; Photovoltaic Power Systems; Solar Heating and Cooling; High-temperature Superconductivity; and Wind Energy. In addition, Japan participates in most of the Fusion Power Implementing Agreements.

coal technologies (China, Indonesia, Mongolia and Russia) and energy conservation (China, Thailand and Vietnam). These activities are co-ordinated and implemented by NEDO. Through co-operation with developing countries, NEDO engages in demonstration trials and research for the introduction and spread of new energy and energy conservation technologies, as well as research and model projects for the diffusion of environment-friendly coal technologies.

CRITIQUE

The Japanese public energy R&D programme has remained stable over the past few years and is the largest among IEA member countries. The overall balance and priorities in Japan's energy R&D portfolio cover a wide range of technologies that could contribute towards its energy and environment policy objectives as well as to the creation of new industry and employment. However, it is difficult to evaluate the level of effort as well as to make comparisons with other countries because it is not clear whether financing for the promotion of renewables and nuclear power is included in Japan's reported R&D budgets.

Further attention should be given to ensure that the overall R&D portfolio is appropriately balanced across the near, mid and long term; across degrees of risk and across other relevant considerations. Traditionally, the Japanese energy R&D programme has included both short- and long-term objectives. However, emphasis has been shifting recently towards more near-term benefits, the main reason being the extremely challenging climate goal for 2010. Subsequently, a balance should be sought, given the long time needed to develop many potentially competitive technologies.

Improved energy technology is essential if the "3 Es" are to be met. More effort is needed, with due consideration to cost-effectiveness, to enhance energy efficiency and drive forward the development of renewables, given the contribution they are expected to make in the medium to longer term. Sharing of experiences with other IEA countries may also offer opportunities in this regard. The contribution Japan is making to multilateral collaboration on both renewables and greenhouse gas R&D with developing countries is to be commended.

Advanced large-scale deployment of many technologies, which could help Japan meet its climate change targets in 2010 and beyond, will require commercial scale demonstration. Such demonstration plants will be particularly important for both advanced coal plants, methane hydrates recovery, large-scale CO_2 sequestration, and new and renewables technologies, given the substantial commercial risk such technologies may pose.

Japan has made significant R&D efforts on fuel cells and hydrogen. However, many important issues such as hydrogen production, transportation, distribution and storage, as well as some focused basic materials research, remain to be solved by Japan and the international scientific community. The government's policy is to shift the focus of R&D on fuel cells from materials research to developing infrastructures and to leave R&D on fuel cells to the industry. This is sensible because much of the basic research has been done and the industry will finally benefit.

The development of methane hydrates may be an interesting long-term prospect for Japan which has few indigenous energy sources. It is, however, a significant challenge both in terms of technology and uncertainty about production costs. Japan is making efforts to overcome these challenges and to start commercial production in the 2010s to the 2020s, but there is great uncertainty within this time frame because the technologies to produce methane hydrates do not yet exist and there is little information on cost and future commercial viability. Nevertheless, efforts could be intensified given that the current expenditure of the total energy R&D budget in this area is well below 1%.

Another promising area receiving attention, but should receive more, is clean coal technologies which only receive about 1% of the total energy R&D budget. Coal is the cheapest fuel for power generation and its use is increasing in the liberalised markets but causes environmental damage and greenhouse gas emissions. The efficiency of coal technologies needs to be further improved and new technologies developed to address these issues. R&D on coal technologies should, however, be conducted in parallel with technologies for addressing CO_2 emissions.

Japan has a programme under way on carbon sequestration. Overall, such research will be very important in making fundamental decisions on the use of fossil energy resources in the future. Japan should pursue aggressive research in this area and continue to search for, and develop, opportunities for collaborative research and demonstration with other countries.

Japan's expenditure on research and development in nuclear energy technologies is considerable and covers a wide range of topics. This is consistent with its strategic approach of developing nuclear energy. However, taking into account the electricity market reform that should also expose nuclear power to competition, and the competitiveness of existing nuclear units, it may be appropriate to re-evaluate the cost-effectiveness of nuclear R&D efforts. R&D on advanced fission reactors is valuable because these may become safer, more sustainable and more cost-effective energy sources in the long term. However, a balance should be sought between public and private expenditures on these technologies. This also applies to R&D in enrichment and MOX technologies which are available on the world market.

Attention should also be given, where it is not already, to monitoring and evaluating the effectiveness of public R&D programmes. Particular care should be given to maintaining the R&D effort, while separately funding deployment activities so that their support does not come at the expense of the core R&D. However, some deployment activities are intended to enhance technology learning, *i.e.* to reduce costs and help technologies become more competitive.

The government is making efforts to co-operate with the industry and to encourage industrial R&D activities. Government-financed R&D can be considered justified in many cases as R&D on some technologies entails risks which the industry cannot carry. However, the government should not finance such R&D, including demonstration, which the industry would conduct without receiving government support, such as energy efficiency measures in the context of the voluntary commitments by the industry.

RECOMMENDATIONS

The government of Japan should:

- *Continue to pursue a balanced portfolio of R&D with due attention to adequate support for long-term R&D.*
- *Seek an increasing cost-sharing from industries where possible, especially when they benefit from successful R&D.*

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	2000	2001	2010	2020	2030
TOTAL PRODUCTION		**29.5**	**73.3**	**105.5**	**104.1**	..	..	..
Coal[1]		17.9	4.6	1.6	1.6	..	..	..
Oil		0.8	0.7	0.8	0.7	..	..	..
Gas		2.3	1.8	2.2	2.2	..	..	..
Comb. Renewables & Wastes[2]		–	4.4	5.8	5.2	..	..	..
Nuclear		2.5	52.7	83.9	83.4	..	..	..
Hydro		5.7	7.7	7.5	7.2	..	..	..
Geothermal		0.2	1.5	2.9	3.0	..	..	..
Solar/Wind/Other		–	0.0	0.9	0.9	..	..	..
TOTAL NET IMPORTS[3]		**300.7**	**364.2**	**422.6**	**413.0**	..	..	..
Coal[1]	Exports	0.4	1.1	1.8	1.2	..	..	..
	Imports	41.3	70.0	96.1	99.5	..	..	..
	Net Imports	40.9	68.9	94.3	98.4	..	..	..
Oil	Exports	2.9	3.8	4.4	4.8	..	..	..
	Imports	276.7	262.6	273.7	261.5	..	..	..
	Bunkers	16.8	5.1	4.8	4.1	..	..	..
	Net Imports	257.0	253.6	264.5	252.6	..	..	..
Gas	Exports	–	–	–	–	..	..	..
	Imports	2.8	41.7	63.8	62.0	..	..	..
	Net Imports	2.8	41.7	63.8	62.0	..	..	..
Electricity	Exports	–	–	–	–	..	..	..
	Imports	–	–	–	–	..	..	..
	Net Imports	–	–	–	–	..	..	..
TOTAL STOCK CHANGES		**-6.6**	**-1.0**	**-3.9**	**3.6**	..	..	..
TOTAL SUPPLY (TPES)		**323.6**	**436.5**	**524.2**	**520.7**	..	..	..
Coal[1]		57.9	74.0	95.7	100.2	..	..	..
Oil		252.2	253.0	261.6	256.1	..	..	..
Gas		5.1	43.3	65.9	64.8	..	..	..
Comb. Renewables & Wastes[2]		–	4.4	5.8	5.2	..	..	..
Nuclear		2.5	52.7	83.9	83.4	..	..	..
Hydro		5.7	7.7	7.5	7.2	..	..	..
Geothermal		0.2	1.5	2.9	3.0	..	..	..
Solar/Wind/Other		–	0.0	0.9	0.9	..	..	..
Electricity Trade[4]		–	–	–	–	..	..	..
Shares (%)								
Coal		*17.9*	*16.9*	*18.3*	*19.2*	..	..	..
Oil		*77.9*	*58.0*	*49.9*	*49.2*	..	..	..
Gas		*1.6*	*9.9*	*12.6*	*12.4*	..	..	..
Comb. Renewables & Wastes		–	*1.0*	*1.1*	*1.0*	..	..	..
Nuclear		*0.8*	*12.1*	*16.0*	*16.0*	..	..	..
Hydro		*1.8*	*1.8*	*1.4*	*1.4*	..	..	..
Geothermal		*0.1*	*0.3*	*0.5*	*0.6*	..	..	..
Solar/Wind/Other		–	–	*0.2*	*0.2*	..	..	..
Electricity Trade		–	–	–	–	..	..	..

0 is negligible, – is nil, .. is not available.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2000	2001	2010	2020	2030
TFC	**234.4**	**293.4**	**347.5**	**342.1**	**..**	**..**	**..**
Coal[1]	20.2	22.5	21.6	20.8	..	..	..
Oil	171.5	188.3	221.0	218.5	..	..	..
Gas	7.0	14.7	20.2	20.4	..	..	..
Comb. Renewables & Wastes[2]	–	2.6	2.7	2.2	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	0.8	0.7	..	..	..
Electricity	35.7	65.1	80.8	79.1	..	..	..
Heat	0.0	0.2	0.4	0.4	..	..	..
Shares (%)							
Coal	*8.6*	*7.7*	*6.2*	*6.1*	..	..	..
Oil	*73.2*	*64.2*	*63.6*	*63.9*	..	..	..
Gas	*3.0*	*5.0*	*5.8*	*6.0*	..	..	..
Comb. Renewables & Wastes	–	*0.9*	*0.8*	*0.7*	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	*0.2*	*0.2*	..	..	..
Electricity	*15.2*	*22.2*	*23.3*	*23.1*	..	..	..
Heat	–	*0.1*	*0.1*	*0.1*	..	..	..
TOTAL INDUSTRY[5]	**140.2**	**134.5**	**139.4**	**131.6**	**..**	**..**	**..**
Coal[1]	18.2	21.7	21.3	20.8	..	..	..
Oil	94.9	73.3	73.4	68.1	..	..	..
Gas	2.1	4.6	8.1	8.4	..	..	..
Comb. Renewables & Wastes[2]	–	2.5	2.7	2.2	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	–	–	..	..	..
Electricity	25.1	32.4	33.9	32.1	..	..	..
Heat	–	–	–	–	..	..	..
Shares (%)							
Coal	*13.0*	*16.2*	*15.3*	*15.8*	..	..	..
Oil	*67.7*	*54.4*	*52.7*	*51.8*	..	..	..
Gas	*1.5*	*3.4*	*5.8*	*6.4*	..	..	..
Comb. Renewables & Wastes	–	*1.8*	*1.9*	*1.7*	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	–	–	..	..	..
Electricity	*17.9*	*24.1*	*24.3*	*24.4*	..	..	..
Heat	–	–	–	–	..	..	..
TRANSPORT[6]	**42.6**	**74.3**	**95.0**	**96.1**	**..**	**..**	**..**
TOTAL OTHER SECTOR[7]	**51.6**	**84.5**	**113.1**	**114.4**	**..**	**..**	**..**
Coal[1]	1.8	0.8	0.2	–	..	..	..
Oil	35.3	42.5	54.1	55.9	..	..	..
Gas	5.0	10.1	12.1	12.0	..	..	..
Comb. Renewables & Wastes[2]	–	0.1	0.0	0.0	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	0.8	0.7	..	..	..
Electricity	9.5	30.9	45.3	45.3	..	..	..
Heat	0.0	0.2	0.4	0.4	..	..	..
Shares (%)							
Coal	*3.4*	*0.9*	*0.2*	–	..	..	..
Oil	*68.5*	*50.2*	*47.9*	*48.8*	..	..	..
Gas	*9.6*	*11.9*	*10.7*	*10.5*	..	..	..
Comb. Renewables & Wastes	–	*0.1*	–	–	..	..	..
Geothermal	–	–	–	–	..	..	..
Solar/Wind/Other	–	–	*0.7*	*0.7*	..	..	..
Electricity	*18.4*	*36.6*	*40.1*	*39.6*	..	..	..
Heat	*0.1*	*0.2*	*0.4*	*0.4*	..	..	..

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2000	2001	2010	2020	2030
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**90.6**	**169.4**	**221.6**	**217.2**	**..**	**..**	**..**
OUTPUT (Mtoe)	**40.0**	**73.2**	**90.9**	**88.9**	**..**	**..**	**..**
(TWh gross)	465.4	850.8	1056.9	1033.2	..	..	..
Output Shares (%)							
Coal	*8.0*	*14.5*	*21.3*	*23.1*	..	..	..
Oil	*73.2*	*29.7*	*13.9*	*11.3*	..	..	..
Gas	*2.3*	*19.4*	*24.5*	*24.9*	..	..	..
Comb. Renewables & Wastes	*–*	*2.0*	*1.2*	*0.7*	..	..	..
Nuclear	*2.1*	*23.8*	*30.5*	*31.0*	..	..	..
Hydro	*14.3*	*10.5*	*8.3*	*8.1*	..	..	..
Geothermal	*0.1*	*0.2*	*0.3*	*0.3*	..	..	..
Solar/Wind/Other	*–*	*0.0*	*0.0*	*0.0*	..	..	..
TOTAL LOSSES	**94.6**	**142.0**	**176.5**	**171.9**	**..**	**..**	**..**
of which:							
Electricity and Heat Generation[9]	50.5	96.1	130.3	128.0	..	..	..
Other Transformation	25.1	23.3	24.4	23.3	..	..	..
Own Use and Losses	19.0	22.6	21.8	20.6	..	..	..
Statistical Differences	**–5.4**	**1.1**	**0.2**	**6.8**	**..**	**..**	**..**

INDICATORS

	1973	1990	2000	2001	2010	2020	2030
GDP (billion 1995 US$)	2618.63	4935.97	5680.57	5647.68	..	..	..
Population (millions)	108.66	123.54	126.93	127.21	..	..	..
TPES/GDP[10]	0.12	0.09	0.09	0.09	..	..	..
Energy Production/TPES	0.09	0.17	0.20	0.20	..	..	..
Per Capita TPES[11]	2.98	3.53	4.13	4.09	..	..	..
Oil Supply/GDP[10]	0.10	0.05	0.05	0.05	..	..	..
TFC/GDP[10]	0.09	0.06	0.06	0.06	..	..	..
Per Capita TFC[11]	2.16	2.37	2.74	2.69	..	..	..
Energy-related CO_2 Emissions (Mt CO_2)[12]	891.2	1018.7	1149.9	1132.3	..	..	..
CO_2 Emissions from Bunkers (Mt CO_2)	58.6	29.6	35.0	31.7	..	..	..

GROWTH RATES (% per year)

	73–79	79–90	90–00	00–01	01–10	10–20	20–30
TPES	1.5	1.9	1.8	–0.7	..	..	..
Coal	–2.0	3.4	2.6	4.6	..	..	..
Oil	0.4	–0.2	0.3	–2.1	..	..	..
Gas	24.2	8.0	4.3	–1.6	..	..	..
Comb. Renewables & Wastes	–	–	2.8	–9.6	..	..	..
Nuclear	39.1	10.1	4.8	–0.7	..	..	..
Hydro	3.2	0.9	–0.2	–3.5	..	..	..
Geothermal	22.3	6.2	6.8	2.5	..	..	..
Solar/Wind/Other	–	4.8	46.5	–5.4	..	..	..
TFC	1.0	1.5	1.7	–1.5	..	..	..
Electricity Consumption	3.9	3.4	2.2	–2.2	..	..	..
Energy Production	4.9	5.8	3.7	–1.4	..	..	..
Net Oil Imports	0.5	–0.4	0.4	–4.5	..	..	..
GDP	3.5	4.0	1.4	–0.6	..	..	..
Growth in the TPES/GDP Ratio	–1.9	–2.0	0.4	–0.1	..	..	..
Growth in the TFC/GDP Ratio	–2.4	–2.4	0.3	–1.0	..	..	..

Please note: Rounding may cause totals to differ from the sum of the elements.

FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

1. Includes lignite and peat.
2. Comprises solid biomass, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
3. Total net imports include combustible renewables and waste.
4. Total supply of electricity represents net trade.
5. Includes non-energy use.
6. Includes less than 1% non-oil fuels.
7. Includes residential, commercial, public service and agricultural sectors.
8. Inputs to electricity generation include inputs to electricity and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear, 10% for geothermal and 100% for hydro.
10. Toe per thousand US dollars at 1995 prices and exchange rates.
11. Toe per person.
12. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

Member countries* of the IEA seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1. **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the Polluter Pays Principle.

4. **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA members wish to retain and improve the nuclear

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention and abbreviated subsequently, this glossary provides a quick and central reference for many of the abbreviations used.

AEC	Atomic Energy Commission.
AIST	National Institute of Advanced Industrial Science and Technology.
ANRE	Agency for Natural Resources and Energy.
APEC	Asia-Pacific Economic Co-operation.
ASEAN	Association of South-East Asian Nations.
bcm	billion cubic metres.
b/d	barrels a day.
BWR	boiling water reactor.
CCGT	combined cycle gas turbine.
CCT	clean coal technology.
CHP	combined production of heat and power or "co-generation".
CO_2	carbon dioxide.
ECCJ	Energy Conservation Centre of Japan.
EPCo	electric power company.
ESCO	energy service company.
EU	European Union.
FBR	fast breeder reactor.
FTC	Fair Trade Commission.
FY	fiscal year (1 April - 31 March).
GDP	gross domestic product.
GHG	greenhouse gases.
GW	gigawatt, or one watt $\times 10^9$.
GWh	gigawatt-hour = one gigawatt $\times$ one hour.
HFC	hydrofluorocarbons.

Hz	hertz.
IEA	International Energy Agency.
IPCC	Intergovernmental Panel on Climate Change.
IPP	independent power producer.
JAPC	Japan Atomic Power Company.
JNC	Japan Nuclear Fuel Cycle Development Institute.
JNES	Japan Nuclear Energy Safety Organisation.
JNFL	Japanese Nuclear Fuel Company Limited.
JNOC	Japan National Oil Corporation.
kl	kilolitre.
km	kilometre.
km^2	square kilometre.
kV	kilovolt, or one volt $\times 10^3$.
kW	kilowatt, or one watt $\times 10^3$.
kWh	kilowatt-hour = one kilowatt $\times$ one hour.
LNG	liquefied natural gas.
LPG	liquefied petroleum gas.
m	metre.
m^2	square metre.
Mb/d	million barrels a day.
mcm	million cubic metres.
METI	Ministry of Economy, Trade and Industry.
MEXT	Ministry of Education, Culture, Sports, Science and Technology.
MOE	Ministry of Environment.
MOX	mixed oxide fuel.
Mt	million tonnes.
Mtoe	million tonnes of oil equivalent; see toe.
MW	megawatt, or one watt $\times 10^6$.
MWh	megawatt-hour = one megawatt $\times$ one hour.
NEDO	New Energy and Industrial Technology Development Organisation.
NGO	non-governmental organisation.
NISA	Nuclear and Industrial Safety Agency.

N_2O	nitrous oxide.
NO_x	nitrogen oxide.
NSC	Nuclear Safety Commission.
NUMO	Nuclear Waste Management Organisation of Japan.
OECD	Organisation for Economic Co-operation and Development.
PFC	perfluorocompounds.
ppm	parts per million.
PV	photovoltaic.
PWR	pressurised water reactor.
R&D	research and development; may include the demonstration and dissemination phases as well.
SF_6	sulphur hexafluoride.
SO_x	sulphur oxide.
TEPCO	Tokyo Electric Power Company.
TFC	total final consumption of energy.
TJ	terajoule, or one joule x 10^{12}.
toe	tonne of oil equivalent, defined as 10^7 kcal.
TPA	third-party access.
TPES	total primary energy supply.
TSO	Transmission System Operator.
TWh	terawatt-hour = one terawatt x one hour.
UNFCCC	United Nations Framework Convention on Climate Change.

ORDER FORM

IEA BOOKS

Fax: +33 (0)1 40 57 65 59
E-mail: books@iea.org
www.iea.org/books

INTERNATIONAL ENERGY AGENCY

9, rue de la Fédération
F-75739 Paris Cedex 15

I would like to order the following publications

PUBLICATIONS	ISBN	QTY	PRICE	TOTAL
☐ **Energy Policies of IEA Countries – Japan – 2003 Review**	**92-64-01474-8**		**€75**	
☐ Energy Policies of IEA Countries – Italy – 2003 Review	92-64-01476-4		€75	
☐ Energy Policies of IEA Countries – Switzerland – 2003 Review	92-64-01478-0		€75	
☐ Energy Policies of IEA Countries – Ireland – 2003 Review	92-64-01472-1		€75	
☐ Energy Policies of IEA Countries – Hungary – 2003 Review	92-64-01470-5		€75	
☐ Energy Policies of IEA Countries – 2002 Review (Compendium)	92-64-19773-7		€120	
☐ Energy Policies of IEA Countries – Austria – 2002 Review	92-64-19772-9		€75	
☐ Energy Policies of IEA Countries – Germany – 2002 Review	92-64-19771-0		€75	
			TOTAL	

DELIVERY DETAILS

Name _____ Organisation _____

Address _____

Country _____ Postcode _____

Telephone _____ E-mail _____

PAYMENT DETAILS

☐ I enclose a cheque payable to IEA Publications for the sum of € _____

☐ Please debit my credit card (tick choice). ☐ Mastercard ☐ VISA ☐ American Express

Card no: _____ Signature:

Expiry date: _____

OECD PARIS CENTRE
Tel: (+33-01) 45 24 81 67
Fax: (+33-01) 49 10 42 76
E-mail: distribution@oecd.org

OECD BONN CENTRE
Tel: (+49-228) 959 12 15
Fax: (+49-228) 959 12 18
E-mail: bonn.contact@oecd.org

OECD MEXICO CENTRE
Tel: (+52-5) 280 12 09
Fax: (+52-5) 280 04 80
E-mail: mexico.contact@oecd.org

You can also send your order to your nearest OECD sales point or through the OECD online services: www.oecd.org/bookshop

OECD TOKYO CENTRE
Tel: (+81-3) 3586 2016
Fax: (+81-3) 3584 7929
E-mail: center@oecdtokyo.org

OECD WASHINGTON CENTER
Tel: (+1-202) 785-6323
Toll-free number for orders:
(+1-800) 456-6323
Fax: (+1-202) 785-0350
E-mail: washington.contact@oecd.org

IEA PUBLICATIONS, 9, rue de la Fédération, 75739 PARIS CEDEX 15
PRINTED IN FRANCE BY STEDI
(61 2003 10 1P1) 92-64-01474-8