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2. Energy Demand-Supply Situation in Japan

日本のエネルギー需給状況

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ENERGY SITUATION OF JAPAN

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Chapter 1 Outline of Energy Demand Structure

1. Structure and Interpretation of Energy Balance Table

The energy balance table expresses the processes from production or import of energy to consumption as they are, or after being converted into secondary energy for all energy sources for a given country. In the table such common energy units as calorie or Joule[1] are used throughout. The energy table is a very effective statistical and analytical tool for analyzing and understanding the flow of energy, interrelationship or competitive relations existing among different sectors, and different energy sources, for a given country. In Japan, the General Policy Division, the Director-General's Secretariat, the Agency of Natural Resources and Energy, the Ministry of Economy, Trade and Industry and the Energy Data and Modeling Center of the Institute of Energy Economics, Japan (IEE) jointly prepare the energy balance. The energy balance thus prepared is entitled "Synthesized Energy Statistics (Red Book, Energy Balance Table)" and is made public. This provides a common ground on which energy forecast and other energy issues may be discussed.

Primary energy supply ⇒	**Energy conversion** ⇒	**Final energy consumption**
Domestic production	Electric utilities	Industrial sector (agriculture, manufacturing)
Import	Oil refining	Residential and commercial (Residential, Commercial)
Total supply	Town gas production	Transportation (passengers and freight)
Stock change	Coke & others	

Domestic Supply

- Composition of primary energy supply, degree of dependence on Oil, degree of dependence on import, composition of energy sources for power generation, electrification rate, conversion loss, sectoral shares in final energy consumption, etc. may noted from the energy balance.
- In-house power generation of plants is counted in "Auto Generation" of the energy conversion category to avoid counting both fuel for in-house power generation and the generated power in duplicate. The in-house generated power and fuel consumption in the final consumption are both counted in "Auto Generation."

[1] Thermal unit: When dealing with quantities of energy, these may be expressed in such independent and mutually unrelated units as kL, bbl, m^3, kt and Wh. These may also be expressed in such thermal units as Joule (J), kcal, ton of oil equivalent (toe = 10^7 kcal), liter of crude oil equivalent (= 9.25×10^6 kcal), after conversion into such units. From the fiscal 1999 version, Joule, the energy unit for the International System of Unit, has been used for the Synthesized Energy Statistics instead of calorie, in accordance with the amendment of the Measurement Law.

Energy conversion factors

Crude oil	9,126 kcal/L	LNG	13,019 kcal/kg
Gasoline	8,266 kcal/L	Town gas	9,818 kcal/m^3
Naphtha	8,146 kcal/L	Coking coal (domestic)	7,700 kcal/kg
Jet fuel	8,767 kcal/L	Coking coal (imported)	6,904 kcal/kg
Kerosene	8,767 kcal/L	Steam coal (domestic)	5,375 kcal/kg
Diesel fuel	9,126 kcal/L	Steam coal (imported)	6,354 kcal/kg
Fuel oil A	9,341 kcal/L	Coke	7,191 kcal/kg
Fuel oil B	9,651 kcal/L	Electric power	860 kcal/kWh
Fuel oil C	9,962 kcal/L	Nuclear power, hydroelectric power	2,150 kcal/kWh
LPG	11,992 kcal/kg	(2,150 = 860/thermal efficiency at 39.98%)	

Source: Agency of Natural Resources and Energy, “Synthesized Energy Statistics”

1 kcal = 4.18605kJ

Table 1-1 Energy Balance Table (Fiscal 2000

10^{13} kcal = Million TOE (tons oil equivalent)

Sector \ Energy source			A	B	C	D	E	F
			Crude oil	Petroleum products	Hydroelectric power, nuclear power	Electric power	Coal, gas, etc.	Total
Primary energy	1	Domestic production	0.7	0.0	88.5	0.0	11.4	100.6
	2	Import	232.1	56.4	0.0	0.0	169.6	458.1
	3	Total primary energy supply	232.8	56.4	88.5	0.0	181.0	558.7
	4	Export	-2.8	-19.2	0.0	0.0	-1.6	-23.6
	5	Primary energy domestic supply	230.0	37.2	88.5	0.0	179.3	535.0
Energy conversion & own use	6	Electric utilities	-7.1	-24.8	-88.5	92.6	-106.3	-134.1
	7	Oil refining	-221.4	220.6	0.0	0.0	0.0	-0.7
	8	Others	-1.5	-2.4	0.0	-0.1	0.7	-3.3
	9	Own uses & losses	0.0	-12.5	0.0	-9.3	-3.9	-25.7
	10	Statistical difference	0.0	3.9	0.0	0.0	0.7	4.5
Final energy	11	Final energy total	0.0	221.9	0.0	83.2	70.6	375.7
	12	Industry	0.0	96.0	0.0	36.6	52.7	185.3
	13	Residential & commercial	0.0	37.1	0.0	44.7	17.9	99.7
	14	Transportation	0.0	88.9	0.0	1.9	0.0	90.7

Note 1: Negative figures in the conversion sector indicate inputs of energy for production, positive figures indicate productions.

Note 2: The non-energy consumption is included in the industrial sector.

Source: Agency of Natural Resources and Energy, “Synthesized Energy Statistics”

$$\text{A. Degree of dependence on petroleum (\%)} = \underset{A3+B3}{(232.8+56.4)} \div \underset{F3}{558.7} = 51.8\%$$

(Total primary energy supply: crude oil + petroleum product) (Total primary energy supply: total)

B. Degreed of dependence on import[2)] (%) = $\underset{F2}{458.1}$ ÷ $\underset{F3}{558.7}$ = 82.0%

(Total import) (Total primary energy supply)

C. Supply and demand of petroleum products

Total supply: $\underset{B2}{56.4} + \underset{B7}{220.6}$ = Total demand: $\underset{B4}{19.2} + \underset{B6+B8+B9}{(24.8+2.4+12.5)} + \underset{B11}{221.9} - \underset{B10}{3.9}$

(Products import) (Domestic refining) (Export) (Consumption in the conversion sector) (Final consumption) (Statistical difference)

D. Electric power demand $\underset{D6}{92.6}$ = $\underset{D9+D8}{(9.3+0.1)}$ + $\underset{D11}{83.2}$

(Power generation) (Own use and others) (Final consumption)

E. Composition of energy sources for power generation $\underset{A6+B6+C6+E6}{(7.1+24.8+88.5+106.3)} - \underset{F6}{134.1} = \underset{D6}{92.6}$

(Input energy) (Generation loss) (Generated electric power)

F. Ratio of power generation loss (%) = $\underset{F6}{134.1}$ ÷ $\underset{A6+B6+C6+E6}{(7.1+24.8+88.5+106.3)}$ = $\underset{D6}{59.2\%}$

(Power generation loss) (Input energy)

[2] Degree of dependence on import: In case imported uranium is used for power generation, the electric power produced is regarded as domestic energy.

Table 1-2 Simplified Energy Balance for fiscal 2000

(unit: 10^{10}kcal)

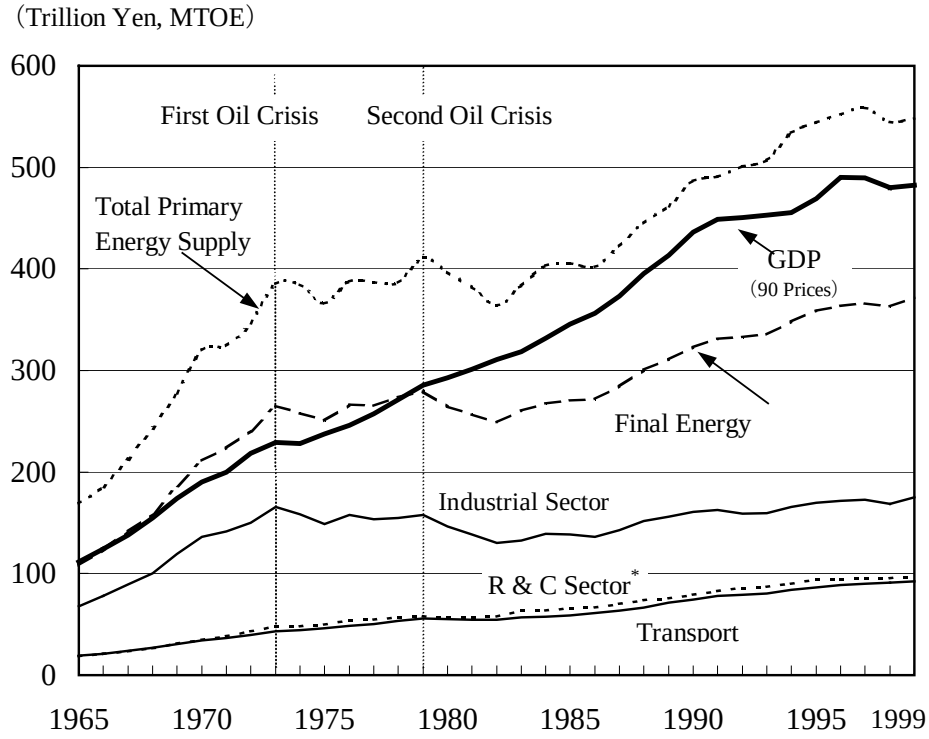
	NO.	1	2	3	4	5	6	7	8	9	10	11	12
		Coal	Cokes	Crude Oil	Oil Products	Natural Gas	Town Gas	Hydro	Nuclear	Geo-thermal	New Energy	Elec-tricity	Total
Primary Energy Supply													
Domestic Production	1	1,614		694		2,442		19,253	69,241	964	6,369		100,576
Import	2	98,608		232,069	56,441	70,956							458,075
Total Primary Energy Supply	3	100,222		232,763	36,441	73,398		19,253	69,241	964	6,369		558,651
Export	4		-1,588		-17,450								-19,038
Stock Change	5	-28		-2,798	-1,769	3							-4,591
Domestic Primary Energy Supply	6	100,194	-1,588	229,966	37,222	73,401		19,253	69,241	964	6,369		535,022
Energy Conversion & Own Use													
Electric Utilities	7	-36,427	-4,938	-7,109	-12,326	-50,855		-18,174	-69,087	-692	-444	79,629	-120,422
Auto Generation	8	-6,022	-2,778		-12,507			-1,079	-153	-51	-4,044	12,970	-13,664
District Heat Supply	9	-14			-41		-382				608	94	76
Town Gas Production	10		-240		-2,990	-20,522	25,347						1,595
Cokes & Gas	11	-40,910	36,857		-865								-4,919
Oil Refining	12			-221,353	220,606								-747
Petrochemical	13			-1,472	1,459								-13
Others	14	-31	28										-4
Own Use & Losses	15	-93	3,050	-12	-12,499	-453	-309					-9,278	-25,694
Statistical Difference	16	-226	598	-20	3,855	-1,079	2	0	0		1,380	0	4,510
Final Energy Consumption	17	16,471	24,888		221,914	492	24,658			221	3,869	83,227	375,740
Industry Total	18	16,471	23,917		88,789	482	9,218			95	2,472	36,647	178,091
Agriculture, Forestry & Fishery	19				10,350					95		330	10,775
Mining	20				583							227	810
Construction	21				3,868							87	3,955
Manufacturing	22	16,471	23,917		73,988	482	9,218				2,472	36,003	162,552
Foods	23				1.934		1.229					2.399	5.562
Textile	24	27			2,030		197				45	673	2,973
Paper & Pulp	25	1,346			3,015		721				2,397	3,092	10,572
Chemicals	26	912	131		43,412	357	1,802				30	5,639	52,283
Ceramics & Cement	27	4,902	383		3,566		389					1,902	11,143
Iron & Steel	28	8,992	22,729		2,907		1,525					7,068	43,220
Non-ferrous Metals	29	106	197		1,049		373					1,736	3,462
Metal Products & Machines	30	103	105		922		1,921					7,375	10,426
Other Manufacturing	31	83	372		15,153	124	1,061					6,118	22,911
Residential & Commercial	32		971		37,095	10	15,439			126	1,397	44,707	99,745
Residential	33		28		20,204		9,491				865	22,804	53,392
Commercial	34		943		16,890	10	5,948			126	532	21,903	46,352
Transport	35				88,866							1.874	90,740
Passengers	36				56,307							1,772	58,079
Freight	37				32,559							102	32,661
Non-Energy	38				7,164								7,164

Source: Agency of Natural Resources and Energy, “Synthesized Energy Statistics”

Shown above is a simplified energy balance with 38 sectors and 12 kinds of energy. The basic energy balance has 45 sectors and 41 kinds of energy.

2. Economic Growth and Energy Demand

Figure 1-1 Trends for Relation between Energy Demand and GDP



Source: Agency of Natural Resources and Energy, "Synthesized Energy Statistics" and Agency of Economic Planning "Quick Estimation of GDP"

Remark: Since the energy crises, a remarkable progress has been made in the field of energy conservation, notably in the manufacturing sector, to boost efficiency of energy consumption. Since the latter half of the 1990 in particular, energy consumption has stayed high in contrast to the low economic growth rate.

GDP Elasticity of Energy

$$\text{GDP Elasticity of Energy} = \frac{\text{Growth rate of energy demand}}{\text{Growth rate of GDP}}$$

The Income elasticity of energy (GDP elasticity)[3] is a convenient measure to directly see

[3] Elasticity of energy to income: This is defined as the change in energy demand caused by the one-percent change in income. Macro analyses often use real GDP in place of income. In case where the rate of growth of GDP is 0.9% and the elasticity to GDP is 1.2, for example, the increase in energy demand is given by: 0.9×1.2=1.08%.

the relationship between the economic growth and the energy consumption. Energy demand of a given country is determined not only by the economic scale but also affected by a number of factors, including the industrial structure, lifestyle of the people, technological standard, climatic condition. The GDP elasticity of energy intends to see the relationship between the energy consumption and the economic growth, while the latter is assumed to represent all these factors.

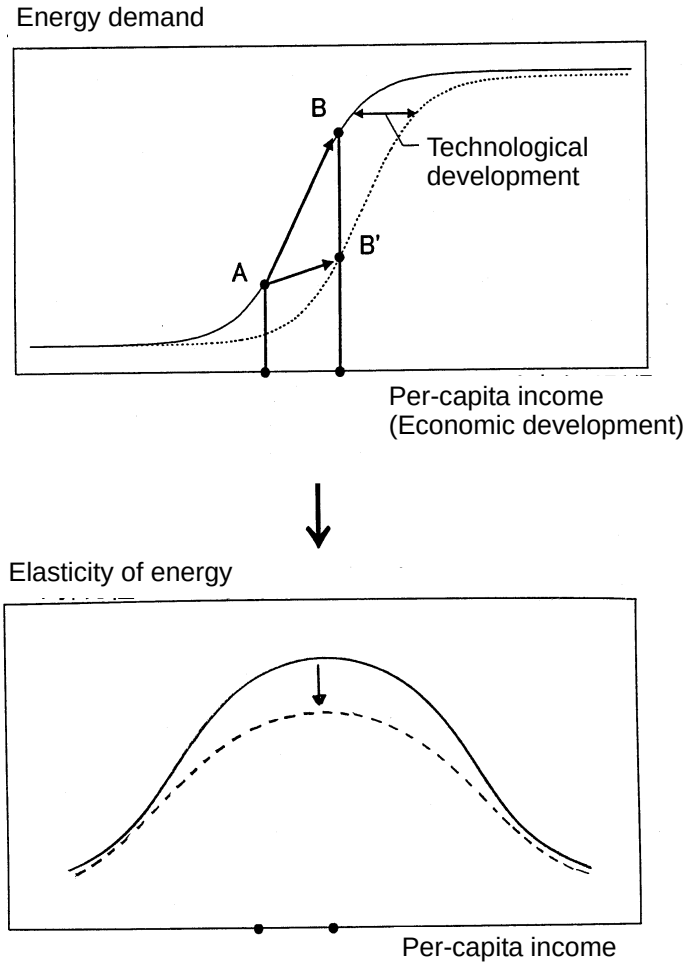
Stage of Economic Growth and Energy Demand

Example of Economic Stage Theory

According to "Stages of Economic Development" by Rostow, W. W. (1960), the economic growth may be broken down into the following five stages.

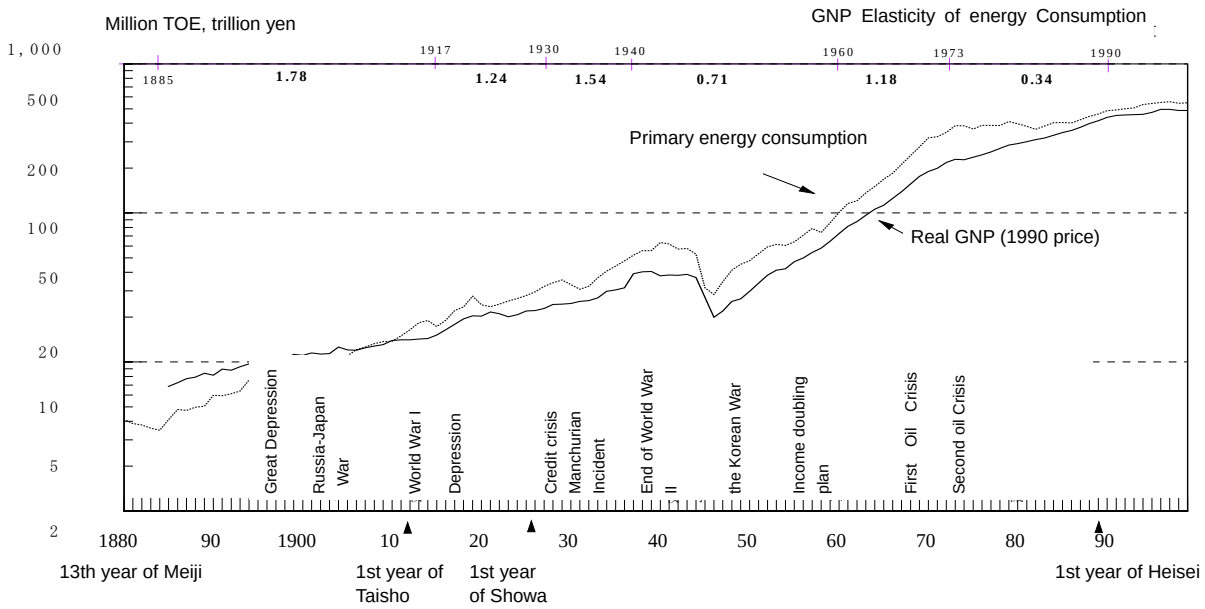
(1) Stage 1 Traditional society: Agriculture is the center of economy, depending upon pre-Newtonian science and technology.
(2) Stage 2 Transitional Stage (the preconditions for takeoff): The society incorporates modern technologies. The society accepts economic growth. The society forms a nation state.
(3) Stage 3 Take Off: At this state, factors hindering economic growth have been eliminated, and the manufacturing industry makes rapid progress.
(4) Stage 4 Drive to Maturity: The economic growth continues and per-capita income increases
(5) Stage 5 High Mass Consumption: This stage represents mass consumption. The major industries are manufacturing of durable goods and services.

Figure 1-2 Economic Growth and Energy Demand



Remark: The rate of increase of energy demand varies with the stage of economic development. Generally, at a high stage of rapid economic development, the demand for energy increases. If technology transfer is done at this stage from advanced countries to developing countries, the same degree of economic growth is achievable in developing countries at smaller energy demands (lowering of elasticity). This is achieved by A → B', not A → B in the above figure.

Figure 1-3 Trends of GNP and Primary Energy Consumption



Period	Annual growth rate (%)		GNP Elasticity of Energy Consumption
	Energy consumption	Real GNP	
1890-1900	5.8	3.1	1.86
1900-1910	2.8	2.3	1.20
1910-1920	5.8	3.8	1.51
1920-1930	3.1	2.0	1.60
1930-1940	6.7	4.4	1.54
1940-1950	-2.8	-2.4	1.18
1950-1960	7.8	9.3	0.83
1960-1970	12.2	10.1	1.21
1970-1975	2.8	2.6	1.08
1975-1980	1.6	6.3	0.26
1980-1985	0.4	3.5	0.12
1985-1990	3.7	4.8	0.77
1990-1995	2.3	1.5	1.48
1995-1999	0.2	0.8	0.29

Source: EDMC Handbook of Energy & Economic Statistics in Japan

Table 1-3 GDP and Primary Energy Supply for Selected Countries

	From 1973 to 1998 Annual growth rate		GDP Elasticity of Energy Consumption	Primary Energy Supply per GDP		Per-capita primary energy supply	
	Real GDP, %	Primary energy supply, %		1973	1998	1973	1998
				toe/US Dollars million (1995 price)		toe/head	
Japan	3.1	1.9	0.62	126	96	2.99	4.04
USA	2.7	1.0	0.35	412	272	8.19	8.07
Germany	2.2	0.1	0.04	221	135	4.28	4.20
France	2.3	1.6	0.68	184	155	3.39	4.34
Canada	2.8	1.6	0.56	508	378	7.20	7.73
Italy	2.3	1.1	0.48	199	149	2.35	2.92
UK	2.0	0.2	0.11	297	195	3.93	3.94
ROK	7.6	8.9	1.17	238	316	0.62	3.52
Malaysia	6.8	9.3	1.38	246	437	0.41	1.86
Former Soviet Union	0.0	0.1	3.12	2,065	2,111	3.40	3.01
China	8.9	4.9	0.54	2,292	913	0.30	0.66
India	5.4	6.1	1.14	529	625	0.11	0.29
Total OECD	2.7	1.3	0.48	279	202	4.17	4.63
Total non-OECD	3.8	3.0	0.79	699	581	0.57	0.73
EU15	2.3	0.9	0.41	219	160	3.34	3.86
ASEAN7	6.1	7.1	1.18	286	364	0.17	0.55
World total	2.9	1.9	0.67	344	274	1.40	1.47

Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The GDP elasticity of energy is getting smaller in many developed countries, while in other countries the energy elasticity exceeds unity, except for China which has a small elasticity. In China, the energy unit consumption used to be very high (in 1973 in particular), China therefore had good room for energy conservation. In addition, statistical inaccuracy is also suspected for China.

Energy Conservation (Macro base)

Energy consumption per unit GDP

$$\text{Energy Intensity} = \frac{\text{Energy consumption}}{\text{GDP}} \rightarrow \text{inverse number : (energy productivity)}$$

Constant Intensity … Elasticity = 1
Increasing Intensity… Elasticity > 1
Decreasing Intensity …Elasticity < 1

In order for the elasticity to be at or less than unity, the energy productivity has to be always on the increase. This requires incessant advancement of energy conservation technology, changes in industrial and consumption structures. If such changes slow down, the elasticity becomes closer to unity.

As economy of a nation matures to some extent, the increase in income is not accompanied by a large increase in energy consumption[4]. As long as economy grows (the change continues), there is room for energy productivity improvement.

→ It follows that the Income elasticity of energy needs not be unity.

Macro factors for energy conservation

(1) Change in industrial structure, change in social structure (changes in lifestyle, traffic system)
(2) Change in product mix
(3) Change in technological intensity

[4] "As economy of a nation matures to some extent……:" The energy consumption in the United States and European countries tends to be low and the elasticity is also small.

Table 1-4 International Comparison of Energy Intensity

	Energy Intensity (Primary energy supply per unit real GDP, 1995 base year)				Rate of change 1998/1973 %
	1973		1998		
	toe/US Dollars million (1995 price)	Japan = 100	toe/US Dollars million (1995 price)	Japan = 100	
Japan	126.4	100.0	95.9	100.0	-24.1
USA	411.8	325.9	271.9	283.6	34.0
Germany	221.3	175.1	134.8	140.6	-39.1
France	183.9	145.5	155.3	162.0	-15.6
Canada	508.0	402.0	378.0	394.2	-25.6
Italy	198.5	157.1	149.0	155.4	-25.0
UK	297.2	235.2	194.9	203.2	-34.4
ROK	237.8	188.2	316.4	329.9	33.0
Malaysia	245.8	194.5	437.2	455.9	77.9
Former Soviet Union	2,064.9	1,634.0	2,110.7	2,201.0	2.2
China	2,291.9	1,813.7	913.4	952.5	-60.1
India	528.7	418.4	625.3	652.0	18.3
Total OECD	279.5	221.2	201.5	210.1	-27.9
Total non-OECD	698.6	552.8	580.7	605.6	16.9
EU15	218.7	173.1	159.7	166.6	-27.0
ASEAN7	285.5	225.9	364.2	379.8	27.6
World total	344.1	272.3	274.5	286.2	-20.2

Source: EDMC Handbook of Energy & Economic Statistics in Japan

Factor Analysis for Changes in Carbon Dioxide Emission

$$C = \frac{C}{E} \times \frac{E}{GDP} \times GDP$$ Equation (1)

C: CO_2

E: Energy

$$\Delta C = \Delta\frac{C}{E} + \Delta\frac{E}{GDP} + \Delta GDP$$ Equation (2)

$\Delta\frac{C}{E}$: Carbon emission reduction

$\Delta\frac{E}{GDP}$: Energy conservation

ΔGDP: Economic growth

Table 1-5 Factor Analysis for Changes in Carbon Dioxide Emission

		1973 to 1990	1990 to 1999	(Annual average growth rate, %)	
				Base case	Target case
CO_2 Emission	C	0.8	1.0	▲0.2	▲0.8
Carbon emission reduction	C/E	▲0.5	▲0.4	▲0.6	▲1.0
Energy conservation	E/GDP	▲2.2	0.4	▲1.9	▲2.0
Economic growth	GDP	3.9	1.1	2.0	2.0

Note: The forecasts are from the "Long-term Energy Supply and Demand Outlook (July 2001)" by the Advisory Committee on Natural Resources and Energy for the Ministry of Economy, Trade and Industry

Column: Characteristics of energy demand

Generally, the energy demand has the following characteristics.

(1) Energy itself can never be counted as demand. Namely, energy demand is always liked with other inputs to yield satisfactory services. (derivative demand).
→ It is important to analyze the demand by End use.

(2) Energy is used as final goods directly consumed at households but is also used as intermediate goods in manufacturing activities.
→ Energy Intensity-based approach

$$\text{Energfy consumption} = \text{Energy Intensity} \times \text{Output}$$

(3) Energy consumption depends upon the stock of durable goods (machines to consume energy) and operating rate.

→ Stock-based approach

$$\text{Energy demand} = \text{Technical factor} \times \text{Operation rate} \times \text{Capital stock to consume energy}$$

$$(\text{Demand for gasoline}) = (\text{Fuel economy}) \times (\text{Mileage}) \times (\text{Number of registered cars})$$

However, the above factors are considered ultimately to be variables of prices and incomes.

Column: Income Price elasticity of Energy Consumption

< Definition of elasticity >

The degree of change of demand in percentage caused by one-percent increase in income (price).

Income (price) Elasticity = Rate of change in demand ÷ Rate of change in income (price)

< Traditional demand function >

- General formula

$$E = f(Y, P)$$ Equation (1)

where E: Energy demand,
Y: Income, P: Energy price

- Formulation

$$\log(E) = a + b \log(Y) + c \log(P)$$ Equation (2)

Where b: Income elasticity
c: Price elasticity

or

$$\log(E) = a + b \log(Y) + c \log(P) + d \log(E_{-1})$$ Equation (3)

Where b: Short-term Income Elasticity,
$b/(1-d)$: Long-term, Income elasticity
c: Short-term Price elasticity,
$c/(1-d)$: Long-term Price elasticity

< Measurement of elasticity >

- Income elasticity by sector: Residential & commercial > Transportation > Industry
- Price elasticity by sector: Industry > Transportation > Residential & commerce
- Income elasticity by energy source: Electric power > Fuel
- Price elasticity by energy source: Fuel > Electric power

Elasticity of final energy demand to income, price (long-range)

	Long-term income elasticity	Long-term price elasticity
Industrial sector	0.481	-0.275
Residential and commercial sector	0.706	-0.084
Transportation sector	0.616	-0.142
Fuel	0.403	-0.232
Electric power	0.742	-0.150

Estimated from the data from fiscal 1970 to fiscal 1999

3. Structure of Final Energy Demand, International Comparison

During the high-growth period the final energy consumption increased almost uniformly in all sectors. After the first Energy Crisis, the industrial structure shifted to a high-value added one and energy conservation technologies made remarkable progresses. As a result, the share of the industrial sector declined while the residential & commercial sector increased the share, prompted by spread and functional improvement of household electrical appliances, and increase in automobile transportation. After 1990, the low economic growth and low IIP[5] held down industrial consumption of energy, while the consumption by the residential & commercial sector and transportation sector, sectors relatively insensitive to economic conditions, increased in relative terms.

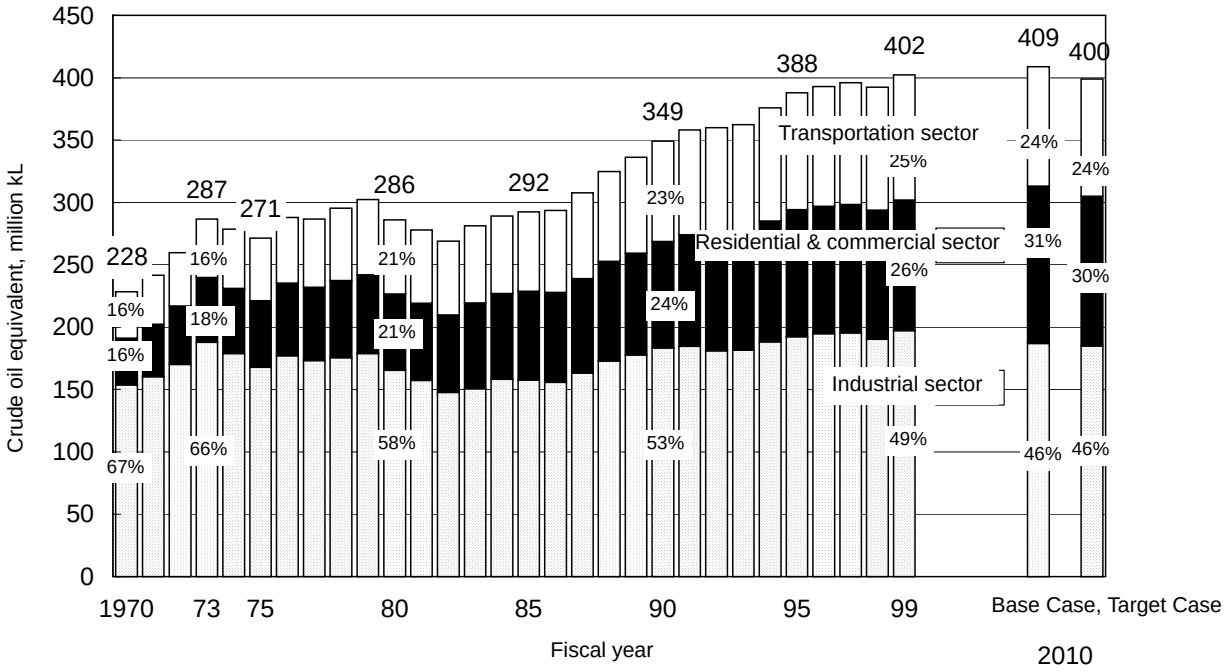
Table 1-6 Final Energy Consumption by Sector

Fiscal year	Annual average growth rate (%)				Share (%)				
	1965-73	1973-80	1980-90	1990-99	1965	1973	1980	1990	1999
Final energy consumption	11.8	0.0	2.0	1.6	100	100	100	100	100
Industrial sector	11.9	-1.8	1.0	0.8	65.2	65.5	57.8	52.5	49.0
Residential & commercial sector	12.5	2.4	3.4	2.3	17.2	18.1	21.4	24.4	26.1
Transportation sector	10.8	3.4	3.1	2.5	17.6	16.4	20.8	23.0	24.9
Real GDP	9.2	3.5	4.1	1.1					
IIP	12.7	2.2	4.1	-0.5					
Crude steel production	14.1	-1.4	0.4	-1.4					
Number of households	3.1	1.6	1.4	1.4					
Number of automobiles	16.7	6.0	4.3	2.4					

Source: EDMC Handbook of Energy & Economic Statistics in Japan

[5] Indices of Industrial Production: a measure of industrial activity with that of base year being 100

Figure 1-4 Trend and Outlook of Fuel Energy Consumption by Sector (July 2001)



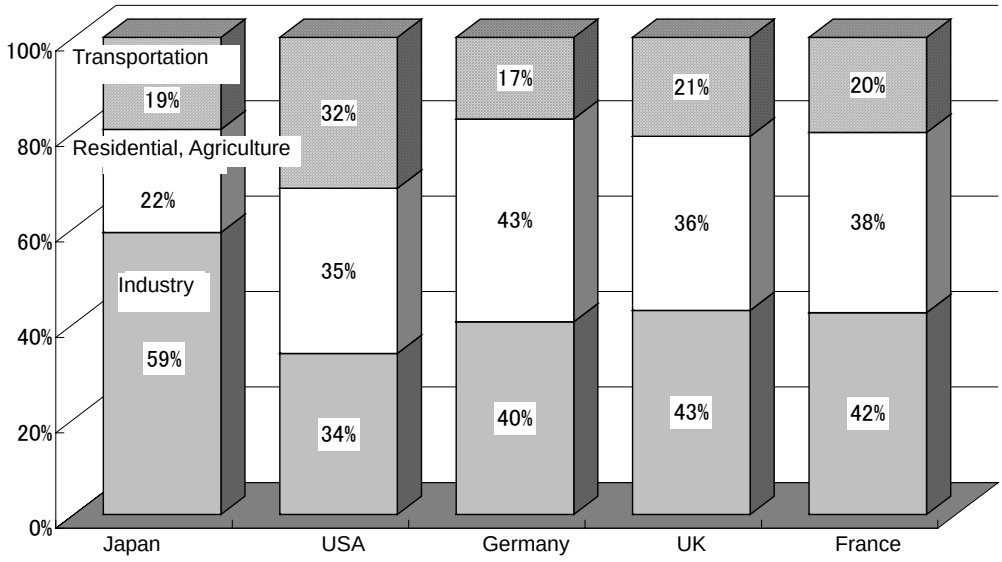
Source: Agency of Natural Resources and Energy "Synthesized Energy Statistics," Long-term Energy Supply and Demand Forecast of Advisory Committee on Natural Resources and Energy (July 2001)

International Comparison of Final Energy Demand Structure

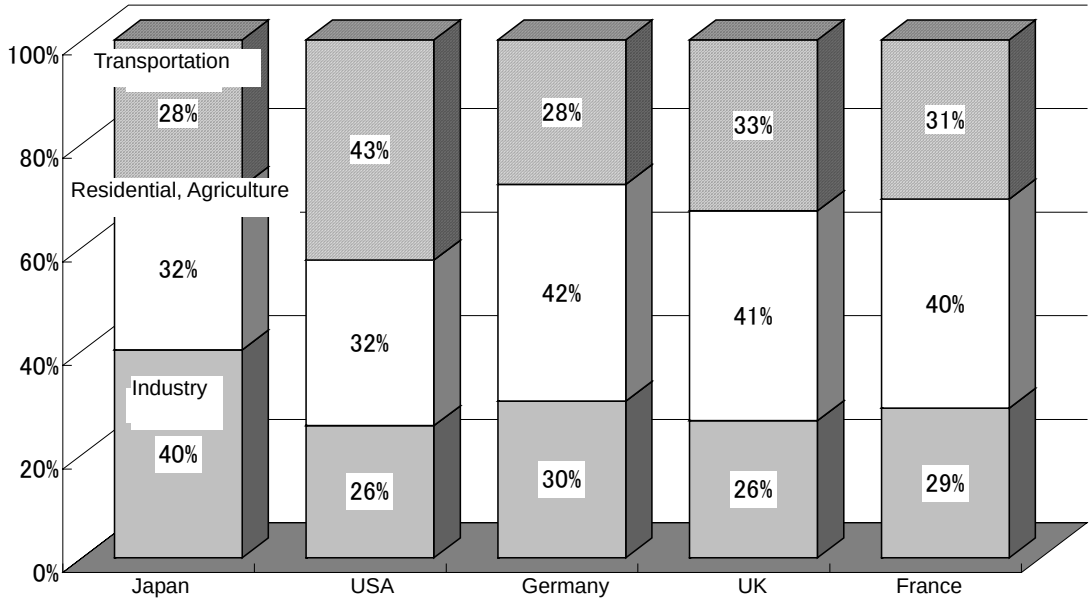
The demand for energy varies with economy, industrial structure, technologies employed, lifestyle, and climatic condition.

Figure 1-5 International Comparison of Final Energy Consumption Structure

1971



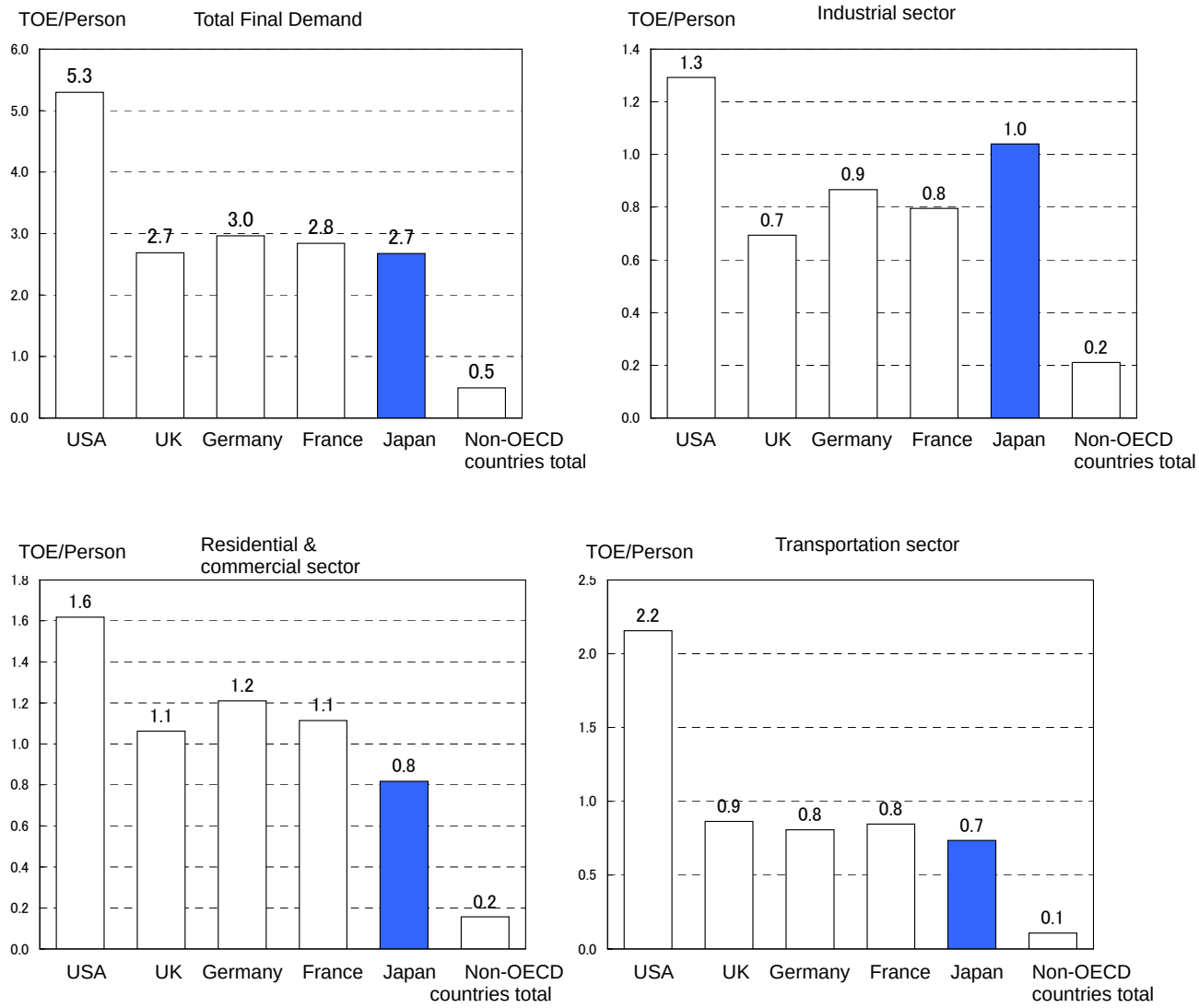
1998



Source: IEA “Energy Balance Table”

Remark: In Japan consumption used to be larger in the industrial sector and smaller in the residential & commercial sector than the United States and European countries. Recently, the share of the industrial sector is nearing that of the United States and European countries. (40 percent in Japan and less than 30 percent in the United States and European countries in 1998)

Figure 1-6 Final Energy Consumption Per-capita (1998)



Source: EDMC Handbook of Energy & Economic Statistics in Japan

The United States is outstanding in per-capita energy consumption. Since the Unites States is an automobile-centered society, the consumption in the transportation sector is disproportionately larger than other countries.

Among three European countries -- UK, Germany and France --, Germany consumes a little more energy than others. This is because Germany has a greater share of the manufacturing

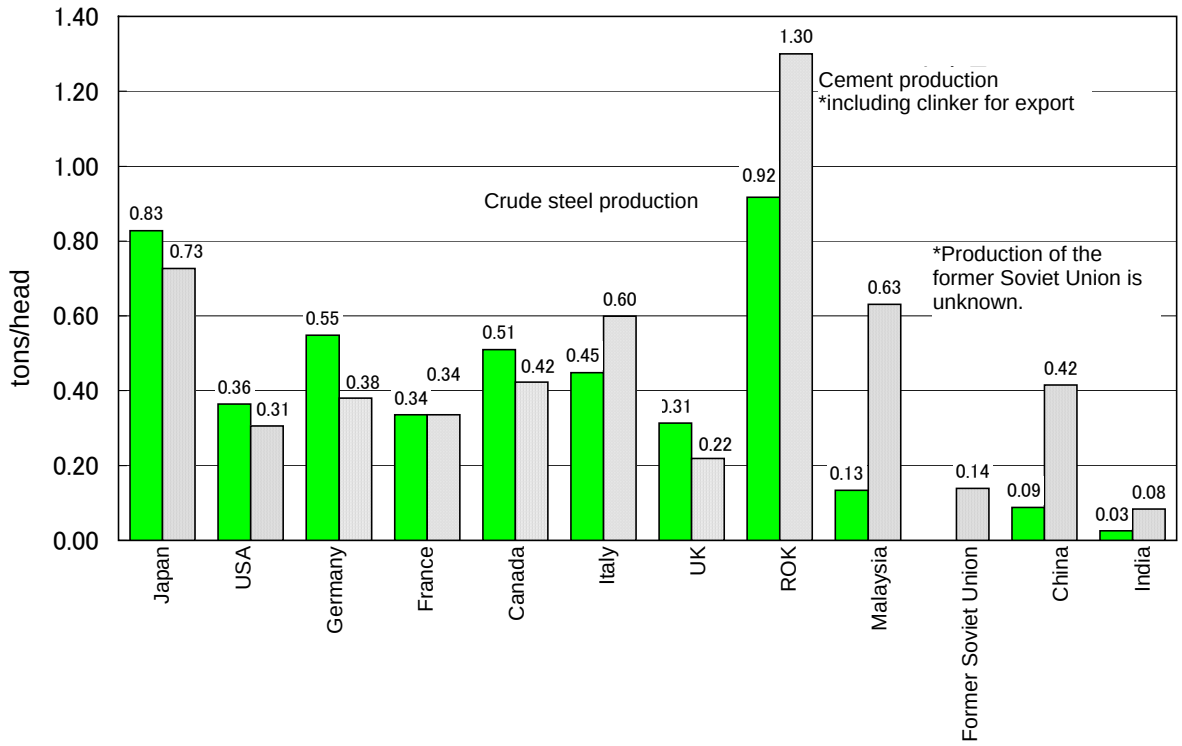
industry and colder[6] than other countries, and therefore energy consumption in the industrial sector and residential & commercial sector is greater.

The energy consumption in Non-OECD countries is small in all sectors. Their energy consumption is expected to increase in keeping pace with their economic development, accompanied by increasing numbers of cars and upgrading of living standards.

Japan produces a variety of basic materials.

In Japan, the basic material industry has a larger proportion compared with the United States and the European countries. Nevertheless, energy consumption per unit GDP is one of the best in the world, thanks greatly to energy conservation.

Figure 1-7 Production of Crude Steel and Cement Per-capita (1997)



Source: Committee on Iron and Steel Statistics "Handbook for Iron and Steel Statistics"
CEMBUTEAU, "World Statistical Review"
World Bank, "World Development Indicators"

Remark: The material manufacturing industries mostly consume large amounts of energy for manufacturing their products. (Steel requires coal, coke, electric power; cement requires coal,

[6] "cooler than other countries:" Germany, the southern highlands in particular, is cold compared with England which is further north than Germany, because England is washed by a warm current.

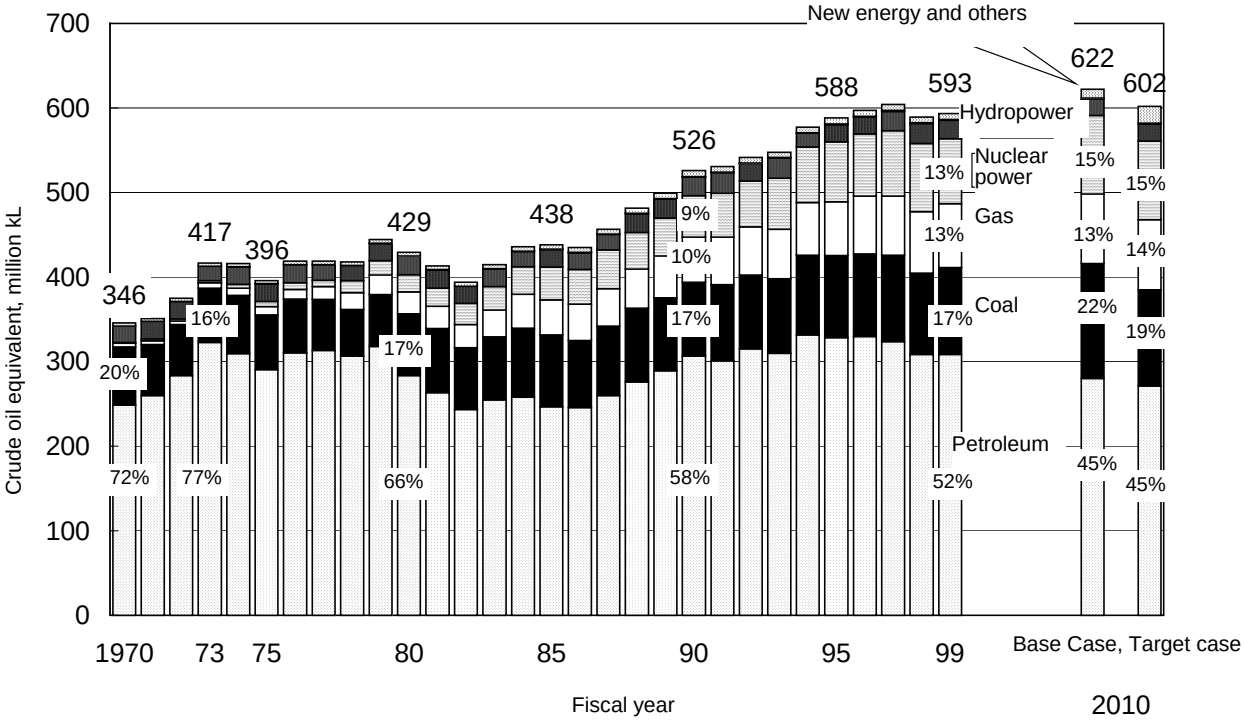
petroleum; paper and pulp require petroleum and electric power.) The chemical industry consumes a large amount of naphtha, though naphtha is not burned. Mass production of these goods is one factor contributing to increasing consumption of industrial energy.

4. Structure of Primary Energy Supply

Supply security requirements

- Reduction of dependence on oil, diversification of energy sources
- Increase self-sufficiency rate of energy supply

Figure 1-8 Trends and Outlook of Total Primary Energy Supply

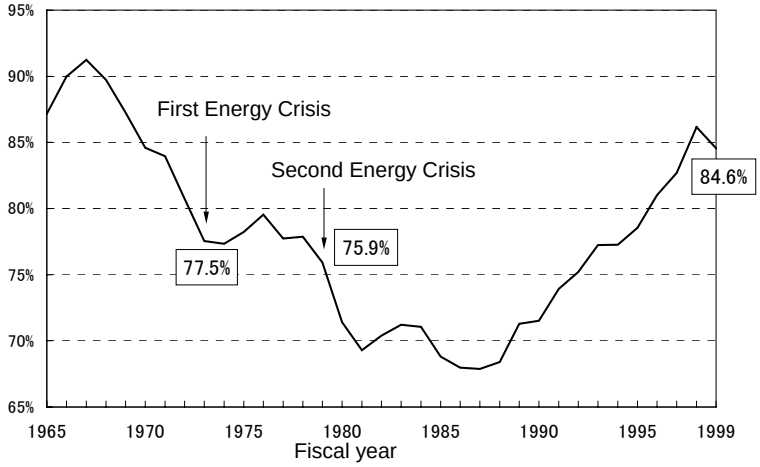


Source: Agency of Natural Resources and Energy "Synthesized Energy Statistics," Long-term Energy Supply and Demand Forecast of Advisory Committee on Natural Resources and Energy (July 2001)

Remark: Oil has been decreasing, coal has remained almost unchanged, and gas and nuclear energy have been increasing, in the total primary energy supply. Notwithstanding, oil accounts for more than half the total supply, being the most important of all the primary energy supply.

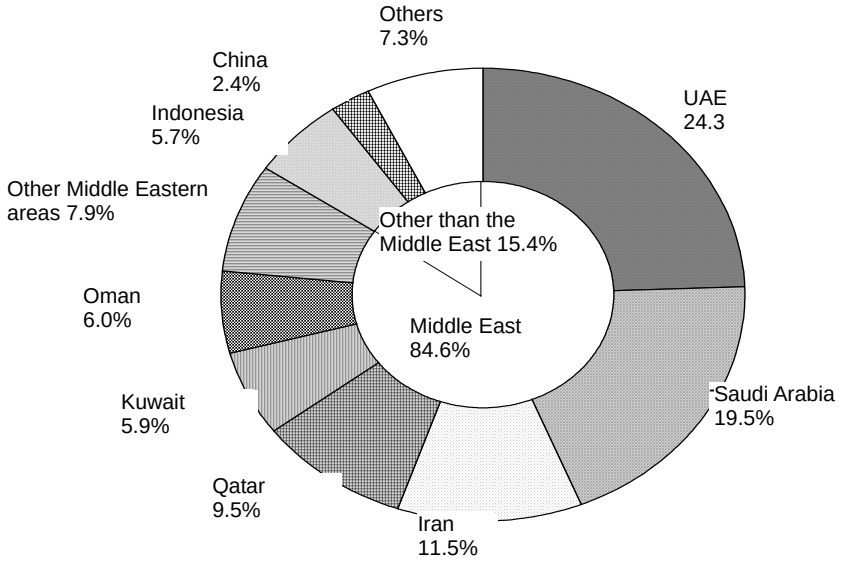
Dependence on the Middle East for import of petroleum

Figure 1-9 Trends for Dependence on the Middle East for Japan's Import of Oil



Source: Ministry of International Trade and Industry, "Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke"

Figure 1-10 Breakdown of Japan's Oil Import by Country of Supply (Fiscal 1999)



Source: Ministry of International Trade and Industry, "Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke"

Remark: The dependence on the Middle East once became lower than 70 percent in the 1980s. Thereafter, the dependence on the Middle East has kept increasing during the 1990s. Today, the dependence on the Middle East is higher than that at the time of the first energy crisis, of 77.5 percent.

Requirements from environmental conservation

- Reduction of fossil fuel use (introduction of nuclear power and new energy)
- Reduction of carbon emission in the use of fossil fuel (shift to natural gas)

Table 1-7 Forecast Supply of New Energy

	Fiscal 1999 performance		Forecast/target for fiscal 2010				2010/1999 Target (case)
			Present measure case		Target case		
	Crude oil equivalent	Capacity	Crude oil equivalent	Capacity	Crude oil equivalent	Capacity	
	10,000 kL	10,000 kL	10,000 kL	10,000 kL	10,000 kL	10,000 kL	
Electric power Photovoltaic power	5.3	20.9	62	254	118	482	about 23-times
Windpower	3.5	8.3	32	78	134	300	about 38-times
Waste power generation	115	90	208	175	552	417	about 5-times
Biomass power generation	5.4	8	13	16	34	33	about 6-times
Thermal energy utilization Solar heat utilization	98	-	72	-	439	-	about 4-times
Unutilized energy (including cold heat of snow and ice)	4.1	-	9.3	-	58	-	about 14-times
Utilization of waste heat	4.4	-	4.4	-	14	-	about 3-times
Utilization of biomass heat	-	-	-	-	67	-	-
Black liquor, waste chips, etc. (*1)	457	-	479	-	494	-	about 1.1-times
Total new energy supply	693	-	878	-	1,910	-	about 3-times
Ratio of new energy to the total primary energy supply	1.2%	-	1.4%	-	about 3%		
Total primary energy supply	about 590 million kL		about 620 million kL		about 600 million kL		

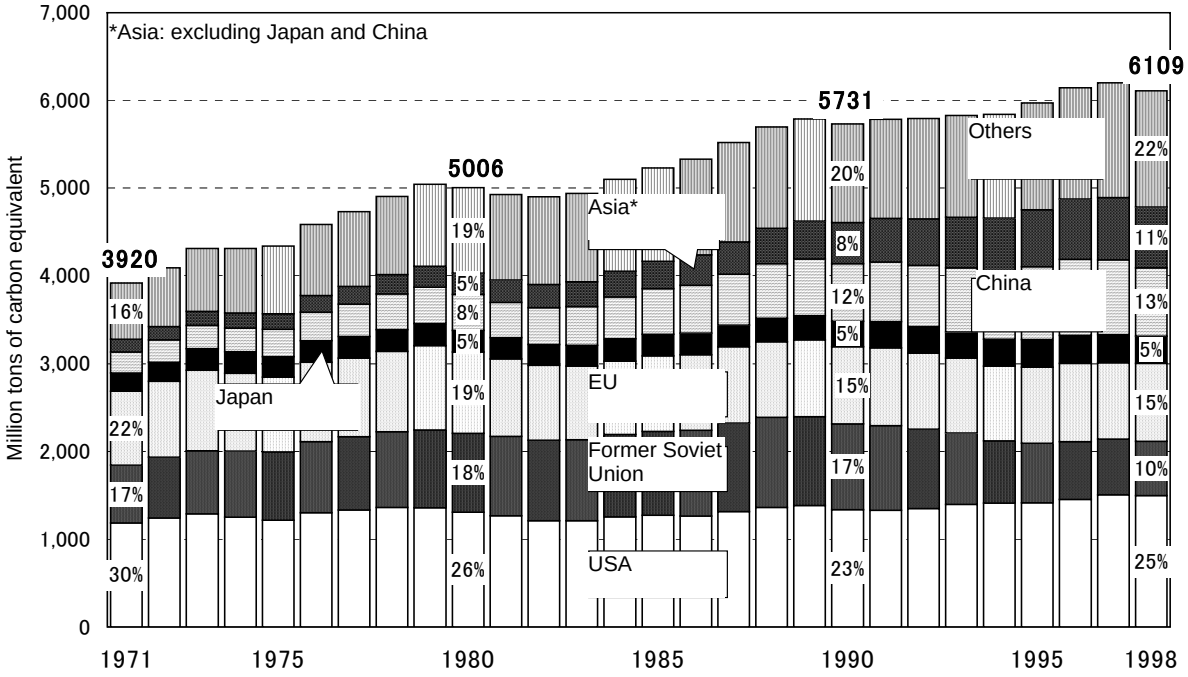
Source: the “Long-term Energy Supply and Demand Forecast (July 2001)” by the Advisory Committee on Natural Resources and Energy

The new energy, considered to have lesser environmental impact, has drawbacks in economic feasibility and stable supply. Various preferential treatments and subsidies are provided to help increased utilization of new energy.

Note: New energy: The “Law Concerning Special Measures to Promote the Use of New Energy” defines the new energy as these kinds of energy which meet the following two requirements. The requirements are (1) the energy is technically at the stage of practical use but is not extensively used for economical constraints, and (2) the energy is necessary particularly to introduce substitute energy for petroleum. Specifically, the new energy includes renewable energy (photovoltaic power generation, windpower, solar heat utilization), recycling type energy (waste power generation, utilization of waste heat, manufacture of RDF), new utilization methods of the conventional energy (clean energy cars, co-generation with natural gas, fuel cells).

Global Warming Problem (carbon dioxide)

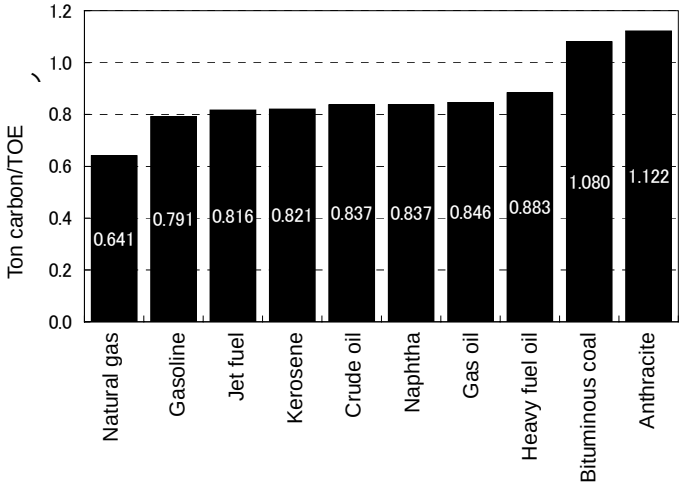
Figure 1-11 Global Emission of Carbon Dioxide



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The emission of carbon dioxide, one of the causes of global warming, is now great not only in advanced countries but also in developing countries in Asia, including China, which ranked second in 1998. In these countries consumption of energy is increasing along with industrial development, increasing coverage of electricity and improvement of living standard.

Figure 1-12 Carbon Intensities



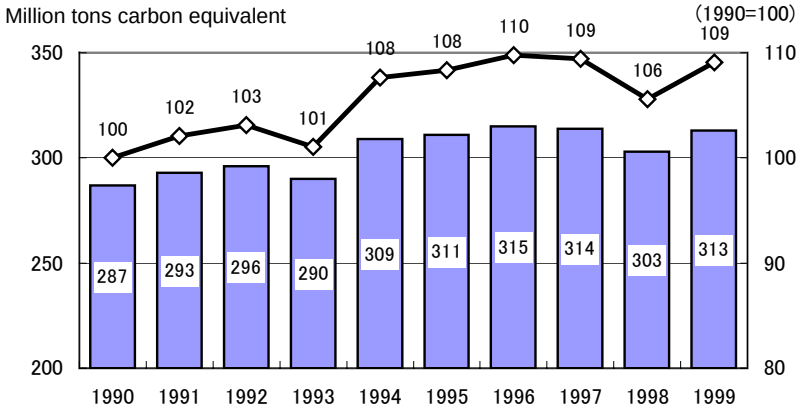
Source: IEA, "CO_2 Emissions from Fuel Combustion"

Remark: Natural gas emits a lesser amount of carbon per unit heat liberation than other fossil fuels, it also emits lesser amounts of nitrogen, and sulfur. The latest gas turbine using natural gas has a very high thermal efficiency. Natural gas has advantageous both in environmental and economic aspects. Shown here are values used by IEA for calculating amounts of carbon dioxide emission. Actually, the amounts of carbon dioxide emitted vary with such factors as combustion conditions.

Table 1-8 Excerpt from COP3 Kyoto Protocol

Target year	2008 to 2012	
Base year	1990	
Subject gas and base year	Carbon dioxide (CO_2), methane (CH_4), dinitrogen monoxide (N_2O) --- base year 1990 Hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6) --- Base year may be set for 1995.	
Joint target of advanced countries and countries that have shifted to market economy	Reduction in emission of greenhouse effect gases by 5 percent at least from the base year	
Reduction rate by country	+10%	Iceland
	+8%	Australia
	+1%	Norway
	±0%	New Zealand, Russia, Ukraine
	-5%	Croatia
	-6%	Japan, Canada, Hungary, Poland
	-7%	USA
	-8%	EU, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxemburg, Monaco, Holland, Portugal, Spain, Sweden, UK, Switzerland, Bulgaria, Czech, Estonia, Latvia, Lithuania, Romania, Slovakia, Slovenia

Figure 1-13 Carbon Dioxide Emission from Japan



Source: Material from the Advisory Committee on Natural Resources and Energy, the Ministry of Economy, Trade and Industry (July 2001)

Remark: Japan's emission of carbon dioxide in 1999 was 9 percent greater than that of 1990, a situation making it difficult for Japan to achieve the reduction target agreed in COP3.

Chapter 2 Energy Consumption in the Industrial Sector

1. Industrial Structural Change and Energy Consumption

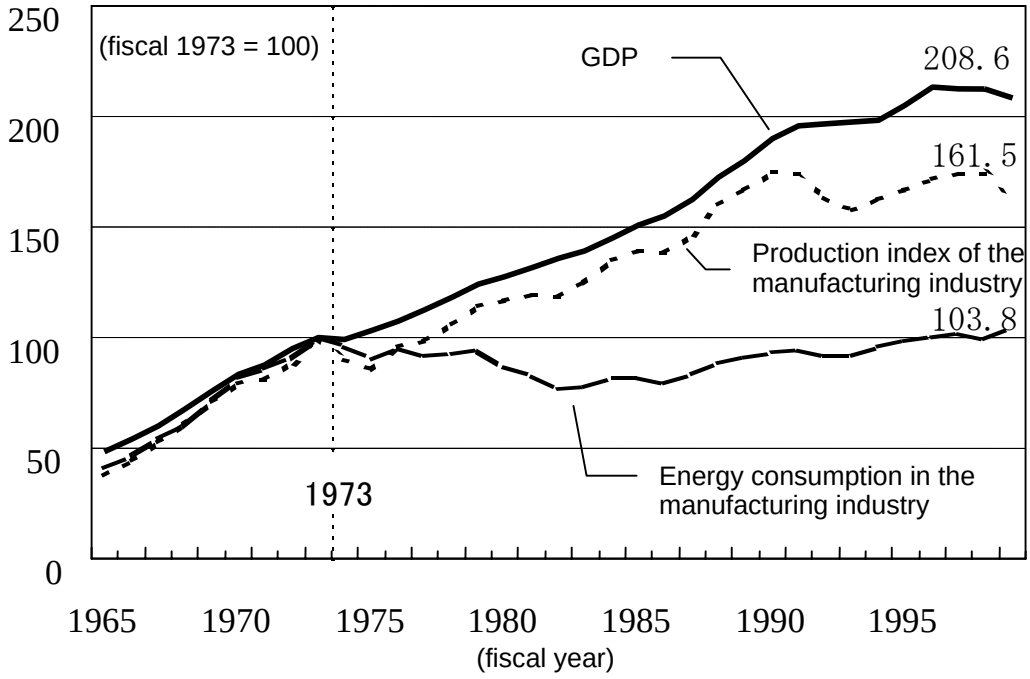
The rate of increase of energy consumption by the industrial sector exceeded that of GDP growth before the first oil crisis (1965 to 1973). This rate greatly declined after the first oil crisis. However, energy consumption by the manufacturing sector took an upward turn in the middle of the 1980s, and now stands at about the same level of 1973 (Refer to Figure 2-1). The major reasons for the decreasing rate of industrial energy consumption vis-à-vis GDP are decreasing energy intensity (promotion of energy conservation) and changing industrial structure toward a high-value added industrial structure (from energy-intensive industries to processing industries).

Shown below are changes that took place after the first oil crisis over a period from 1973 to 1999.

	Ratio, 1999 to 1973	Annual rate of increase
Energy consumption in the industrial sector	1.06-times	(0.21%)
Energy consumption in the manufacturing industry	1.04- times	(0.14%)
GDP	2.09- times	(2.88%)
Index of industrial production (IIP)	1.66- times	(1.97%)

Share in manufacturing production	1973	1985	1999
Material production industries	24.5%	21.9%	21.0%
Processing industries	24.5%	40.0%	48.3%

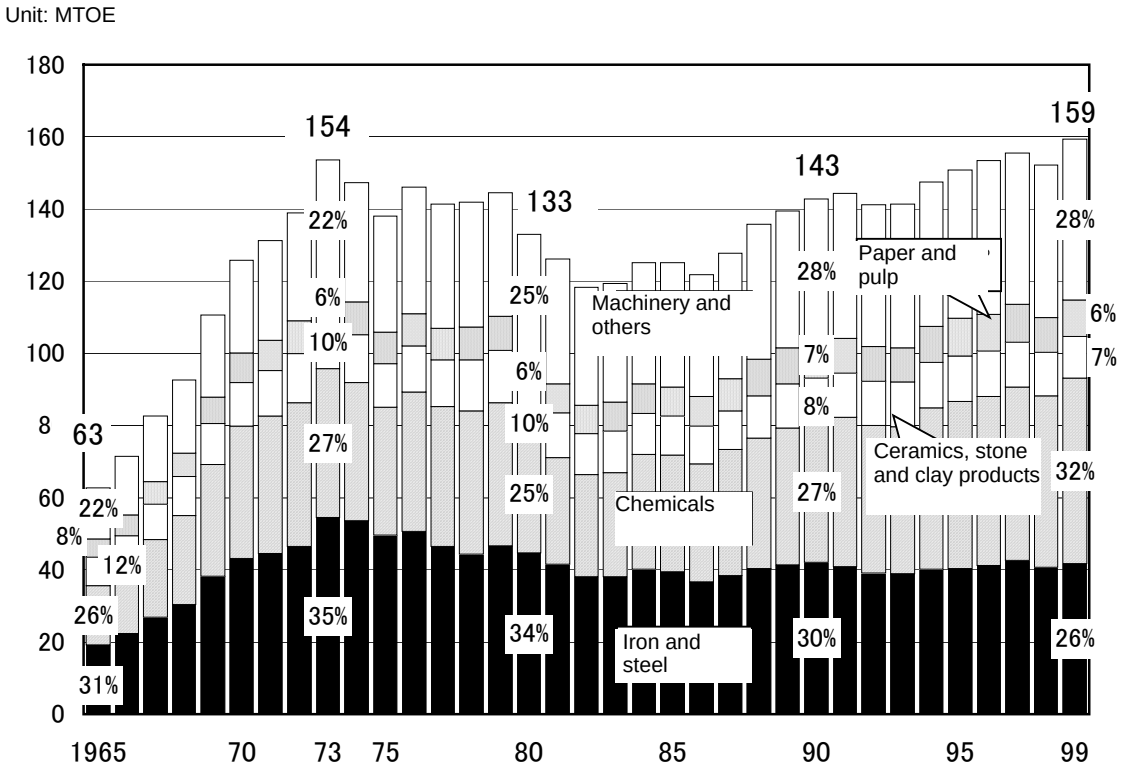
Figure 2-1 Energy Consumption in the Manufacturing Industry



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: Japan's economy doubled in scale over a period from 1973 to 1999; however, the energy consumption in the manufacturing industry remained unchanged.

Figure 2-2 Energy Consumption by type of Manufacturing



Source: Agency of Natural Resources and Energy, "Synthesized Energy Statistics"

Remark: The manufacturing industry keenly promoted energy conservation since the oil crisis of 1973. The manufacturing industry's energy consumption took an upward turn from the middle of the 1980s and, consequently, the industry's present energy consumption is about the same as that of 1973. The iron and steel industry consumed energy most in 1973, but now the chemical industry is the largest energy consumer of the manufacturing industry.

Table 2-1 Share and Growth Rate of Energy Consumption

(%)

	1973	1990	1999
Share of energy intensive industries in the manufacturing industry	78.4	72.1	72.0
Share of energy intensive industries in the final energy consumption	45.4	31.9	30.9

Rate of increase of energy consumption (annual average)	1965 to 1973	1973 to 1990	1990 to 1999
Energy intensive industries	12.0	-0.9	1.2
Total manufacturing industries	11.8	-0.4	1.2
Total of the final demand	11.8	1.2	1.6

Note: Energy intensive industries are the iron and steel industry, chemical industry, ceramic and stone and clay products industry, paper and pulp manufacturing industry and paper product manufacturing industry.

Source: Agency of Natural Resources and Energy, "Synthesized Energy Statistics"

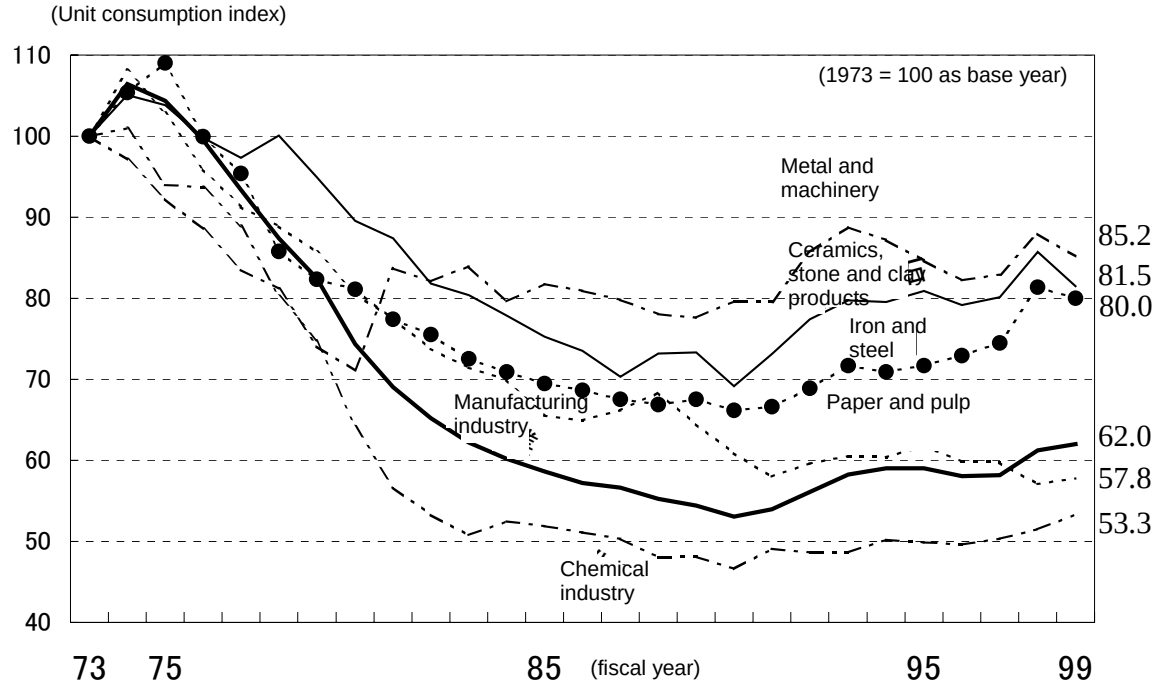
Remark: The material industries account for about 70 to 80 percent of the total energy consumption of the manufacturing industry. Around 1973, the energy intensive industries represented about half the final energy demand. Thereafter, their shares declined and presently their shares are about 30 percent of the total.

2. Energy Intensity

The energy consumption per IIP (index of industrial production) of the total manufacturing industry declined from 100 of 1973 as base year to 53 in 1990. In recent few years, this figure is increasing a little (Refer to Figure 2-3).

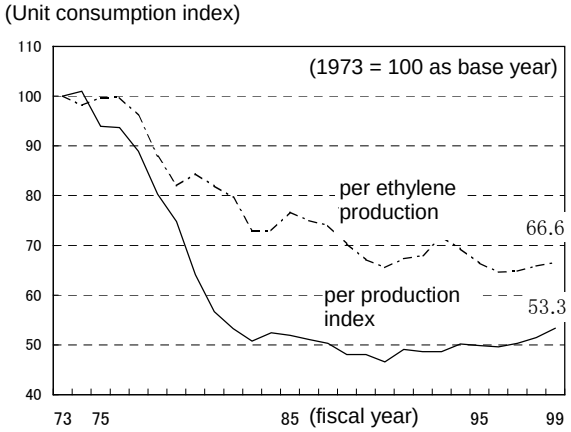
This decline was brought about not only by the energy conservation in narrower meaning (technical energy conservation) but by changes within the industries of product mixes towards making high value added products.

Figure 2-3 Energy Consumption per Unit IIP

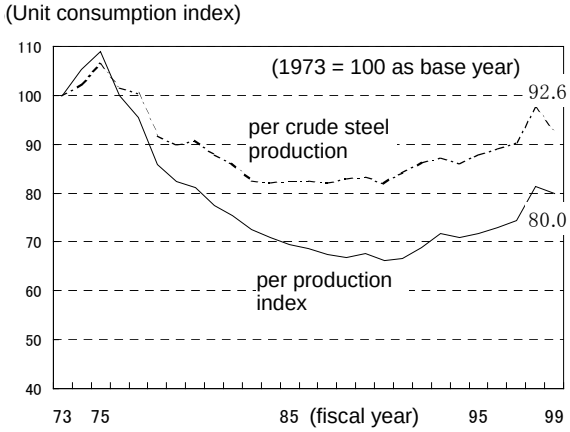


Source: EDMC Handbook of Energy & Economic Statistics in Japan

Figure 2-4 Energy Intensity of Chemical Industry Figure



2-5 Energy Intensity of Iron and Steel Industry

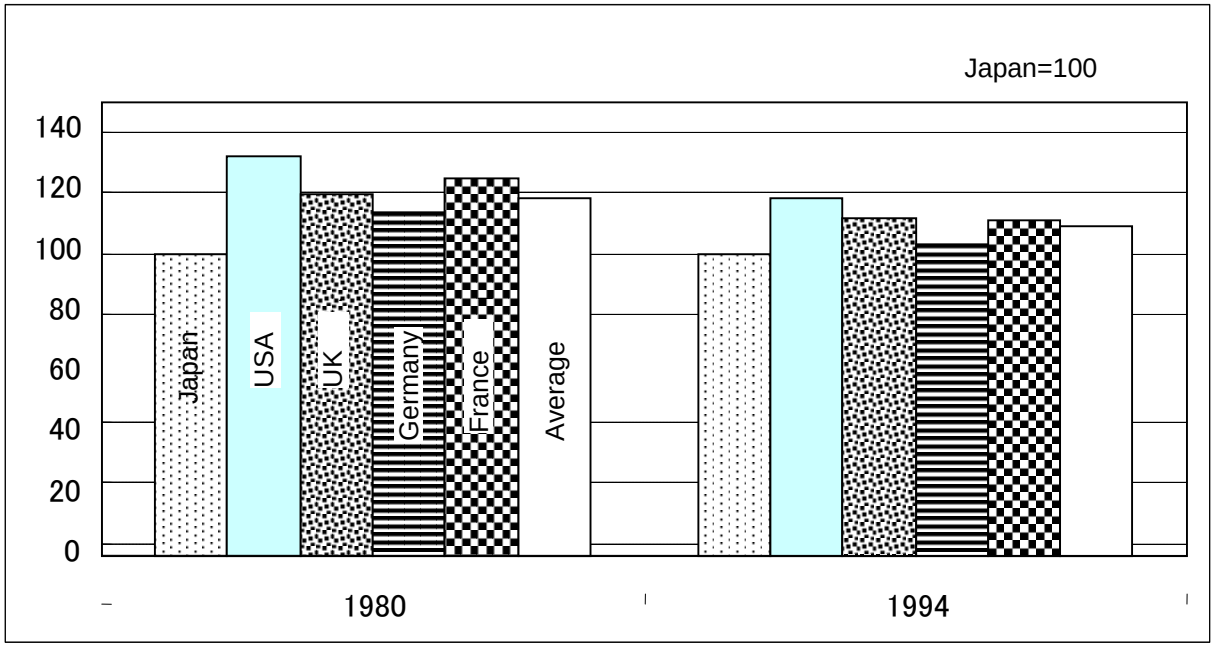


Source: EDMC Handbook of Energy & Economic Statistics in Japan

(International Comparison in Energy Intensity)

The manufacturing industry of Japan introduced energy conservation facilities ahead of their US and European counterparts. Consequently, energy conservation of the manufacturing industry of Japan ranks the highest in the world (Refer to Figures 2-6 and 2-7).

Figure 2-6 International Comparison in Energy Intensity of Iron and Steel Industry (Japan = 100)

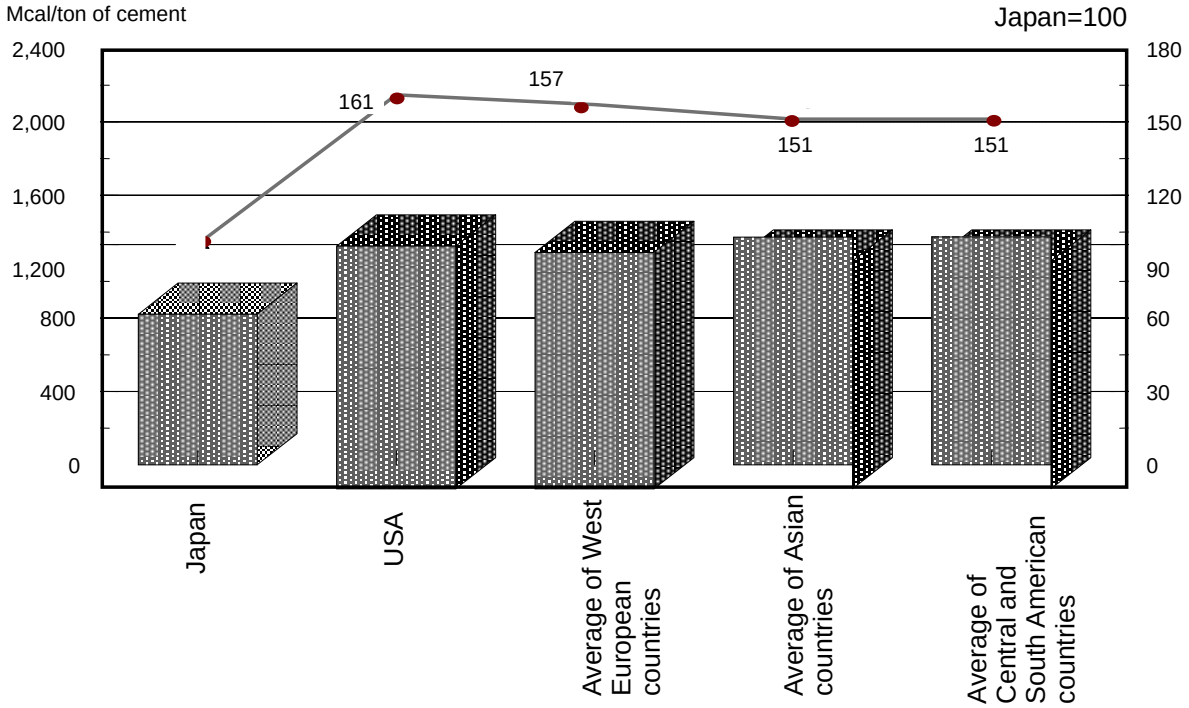


Note: The averages are arithmetic averages for respective countries.

Source: For 1980, 1988 and 1990 “First Mission to Europe for Energy” by the Energy Measure Committee of THE JAPAN IRON and STEEL FEDERATION; for 1987 “Handbook for Prevention of Global Warming” of the Environment Agency; for 1994 materials of the JAPAN IRON and STEEL FEDERATION

Remark: The energy intensity of the Japanese iron and steel industry is about 10 percent less than those of foreign countries.

Figure 2-7 International Comparison in Energy Intensity of Cement Industry



Note: The unsmoothed line represents production with Japan being 100.
Source: CEMBUREAU, "WORLD CEMENT DIRECTORY"

Remark: The Japanese cement manufacturing industry consumes about 35 percent less energy than its foreign counterparts.

(Energy Productivity (Added value/amount of energy consumed))

The Japanese manufacturing industry has achieved dual objectives of contribution to economic growth and of reduction of energy consumption by shifting from material manufacturing to processing industries (machines and likes).

	1973		1999
Average of the manufacturing industries	41 yen/1,000 kcal		83 yen/1,000 kcal
Average of material manufacturing industries	12 yen	→	24 yen
Iron and steel industry	11 yen		17 yen
Machinery industry	308 yen		711 yen

Table 2-2 Production, Value added, Energy Consumption of Manufacturing Industry (1973)

	Production ratio, (%)	Value added ratio, (%)	Value added rate, (%)	Energy consumption ratio, (%)	Value added/energy (yen/1,000 kcal)
Total manufacturing industry	100.0	100.0	31.7	100.0	40.9
Food	11.3	16.0	45.1	3.0	215.5
Textile	4.1	3.6	28.0	4.3	35.0
Total material manufacturing	32.3	24.5	24.2	81.4	12.3
Paper and pulp	3.5	2.9	26.3	6.4	18.5
Chemicals	7.1	3.9	17.2	6.9	5.9
Ceramics, stone and clay products	4.8	6.0	39.6	9.6	25.9
Iron and steel	14.4	9.3	20.6	35.5	10.8
Nonferrous metals	2.4	2.4	31.4	3.1	32.5
Machinery and likes	52.4	55.8	33.8	11.3	202.5
Machinery	29.7	24.5	26.2	3.3	308.1
Others	22.7	31.3	43.8	8.0	159.6

Table 2-3 Production, Value added, Energy Consumption of Manufacturing Industry (1999)

	Production ratio, (%)	Value added ratio, (%)	Value added rate, (%)	Energy consumption ratio, (%)	Value added/energy (yen/1,000 kcal)
Total manufacturing industry	100.0	100.0	31.7	100.0	83.4
Food	10.0	9.9	36.6	3.5	235.9
Textile	1.2	1.2	35.2	2.0	47.5
Total material manufacturing	22.9	21.0	34.0	74.0	23.7
Paper and pulp	2.6	2.2	32.4	6.3	29.8
Chemicals	8.2	9.3	42.4	32.3	24.1
Ceramics, stone and clay products	2.4	2.9	44.6	7.4	32.7
Iron and steel	7.6	5.2	25.4	25.9	16.8
Nonferrous metals	2.2	1.5	24.6	2.2	54.9
Machinery and likes	65.8	68.0	38.4	20.5	276.7
Machinery	50.8	54.5	39.9	6.4	710.8
Others	15.2	14.2	34.7	14.1	83.9

Note: The value added rate is the portion of the value added in the production value.

Source: Calculated from Economic Planning Agency, “Annual Report on National Accounts”, Agency of Natural Resources and Energy “Synthesized Energy Statistics”

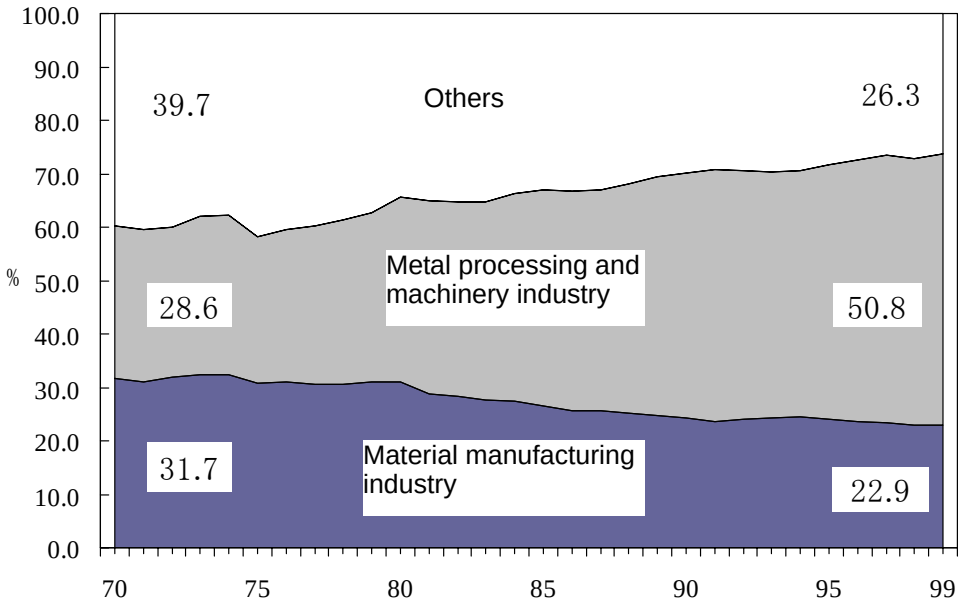
Remark: Comparison of given industries before and after a certain time space indicates that the value added per unit energy increased, or energy productivity increased. Both the production ratios and value added ratios indicate that a shift from the material manufacturing industry to the

machinery industry is underway. It is also seen from increasing value added rates for most industrial sectors that energy intensity (inverse number of energy productivity) has improved for reasons including but not limited to energy conservation.

Changes in Industrial Structure

In terms of the shares in production of various industries within the manufacturing industry, the metal processing and machinery industry are increasing their shares while the material production industry is decreasing the share. This is a sign of the industrial structure shifting toward high-value added one (Refer to Figure 2-8).

Figure 2-8 Trend of Production Share in Manufacturing Industry



Note: (1) metal processing and machinery industry; metal products, machinery, (2) material manufacturing industry; paper and pulp, chemicals, ceramics and stone and clay products, iron and steel, nonferrous metals, (3) others; food, textile, petroleum and petroleum products, coal products, other manufacturing industries

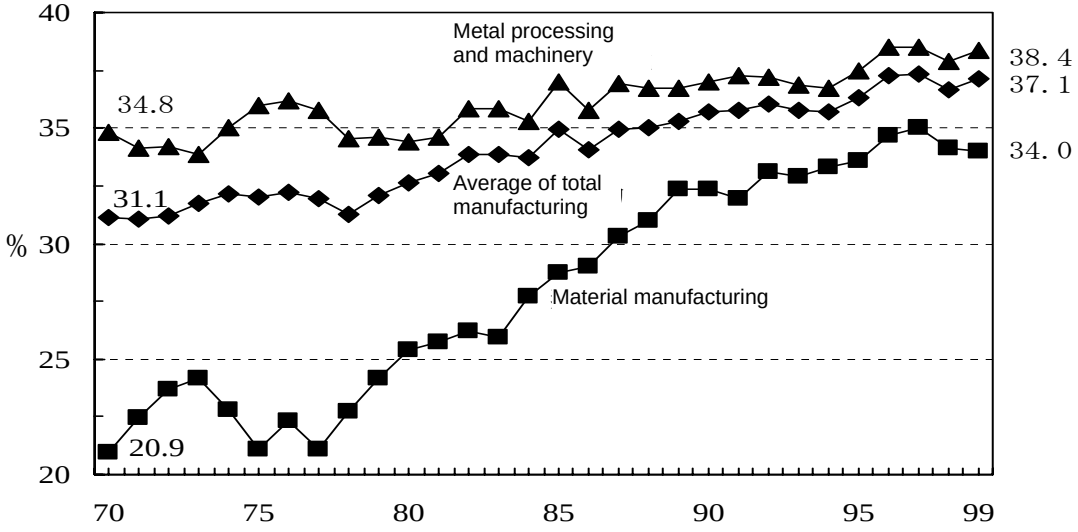
Source: Economic Planning Agency, "Annual Report on National Accounts"

Remark: The industrial structure is undergoing a change from material production toward a higher value-added metal processing and machinery production.

Change in Product Mix

The value added rate is increasing in every industry, indicating that each industry is now making higher value-added products more than before (Refer to Figure 2-9).

Figure 2-9 Trends of Value Added Rate



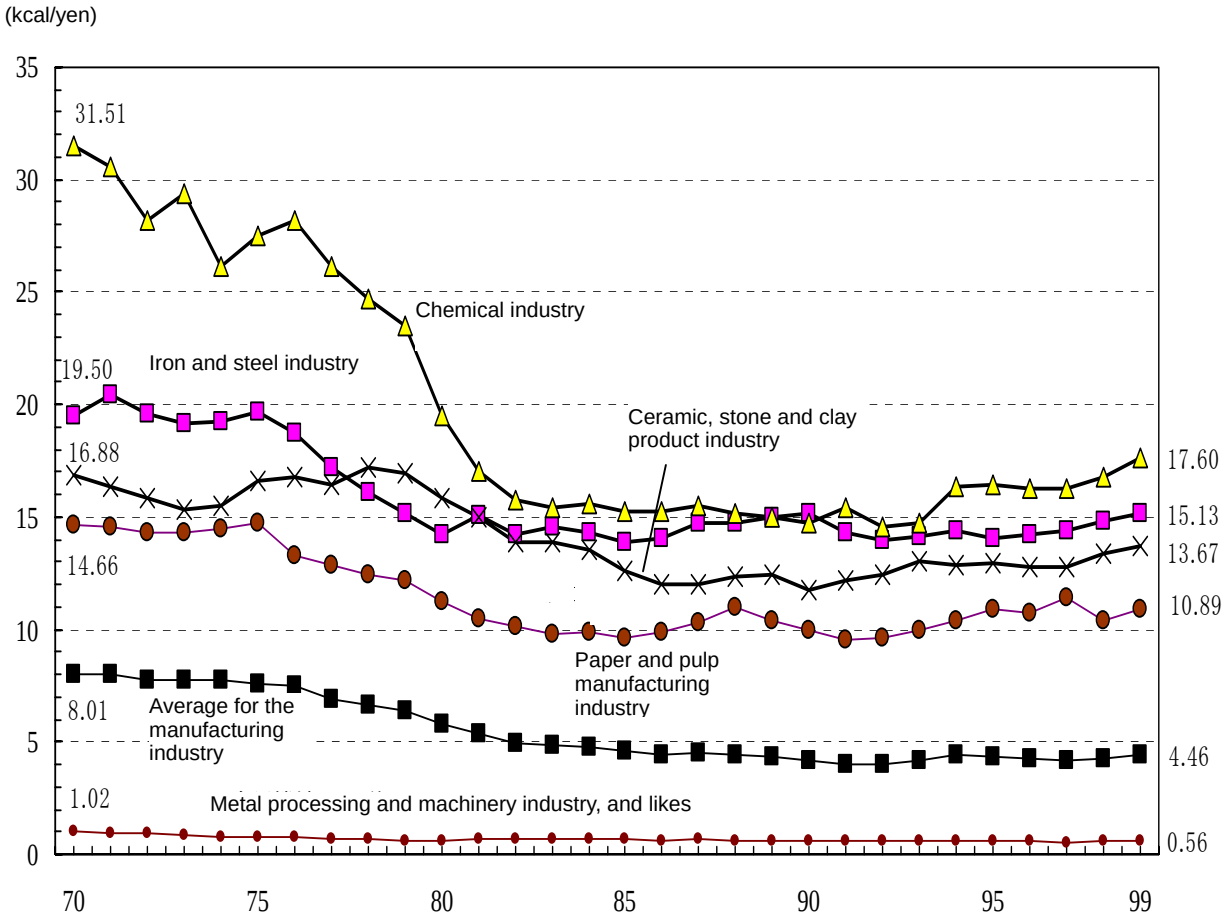
Note: The classification of industry is the same as that for Figure 2-8.
Source: Economic Planning Agency, "Annual Report on National Accounts"

Remark: In each industrial area, the change in product mix is underway toward higher value-added one.

Changes in Energy Intensity

Remarkable progress has been made in energy conservation in such energy intensive industries as chemical industry, iron and steel industry, ceramic and stone and clay product industry and paper and pulp industry during a period from 1975 to 1985 (Refer to Figure 2-10). Even in such non-energy intensive industries as metal processing and machinery, significant progress has been made in energy conservation during the same period. Consequently, the energy intensity of the manufacturing industry decreased by half from 1970 to 1999.

Figure 2-10 Trends in Changes of Unit Energy Consumption by Production



Source: Economic Planning Agency, "Annual Report on National Accounts," Agency of Natural Resources and Energy, "Synthesized Energy Statistics"

Remark: The energy intensity greatly improved from 1975 to 1980, but thereafter it remained almost unchanged.

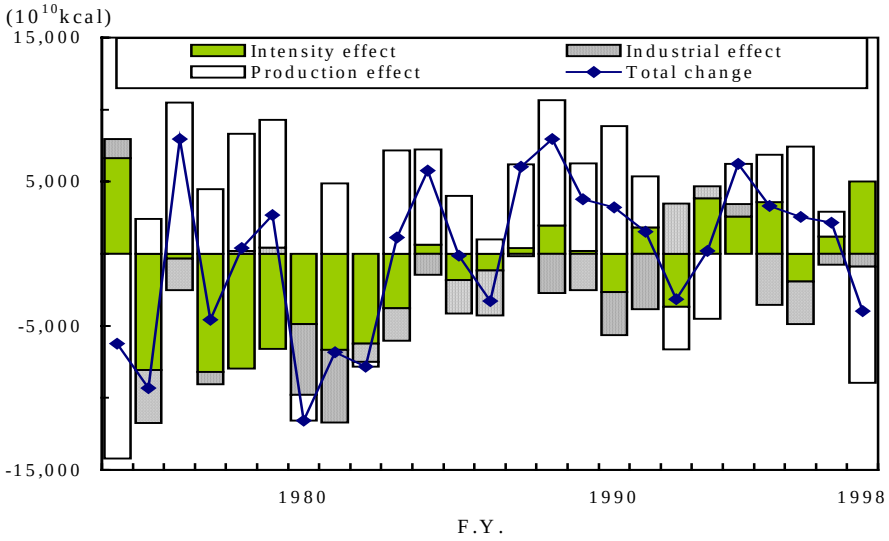
3. Factor Analysis of Energy Consumption in the Manufacturing Industry

A factor analysis of energy consumption in the manufacturing industry was conducted on the following three factors; namely, (1) energy conservation (intensity factor), (2) change in industrial structure (structural factor), and (3) change in production (production factor) (Refer to Figure 2-11).

The index of industrial production (IIP) of the total manufacturing industry increased 1.66-times over a period from 1973 to 1999 while the energy consumption increased only 1.04-times. This is because increase of energy consumption by expansion of production (production factor) was almost offset by reduction of energy consumption due to the intensity factor and to the structural factor (Refer to Figure 2-11).

The intensity factor and the structural factor contribute to reduction of energy consumption to the extents of 60 percent and 40 percent, respectively. However, the intensity factor includes changes in product mix; therefore, the contribution by the technical energy conservation alone is considered to be smaller than the above figure.

Figure 2-11 Factors Analysis of Energy Consumption in the Manufacturing Industry



Remark: The intensity factor was most influential in reduction of energy consumption from 1976 to 1985; however, from 1986 to 1990, the production factor became significant through production of various products in small quantities.

As a reference, a forecast energy demand by the industrial sector up to 2010 is shown.

Table 2-4 Long-term Energy Demand Outlook

	fiscal 1999 record	forecast for fiscal 2010		Annual rate of increase from 1999 to 2010	
		Base case	Target case	Base case	Target case
Industrial sector	197	187	about 185	- 0.47%	about - 0.57%
Total final demand	402	409	about 400	0.16%	about - 0.05%

Source: Advisory Committee on Natural Resources and Energy (July 2001)

4. Measures Taken by the Industry for Global Environmental Problems

The Japan Federation of Economic Organizations has formulated action plans for countermeasures for such global environmental problems as global warming. The organization executes the plans and reviews the implementation. Table 2-5 shows measures taken by the energy intensive industries out of 31 industries of the federation.

Table 2-5 Results of the 3rd Follow-up to the Keidanren Voluntary Action Plan on the Environment (1999 Version)

Types	Target	Ratio to 1990 consumption	Countermeasure
Paper making	・ To reduce by 2010 purchased energy consumption per unit product by 10 percent from the 1990 level	1997: 6.7% 1998: 4.6% 1999: 7 %	・ Utilization of pulp spent liquor ・ Adoption of co-generation ・ Prevention of heat loss and recovery and utilization of waste heat ・ Rationalization of fuel use and use of substitute energy ・ Effective control of raw materials and chemical, and others
Chemical industry	・ To reduce by fiscal 2010 unit energy consumption to 90 percent level of fiscal 1990	1997: 96% 1998: 109% 1999: 95%	・ Improvement of facility and equipment efficiency ・ Improvement of operation through reuse, recycling, optimization of pressure, temperature, flow rates, and others ・ Recovery of effluent waste energy by effective utilization of heat and cold heat ・ Rationalization of processes, improvement of processes by modifications of manufacturing methods
Petroleum industry	[Manufacturing and transportation stages] ・ To reduce by fiscal 2010 corrected unit energy consumption at refineries by 10 percent from the fiscal 1990 level ・ To reduce by fiscal 2010 fuel consumption for transportation of petroleum products by 9 percent from the fiscal 1990 level [Consumption stage] ・ To reduce petroleum consumption by one million kiloliters per year by	 1997: 8% 1998: 8% 1999:11% 1997: 8.5% 1998: 17.6% 1999: 13.7% 1997: 390 thousand kl/year 1998: 460 thousand kl/year 1999: a million kl/year	・ Advanced energy conservation and control ・ Reduction of steam consumption, recovery of waste heat ・ Adoption and development of new technologies, others ・ Improvement of efficiency of land transportation by means of large tank trucks, improvement of mileage, increase of loadage, adoption of high-mileage tank trucks ・ Improvement of efficiency of marine transportation by means of reduction of the amount transported, use of larger vessels, reduction of transportation

Types	Target	Ratio to 1990 consumption	Countermeasure
	extensive use of co-generation		distance ・ Extension of co-generation systems by petroleum-derived fuels ・ Extension of kerosene burning equipment through direct approaches to consumers
Cement industry	・ To reduce by 2010 unit energy consumption (fossil fuels and oil coke) by about 3 percent from the 1990 level	1997: 0.6% 1998: 1.0% 1999: 1.7%	・ Extension and promotion of energy conservation equipment ・ Increased use of RDF ・ Increased use of industrial wastes ・ Increased production of blended cement
Iron and steel industry	・ To reduce by fiscal 2010 energy consumption by 10 percent from the fiscal 1990 level, Additionally, to use waste plastics in the blast furnaces and others to the extent of 1.5 percent of the energy consumption of fiscal 1990 (subject to establishment of a collection system)	1997: 3.1% 1998: 9.6% 1999: 6.1%	・ Extension and adoption of existing energy conservation technologies, commercialization, extension and promotion of innovating technologies ・ Utilization of waste plastics at iron and steel mills, with cooperation by the central and local governments, utilization of unused energy in the communities ・ Development and extensive utilization of high function steels (high tension steel plates, electromagnetic steel plates) ・ Cooperation to energy conservation through the Activities Implemented Jointly

Source: Keidanren's homepage, "Fiscal 2000 Keidanren Voluntary Action Plan (Global Warming Measures), Summary Version

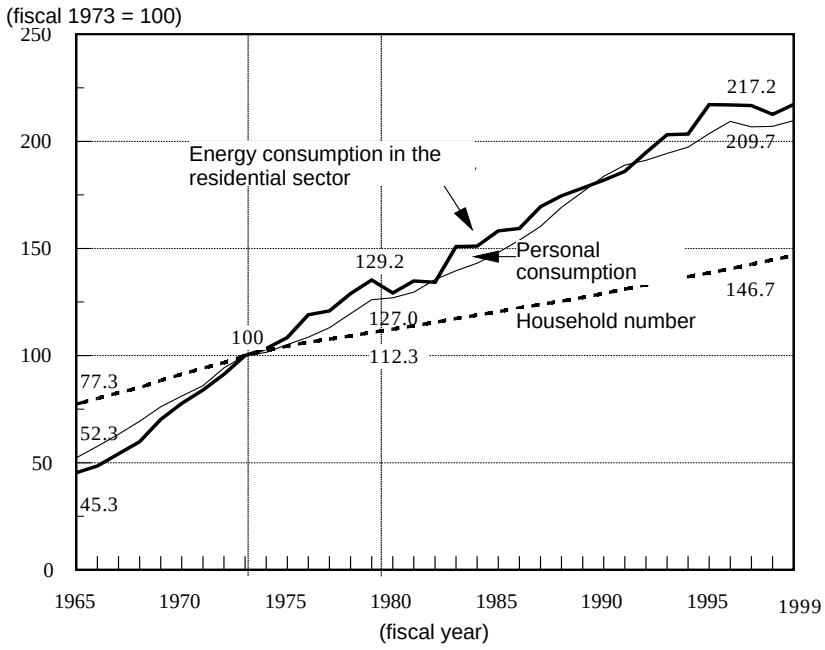
Remark: Each business group develops its own action plan and conducts a following up work every year.

Chapter 3 Energy Consumption in the Residential Sector

1. Number of Households and Energy Consumption by End-Use

The energy consumption in the residential sector has steadily increased, although the two oil crises slowed down its growth. The consumption in fiscal 1999 is more than double that in fiscal 1973 when the first oil crisis took place, the index of the former being 217 with the latter being the base at 100. The share in the final energy consumption of the residential sector grew from 9 percent of 1973 to 14 percent of 1999.

Figure 3-1 Trends of Energy Consumption in the Residential Sector



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The growth of residential energy consumption declined as a result of the two oil crises in 1973 and 1979. Notwithstanding, the residential energy consumption is now more than twice that in 1973. It may be noted from the figure that the sector consumption is intimately linked with personal consumption.

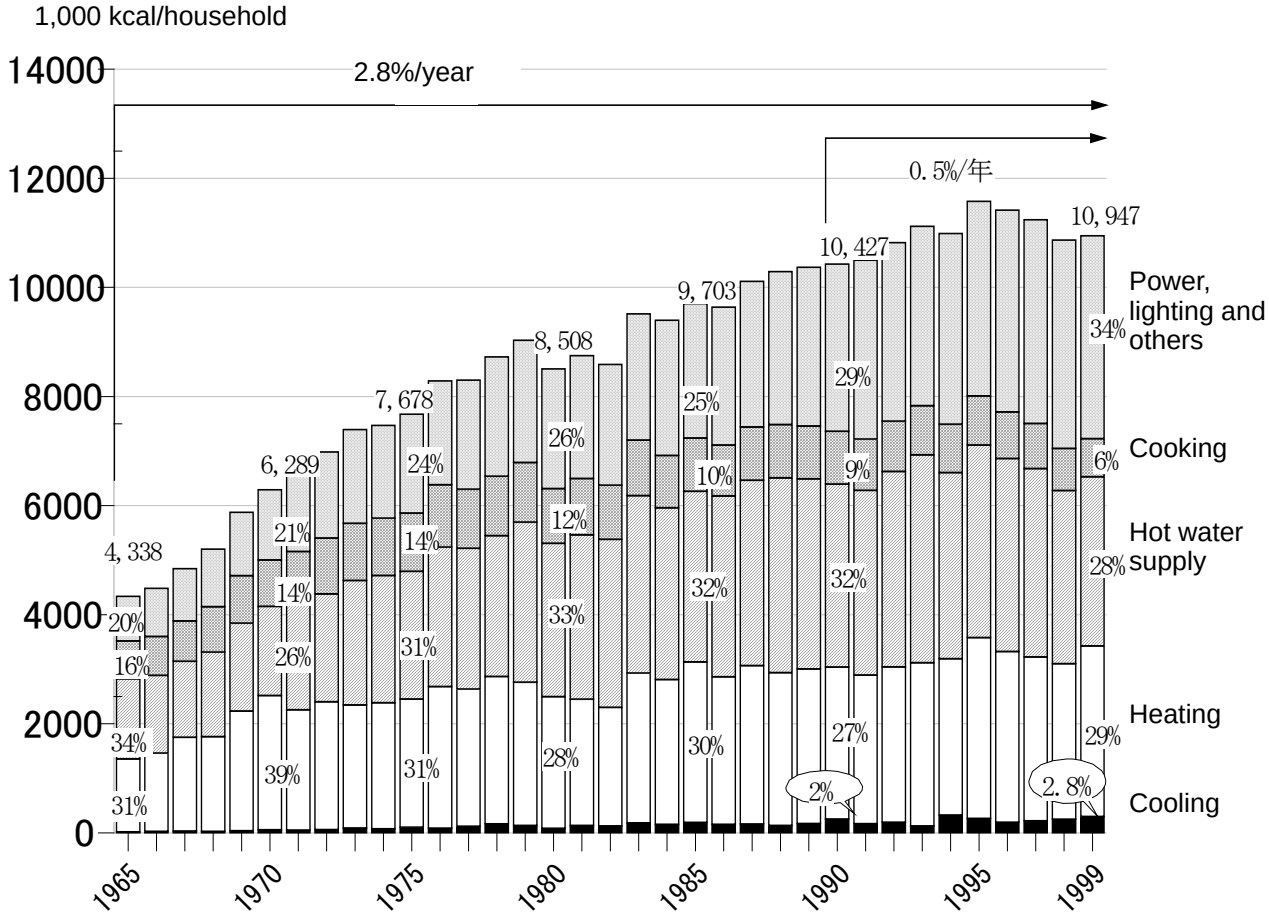
Energy consumption in the residential sector = energy consumption per household × the number of households

Table 3-1 Income and Energy Consumption (Average annual growth rate)

	1965 to 1973 (%)	1973 to 19 90 (%)	1990 to 1999 (%)
Energy consumption	10.4	3.6	2.0
Real private final consumption	8.4	3.6	1.5
Number of households	3.3	1.6	1.4
Energy consumption per household	6.9	2.0	0.5
Real personal consumption per household	5.0	2.0	0.1
Income Elasticity of energy (private final consumption base)	1.23	0.98	1.34

Remark: The residential energy consumption exhibits steady growth as a result of steady increases in household number and in energy intensity associated with the income rise.

Figure 3-2 Energy Intensity by End-Use (per Household)



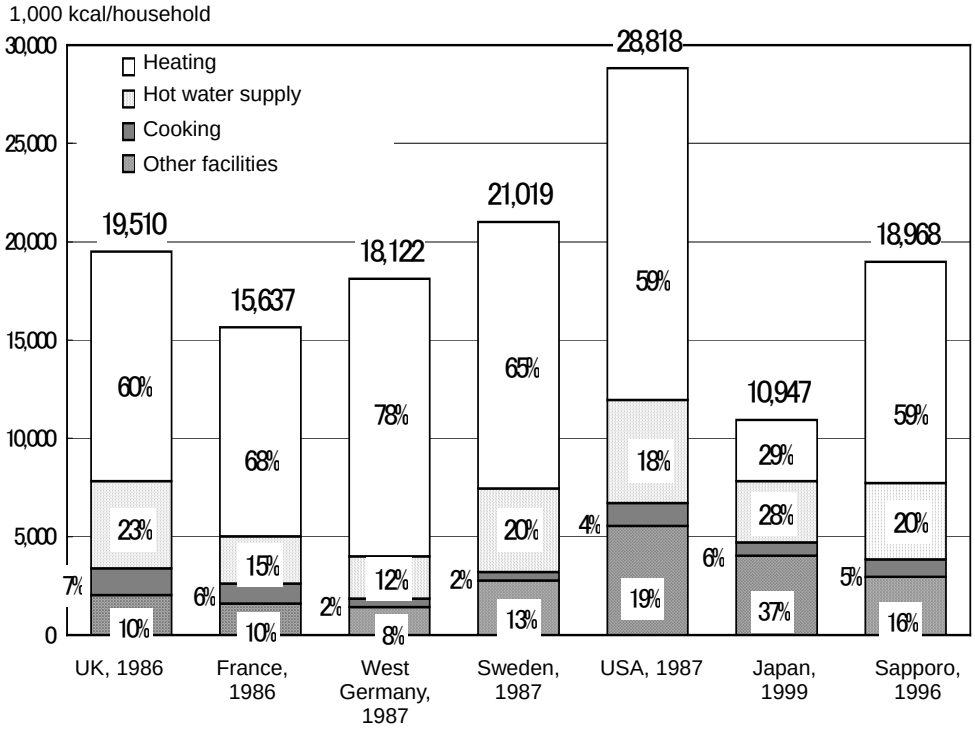
Source: Handbook of Energy & Economic Statistics in Japan

Table 3-2 Energy Intensity by End-Use (per Household)

	(Average growth rate) (%)			(Share)¥ (%)			
	1965 to 1973	1973 to 1990	1990 to 1999	1965	1973	1990	1999
Heating	6.8	1.2	1.3	30.9	30.5	26.7	28.6
Cooling	22.8	6.4	2.0	0.4	1.2	2.4	2.7
Hot water supply	5.6	2.3	-0.9	33.8	30.9	32.2	28.3
Cooking	5.3	-0.5	-3.6	16.0	14.2	9.3	6.4
Power, lighting	9.7	3.5	2.2	18.9	23.2	29.4	34.0
Total	6.9	2.0	0.5	100	100	100	100

Remark: The share of the power and lighting has increased with penetration of household electric appliances and with upgrading of lifestyles. Likewise, air-conditioning is becoming very common and this increases the consumption for heating and cooling. The cooking energy is decreasing as the habit of eating out becomes common and the retort food is increasingly accepted.

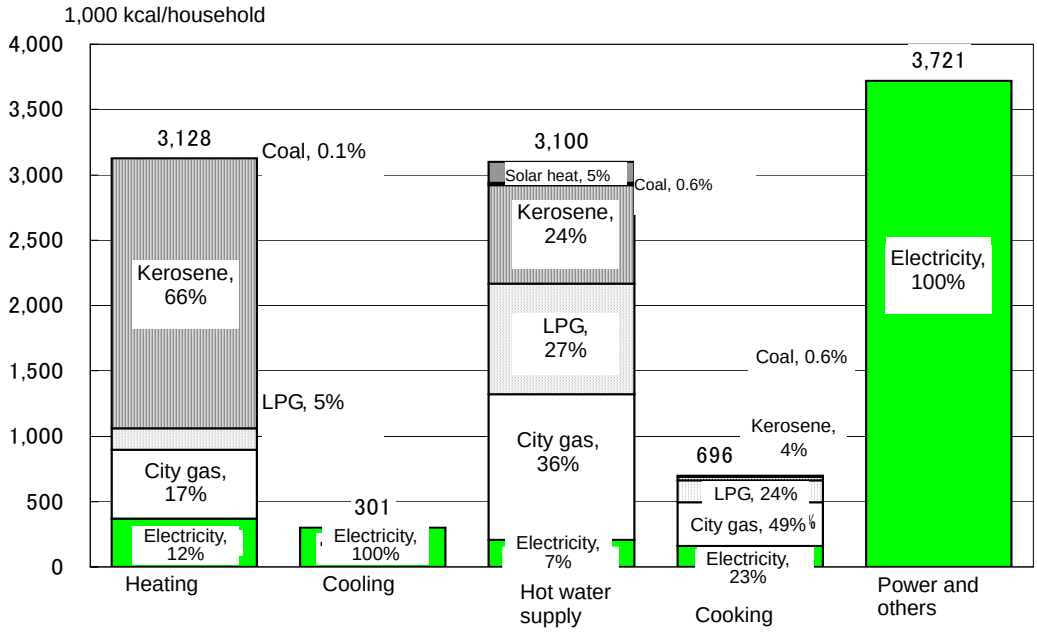
Figure 3-3 International Comparison of Energy Consumption in the Residential Sector (per Household)



Source: USA and Europe: Institute of Energy Economics, Japan, "Energy Economics," June 1990
EDMC Handbook of Energy & Economic Statistics in Japan
Data for Hokkaido; EDMC "Survey on Residential Sector Energy Consumption in Hokkaido, Japan," fiscal 1997

Remark: The residential sector energy consumption of Japan per household is about one third that of the United States and about half that of Europe. The difference between Japan and Europe is attributable mainly to the difference in climatic condition. In Hokkaido where heating consumption is great, the breakdown as well as unit consumption is similar to Europe.

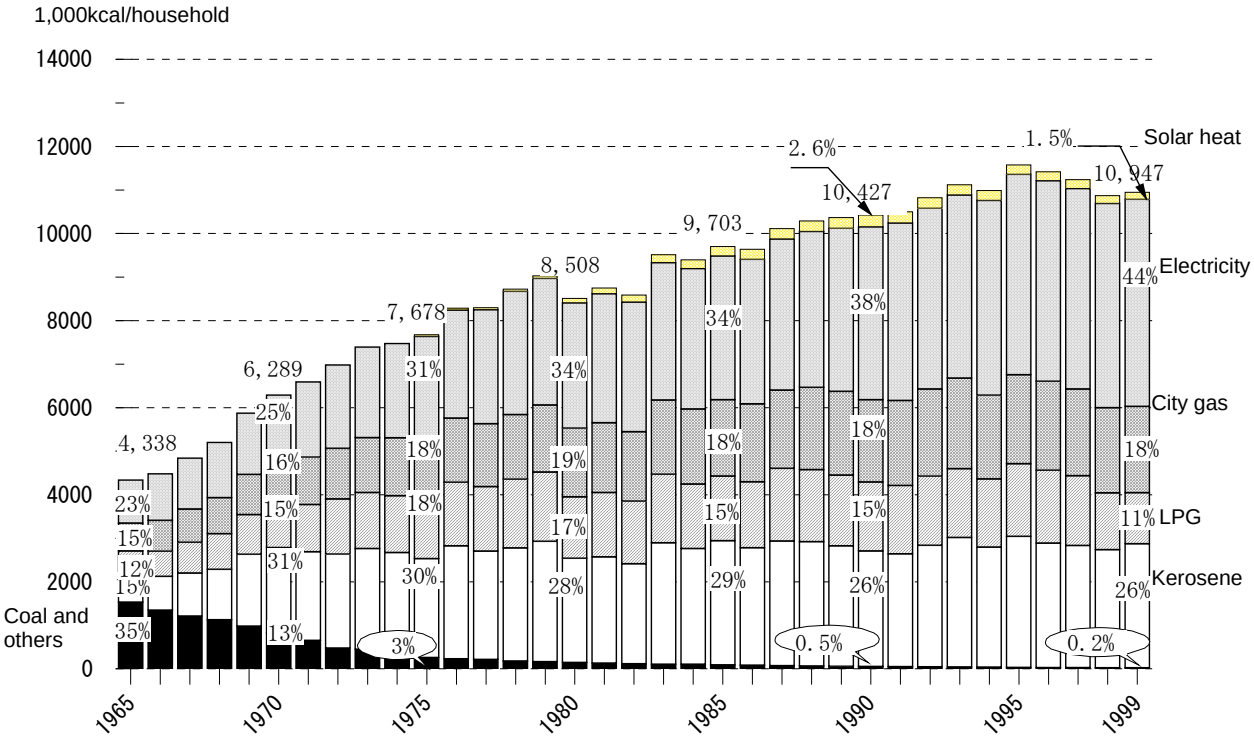
Figure 3-4 Energy Consumption in the Residential Sector by End-Use and by Source (1999)



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The energy source varies greatly depending upon the use. For heating, kerosene is the most important, particularly in colder areas like Hokkaido, while for cooling and power, electric power is used almost exclusively.

Figure 3-5 Energy Intensity in the Residential Sector by Source (per Household)



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The increasing penetration of household electric appliances and increasing demand for power and lighting and heat, spreading use of heat pumps account for increasing share of electric power.

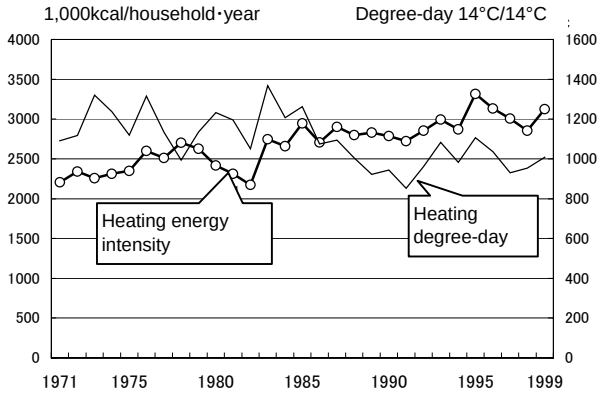
・Effect of temperature

The consumption for heating, cooling and hot water supply is susceptible to atmospheric temperature. Close correlation is found between the energy consumption for heating and cooling with temperature. The heating demand increases in colder winters and the cooling demand increases in hotter summers. The parameters for expressing such climatic features are heating degree-day[1] and cooling degree-day[2].

[1] The concept of heating degree-day assumes that people use heating when atmospheric temperature lowers below a certain base temperature. In the case of this study the base temperature is set at 14°C. Heating degree-day is a parameter indicating the necessity of heating, and is defined as the sum of the differences between the average temperatures of the days below the base temperature and 14°C.

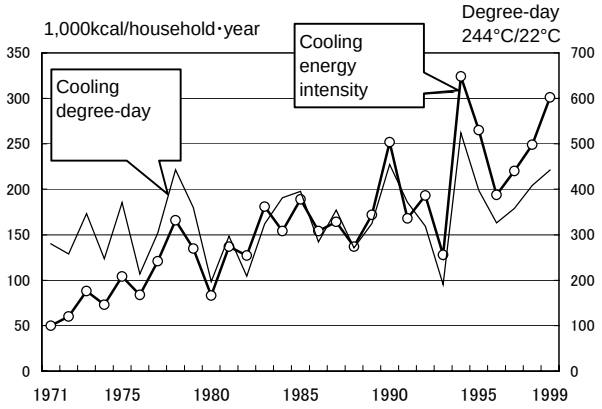
[2] The concept of cooling degree-day assumes that the people use cooling when atmospheric temperature exceeds a certain base temperature. In the case of this study the base temperature is set at 24°C. Cooling degree-temperature is a parameter indicating the necessity of cooling, and is defined as the sum of the difference between the average temperatures of the days above the base temperature and 22°C.

Figure 3-6 Heating Energy Intensity and Heating Degree-day



Source: EDMC's Estimate

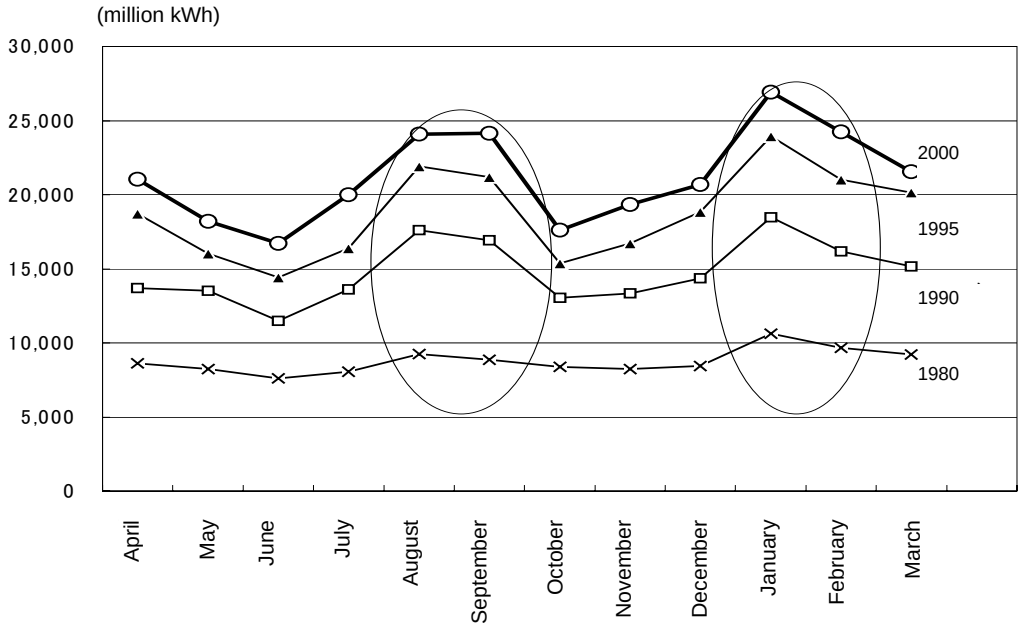
Figure 3-7 Cooling Energy Intensity and Cooling Degree-day



Source: EDMC's Estimate

Remark: It may be noted from Figures 3-6 and 3-7 that when heating degree-day is large the heating energy intensity is large, and when cooling degree-day is large the cooling energy intensity is large. Positive correlation is clearly noted for each of them. Recently, a cool summer was experienced in 1993, and a very hot summer was experienced in 1994. The energy intensity is increasing every year with some fluctuations due to changes in degree-days.

Figure 3-8 Monthly Electric Power Consumption
(top 10 regional electric power companies)



Source: DEMC's development from the Monthly Report on Electric Power Statistics

Remark (1) The residential sector increases its electric power consumption every year. (The graph is moving upward every year.)

(2) Increasing penetration of air conditioners makes both the winter peak and summer peak more outstanding.
Leveling of load is desired from the viewpoint of improving efficiency of the facilities.

2. Lifestyle and Energy Consumption

(keywords)

Aging population, increasing free time, social advancement of women, privatism, leeway in life, comfort….. → Time to stay at home, to own facilities, how to use them

(1) Household Attributes

Ratio of old population:	persons older than 65; 7.1% in 1970 → 17.2% in 2000, 26.9% in 2020
Persons per household:	3.55 in 1970 → 2.70 in 2000, 2.49 in 2020
Area of a house (exclusively for living):	70.2 m^2 in 1973 → 89.6 m^2 in 1998

(2) Lifestyle

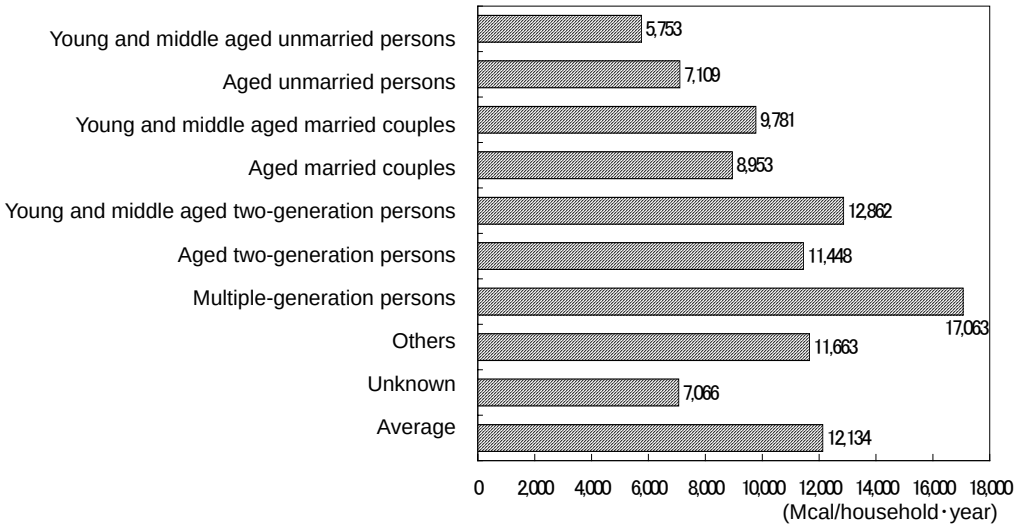
Sleeping pattern:	toward being active in mid night
Double income:	full-time housewives; 37% in 1975 → 31% in 1999
	employment of women; 45% in 1975 → 47% in 2000
Expense for eating out:	10% in 1970 → 17% in 2000

(3) Utilization of Facilities and Equipment

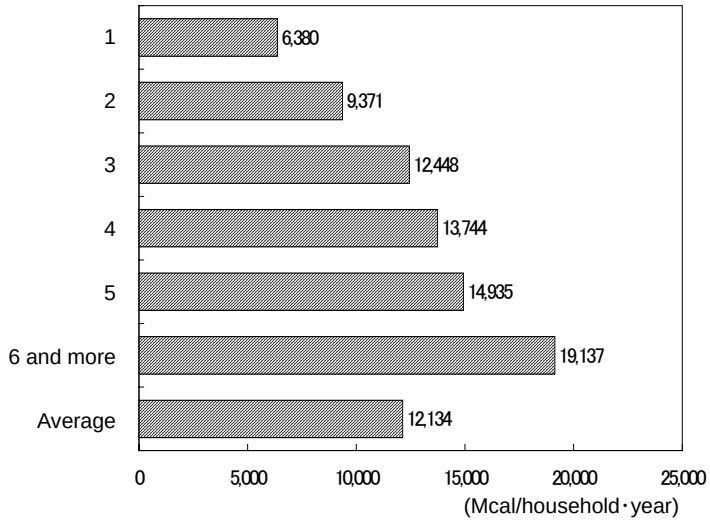
Heating and cooling:	Longer use time (increasing with aging population), insulation of houses
Hot water supply:	(Frequency of taking bath, taking morning showers)
Kitchen utensils:	(number of people eating, frequency of eating out)
Power, lighting:	(Advancement of lifestyle, increasing use of electronics)
	Buying larger units at the times of replacement (television set, refrigerator, washing machine)
	Standby electric power consumption

Figure 3-9 Household Attributes and Energy Consumption

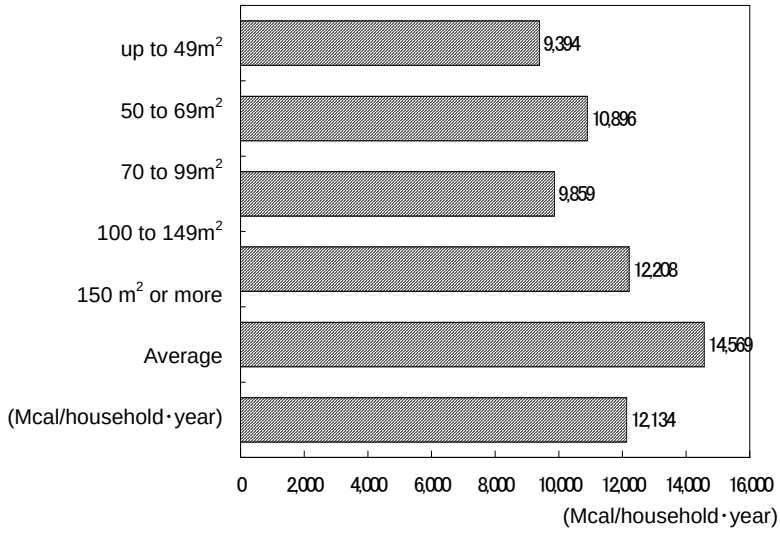
(Classification by Household Attributes)



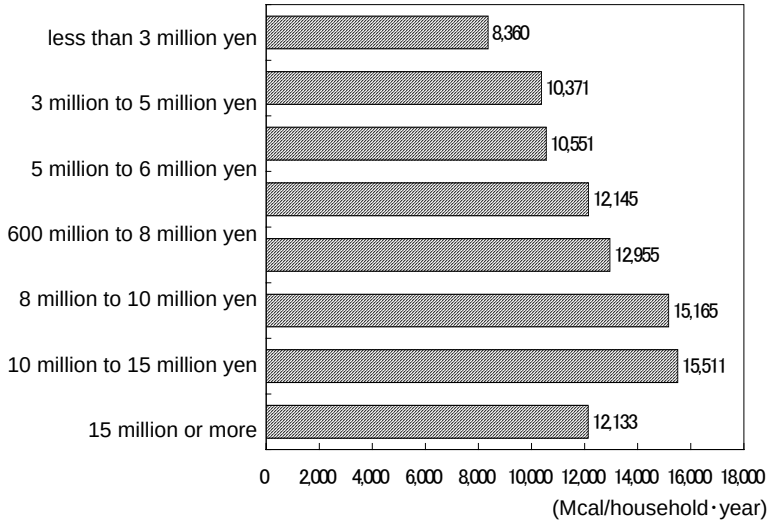
(Number of persons per household)



(Floor area of a residence)



(by Annual Income)



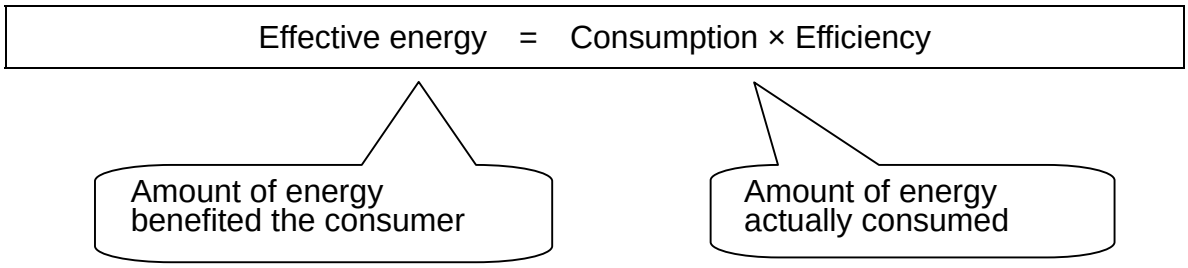
Note: (1) Stand-alone houses in local medium- and small-sized towns and villages except for Hokkaido were surveyed.

(2) "Aged" means a family of which the eldest person is 65 years old or older.

Source: NEDO, EDMC "Report on Energy Consumption in the Residential & Commercial Sector of Japan" (March 1999)

Remark: The graph for "Classification by Household Attributes" does not indicate an increase of energy consumption attributable to longer time to stay at home of elderly persons. This is probably because the present elderly persons were grown up with the principle that saving is a virtue. Such factors as number of persons per household, floor area, annual incomes are considered to increase energy consumption.

3. Penetration of Electrical Appliances and Energy Consumption (Energy Conservation)



・ Improvement of efficiency of major appliances, 1973 → 1994

Refrigerator (efficiency 66% reduction), TV set (unit consumption 43% reduction), air-conditioner (efficiency 44% reduction)

・ Recent efficiency improvement of household electric appliances

Refrigerator (1995 → 1997: 22% reduction in annual consumption), TV set (1990 → 1998: unit consumption 22% reduction), air-conditioner (1995 → 1999: 30% annual reduction)

Figure 3-10 Improvement in Energy Efficiency of Major Household Electric Appliances

Refrigerator with freezer

Trends of average monthly electric power consumption of 170 liter class two-door refrigerator with a freezer, (base year fiscal 1973 = 100) (Fiscal year means refrigeration fiscal year from October of the preceding year to the September of the concerned year)

fiscal 1973, 79.6kWh/month	fiscal 1991, 27.0kWh/month
fiscal 1986, 26.0kWh/month	fiscal 1992, 27.0kWh/month
fiscal 1987, 26.0kWh/month	fiscal 1993, 27.0kWh/month
fiscal 1988, 26.0kWh/month	fiscal 1994, 27.0kWh/month
fiscal 1989, 27.0kWh/month	
fiscal 1990, 27.0kWh/month	

Color TV set

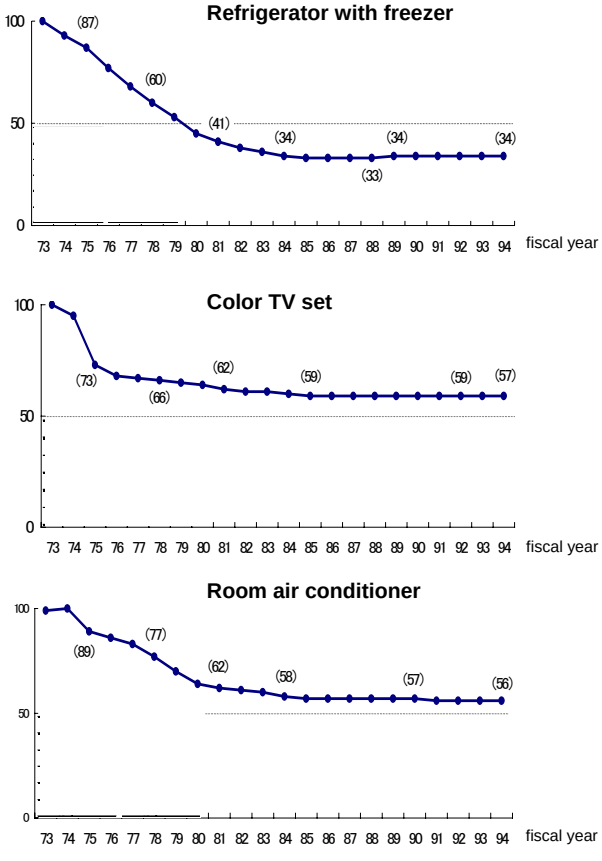
Trends of electric power consumption by 19 and 20 inch type TV set (base year fiscal 1973 = 100)

fiscal 1973, 140W	fiscal 1991, 83W
fiscal 1986, 830W	fiscal 1992, 83W
fiscal 1987, 83W	fiscal 1993, 80W
fiscal 1988, 83W	fiscal 1994, 80W
fiscal 1989, 83W	
fiscal 1990, 83W	

Room air conditioner

Trends of electric power consumption of separate type air conditioners, (base year fiscal 1973 = 100)

fiscal 1973, 847W	fiscal 1991, 476W
fiscal 1986, 488W	fiscal 1992, 473W
fiscal 1987, 483W	fiscal 1993, 473W
fiscal 1988, 482W	fiscal 1994, 472W
fiscal 1989, 482W	
fiscal 1990, 479W	



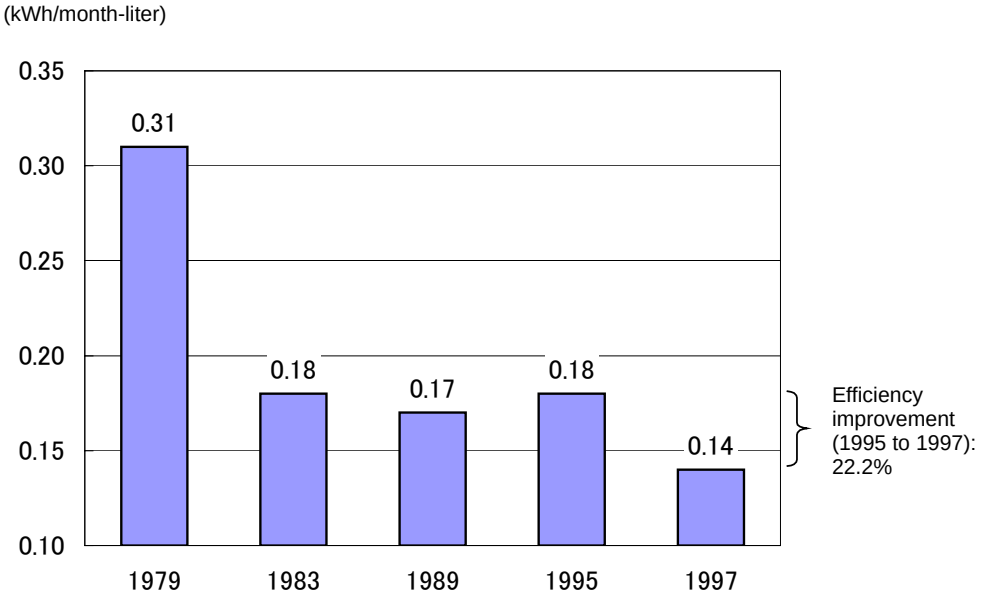
Source: Association for Electric Home Appliances

Remark: Consistent data for every year were available up to 1994. The graphs seem to indicate that energy conservation has been slowing down during the later period. As a matter of fact, spectacular achievements have been made in recent years, due partly to amendments of the Energy Conservation Law.

(1) Electric power consumption of refrigerators (kWh/liter-month): efficiency improvement from 1995 to 1997; 22.2 percent.

* Average electric power consumption per month per liter of major models of leading manufacturers

Figure 3-11 Trends of Energy Efficiency Improvement of Refrigerators



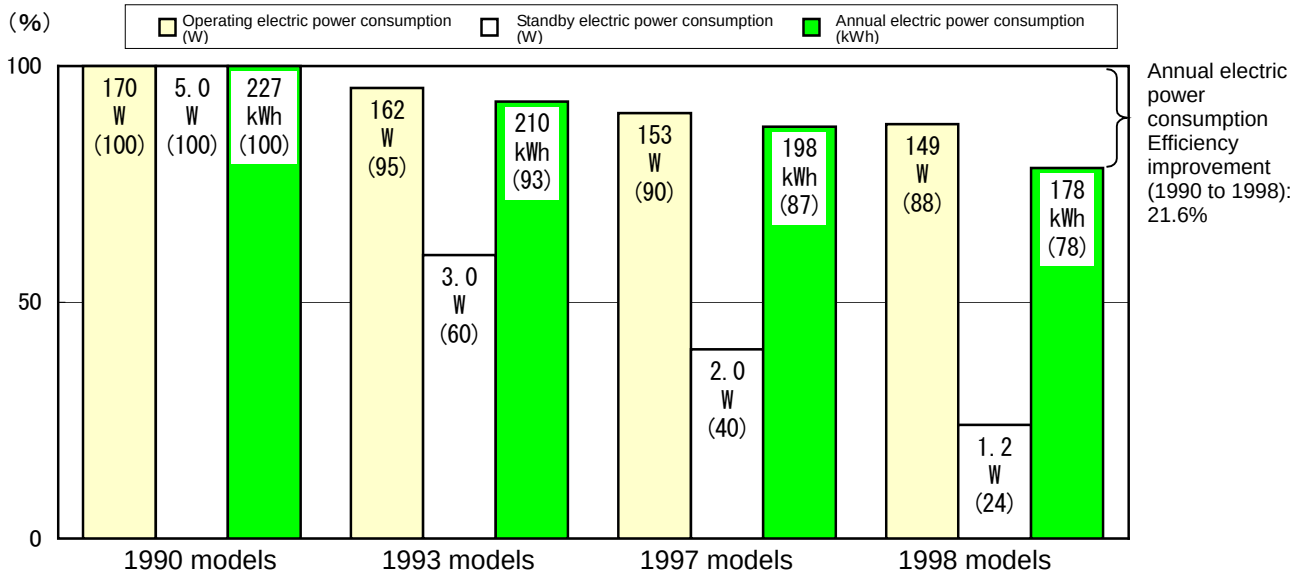
Source: the Energy Conservation Center, Japan, "Energy Conservation Performance 2001 Summer"

Remark: Use of designated frons for refrigerator was totally prohibited in 1995. There was a temporary decline of heat insulation or cooling performance; however, more than 20 percent energy conservation was achieved in only 2 years thereafter, with the use of inverter, for example.

(2) Electric power consumption of TV sets (W・kWh/year): efficiency improvement from 1990 to 1998; 21.6 percent

* Average of 28, 29 type BS TV set (weighted average of shipped TV sets)

Figure 3-12 Trends of Efficiency Improvement of TV Sets



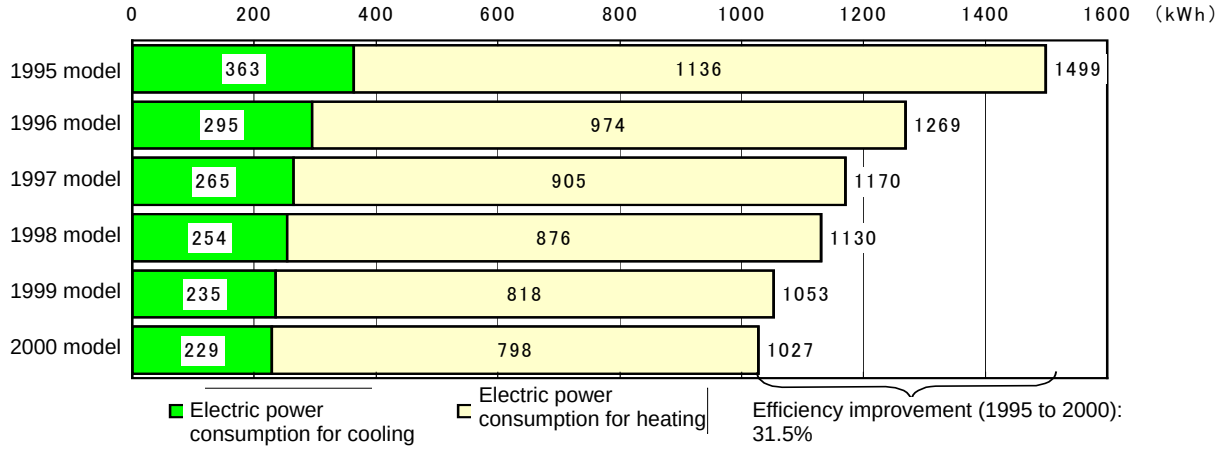
Source: the Energy Conservation Center, Japan, "Energy Conservation Performance 2001 Summer"

Remark: TV sets have achieved great reductions in standby electric power consumption, a theme of great attention recently. On the other hand, there are more TV sets with a flat and large display, factors increasing electric power consumption.

(3) Electric power consumption of air conditioners (kWh/year): efficiency improvement from 1995 to 2000: 31.5 percent

* Arithmetic average of representative energy conservation type wall-mounted air-conditions for both cooling and heating (cooling capacity 2.8kWh class)

Figure 3-13 Trends of Efficiency Improvement of Air-conditioners

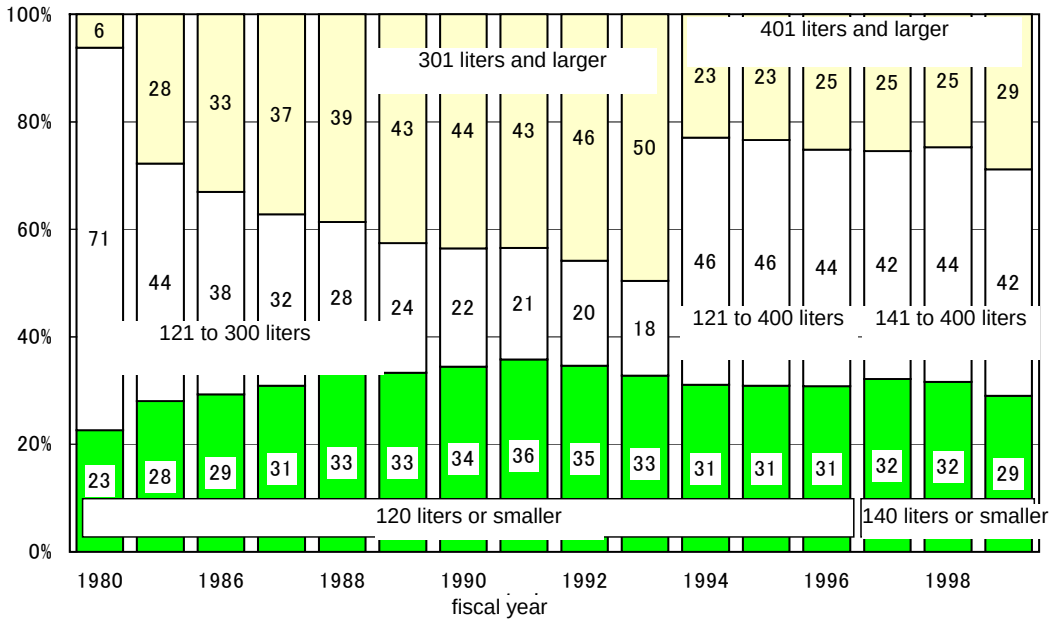


Source: the Energy Conservation Center, Japan, "Energy Conservation Performance 2001 Summer"

Remark: Reduction of 30 percent in electric power consumption was achieved over a five-year period from 1995 to 2000 by improvement of coefficient of performance (COP), or cooling and heating capacity per unit energy consumption.

- **Tendency toward using large household electric appliances**

Figure 3-14 Shares of Refrigerators Shipped to the Domestic Market by Size

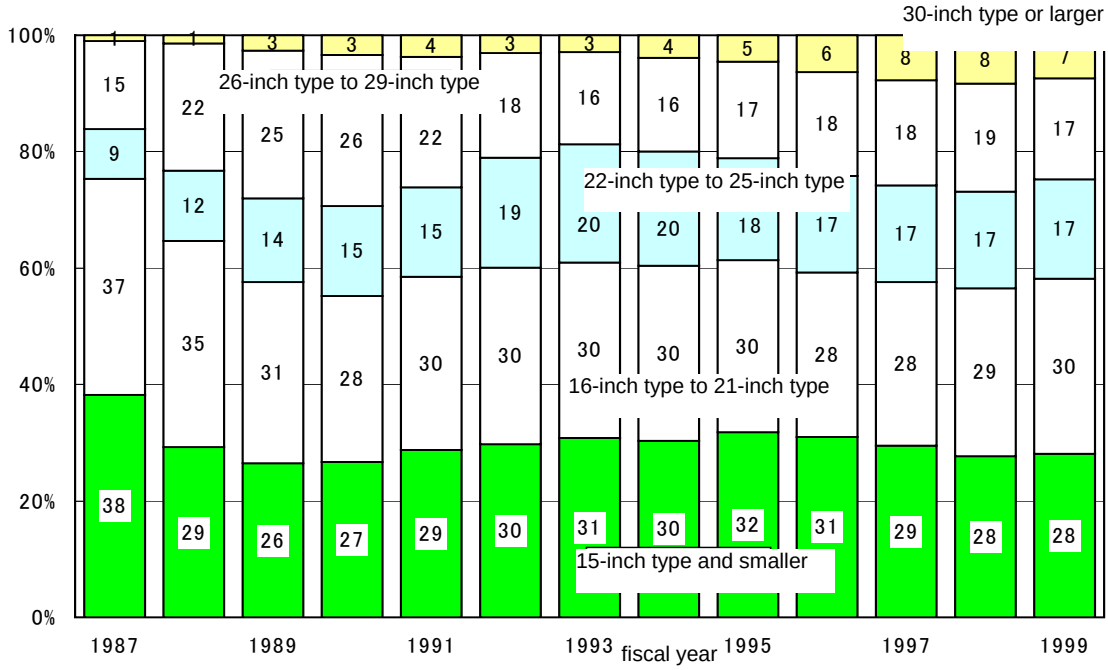


Note: Standard sizes for classification for refrigerators are 120 and 300 liters in 1993 and before, 120 and 400 liters from 1994 to 1996, and 140 and 400 liters from 1997 and onward.

Source: Household Appliance Industry Handbook 2000

Remark: There seems a trend toward using larger refrigerators. Although electric power consumption per one liter capacity is decreasing, increasing capacities of refrigerators being sold out do the improving efficiency in electric power consumption. (Since larger refrigerators become increasingly popular in recent years, the standards capacities classifying the commodities have been revised.)

Figure 3-15 Shares of Color TV Sets Shipped to the Domestic Market by Size



Source: Household Appliance Industry Handbook 2000

Remark: As efficiency of each unit improves, larger color TV sets are being marketed. As households tend to have more than one TV set, polarization of consumers' tendency to buy larger sets and to buy smaller sets is noticed.

Figure 3-16 Diffusion Rates of Household Electric Appliances

	Appliances	1965	1970	1975	1980	1985	1990	1995	1996	1997	1998	1999
Number of Holding (Per 100 Households)	Air Conditioner	-	8.8	24.8	57.9	88.0	126.5	166.1	179.3	191.7	200.7	207.6
	Refrigerator	-	94.4	108.9	115.2	114.3	119.4	119.4	120.6	120.7	120.7	121.6
	Color TV Set	-	43.5	117.2	150.9	174.7	201.3	215.1	219.9	224.6	224.0	226.2
	Oil Stove	-	109.2	157.1	174.9	161.0	145.6	118.2	117.7	107.4	105.8	105.0

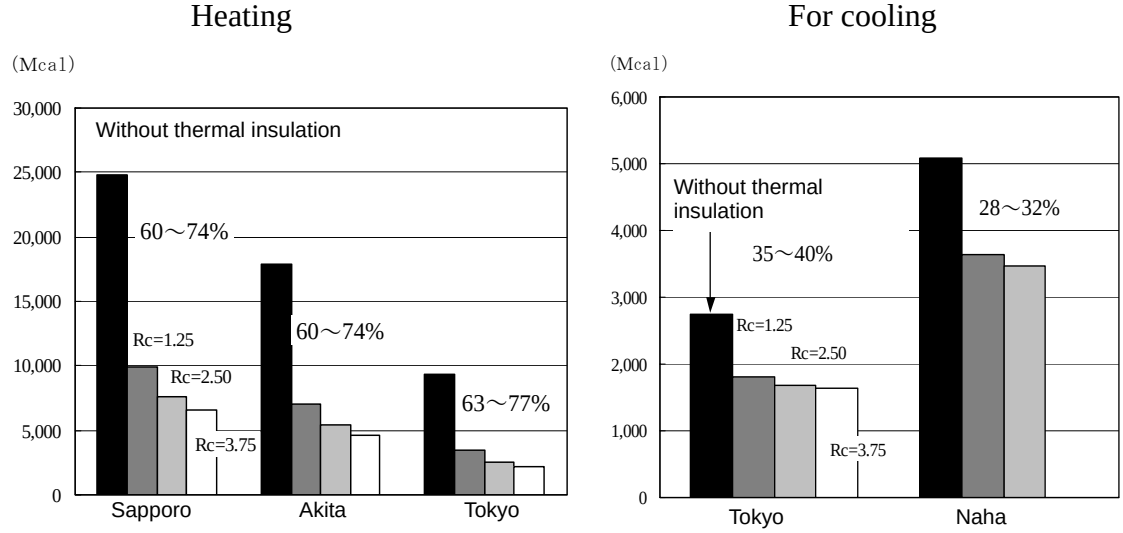
Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The diffusion of household electric appliances is spectacular in Japan. Many households own more than one color TV set and air-conditioner (including cooler).

・ **Insulation of Houses**

Rate of reduction of energy consumption for heating (- 60%), for cooling (- 30%): difference due to internal heat generation

Figure 3-17 Rate of Energy Conservation for Housing Heating and Cooling by Insulation



Note: Rc represents thermal resistance. Values of Rc at 1.25, 2.50 and 3.75 correspond to thermal resistance of 50, 100, and 150 millimeter glass wool insulation, respectively. The unit of the ordinate is 1,000 kcal.

Source: Agency of Natural Resources and Energy "Energy Conservation" Handbook 1997"

Remark: The above table shows the result of a calculation of annual energy consumption in heating and cooling of a model house at different locations and different conditions of thermal insulation. Naturally, the thicker is the insulation, the more effective is the insulation in reducing energy consumption. The insulation is less effective in cooling case than heating case, because heat generation inside the house acts as a load in the case of cooling.

(Reference)

Table 3-2 Long-term Energy Supply Demand Forecast

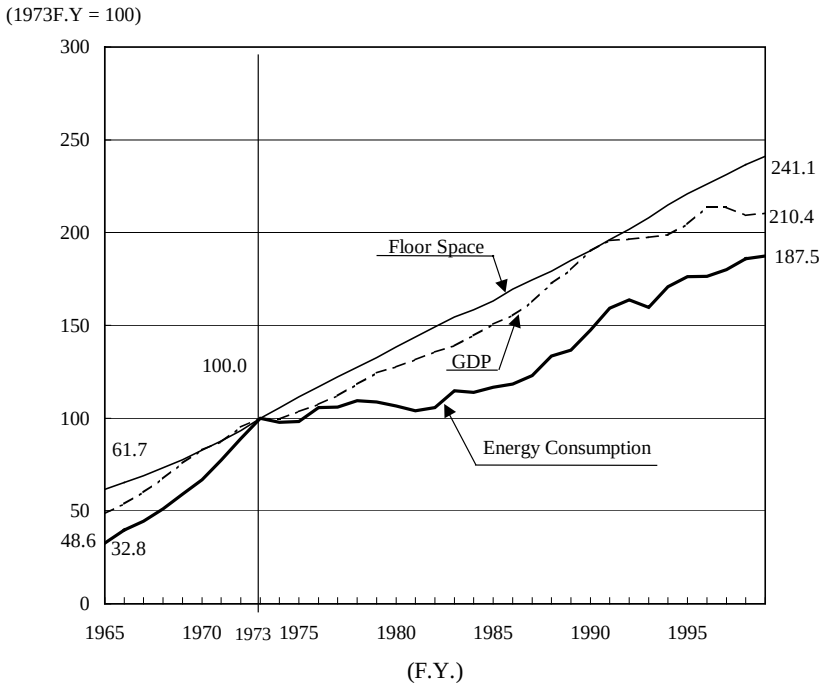
(Unit: crude oil equivalent, million kiloliters)

	Fiscal 1999 record	Forecast for fiscal 2010		Annual growth rate from 1999 to 2010	
		Base case	Target case	Base case	Target case
Residential sector	55	60	about 58	0.79%	about 0.48%
Final demand total	402	409	about 400	0.16%	about - 0.05%

Source: Advisory Committee on Natural Resources and Energy (July 2001)

Chapter 4 Energy Consumption in the Commercial Sector

Figure 4-1 Energy Consumption in the Commercial Sector



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The floor space used by the commercial sector has increased almost at the same rate as the GDP growth rate. While on the **other hand, energy consumption by the commercial sector remained almost unchanged from the** first energy crisis to the bubble economy. Since the bubble economy, the energy consumption has steadily increased. Recently, despite the staggering economy, the energy consumption by the commercial sector is increasing.

Energy consumption by the commercial sector
= Energy consumption per floor space × floor space

Table 4-1 Rate of Increase of Commercial Floor Space and Energy Consumption in the Commercial Sector

	1965 to 1973	1973 to 1990	1990 to 1999
Energy consumption by the business sector	15.0%	2.3%	2.7%
Total floor area	6.2%	3.9%	2.7%
Unit consumption per floor area	8.2%	- 1.5%	0.0%
Real GDP	9.4%	3.9%	1.1%
Elasticity of total floor area to GDP	0.66	1.00	2.37

Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The energy consumption per floor space dropped sharply after the first oil crisis. It began to level off or to slightly increase in the latter half of the 1980s.

1. Scope of the Commercial Sector, Trends of Floor Space

Table 4-2 Breakdown of the Commercial Sector

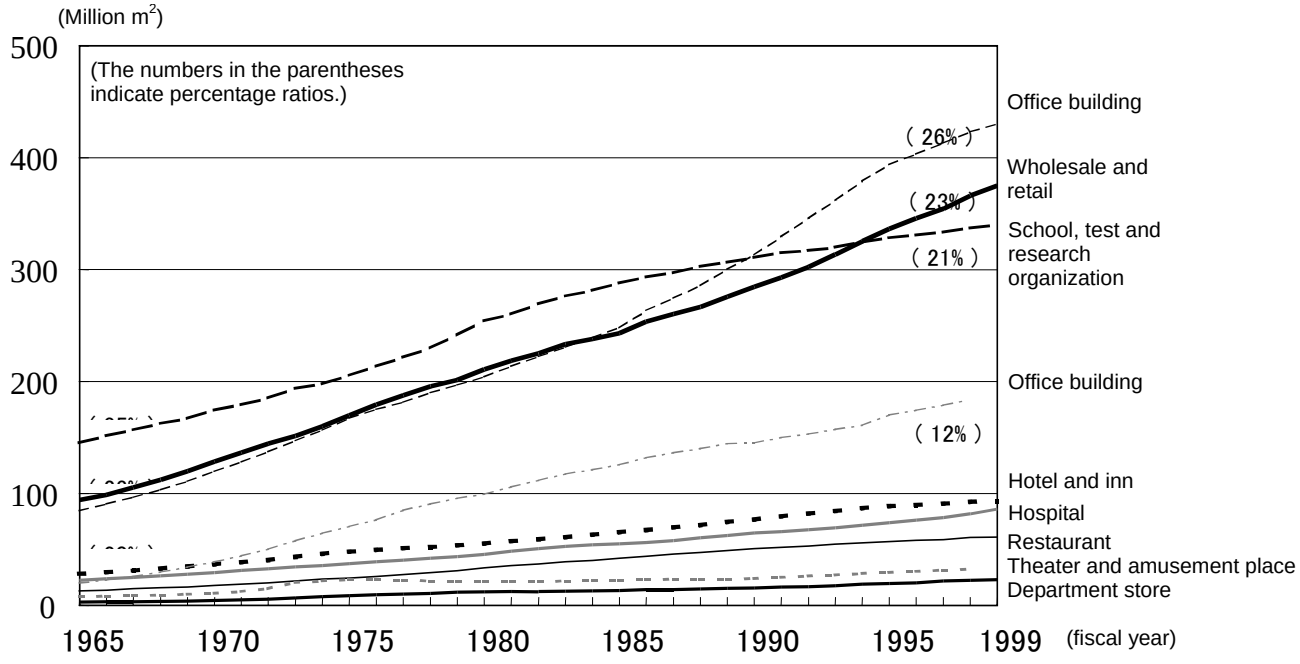
Classification	sub-classification
Office building	Office, bank, government-owned building, local-government-owned building, etc.
Wholesale and retail	Dwelling house combined with shop, shop, market
Restaurant	Dwelling house combined with restaurant, restaurant
School, test and research organization	Nursery school, elementary school, junior high school, senior high school, vocational high school, junior college, university or college, other schools, test and research organizations
Hotel and inn	Inn, hotel, group tour accommodation, etc.
Theater and amusement place	Theater, movie theater, halls, prefectural hall, city hall, public hall
Hospital and clinic	Hospital, government-run hospital, public hospital, clinic, etc.
Other service industries	Such social welfare facilities as child welfare facility (excluding nursery school), facilities for old people, shelters; children's center, neighborhood house, community center, library, museum, gymnasium, youth's house, nature recreation house, working youth's house, meeting place, public bath, etc.

Source: NEDO, EDMC "Report on Energy Consumption in the Residential & Commercial Sector of Japan" (1996)

Remark: The commercial sector indicates "commercial and service sectors" including shops, office buildings, hospitals, various schools and welfare facilities. The administrative portion of the industrial sector such as head office buildings is included but electricity and gas utility and

transportation business are excluded. The transportation for own businesses, taxies and buses for example, is excluded.

Figure 4-2 Floor Space of Commercial Building

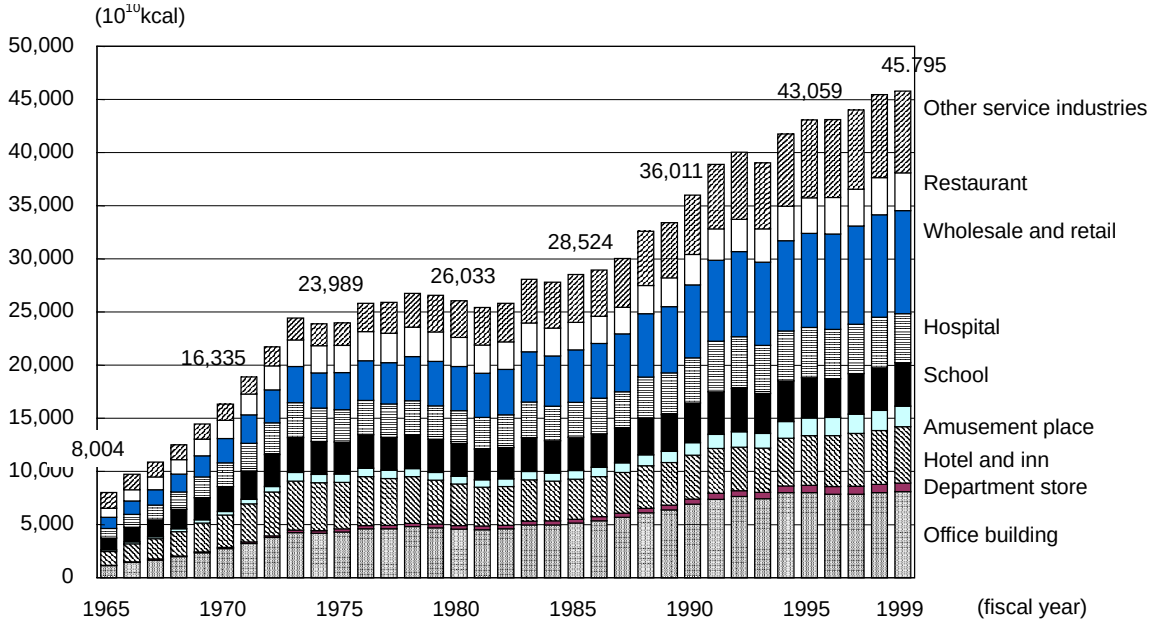


Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The office building, whole sale and retail, school and test and research organization accounts for about 70 percent of the total business floor space. Since 1985 the rate of increase of the floor space of the office building, wholesale and retail has been increasing while that for the school, test and research organization has been decreasing.

2. Energy Consumption by Business Classification

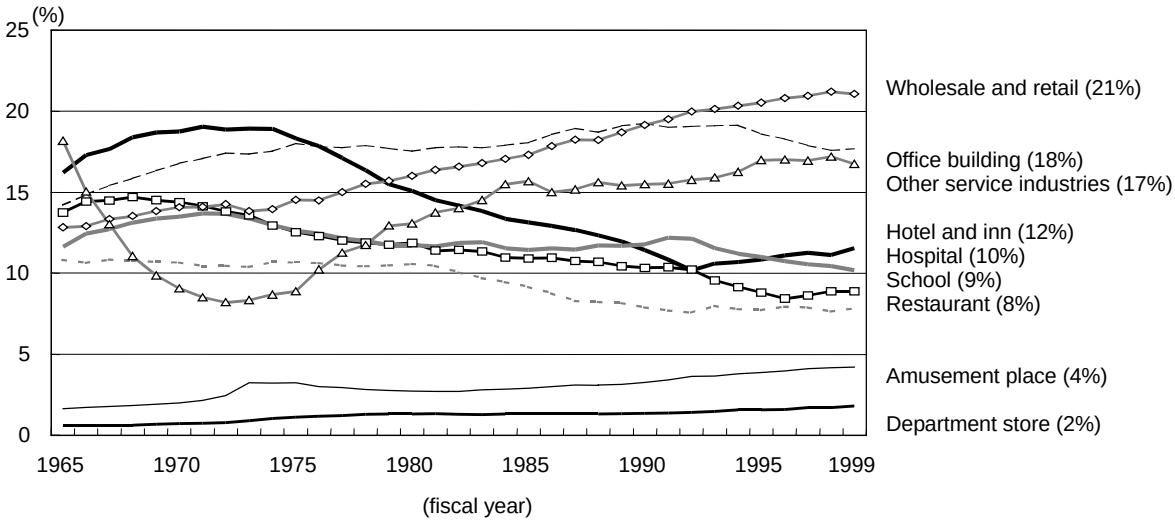
Figure 4-3 Energy Consumption in the Commercial Sector by Business Classification



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: In this paper the energy consumption by a given business classification is the annual total energy consumption of that business classification. The wholesale and retail ranked first at $9{,}648\times10^{10}$kcal in fiscal 1999, followed by the office building at $8{,}097\times10^{10}$kcal and the others at $7{,}675\times10^{10}$kcal.

Figure 4-4 Commercial Energy Consumption by Business Type



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: Formerly, the hotel and office building accounted for the greater part of the energy consumption. Recently, however, the wholesale and retail rank first at 21 percent in 1999. Also, the other service industries such as welfare facilities are increasing their shares. The school shows a declining share, 9 percent in 1999, because their floor area is not increasing fast enough.

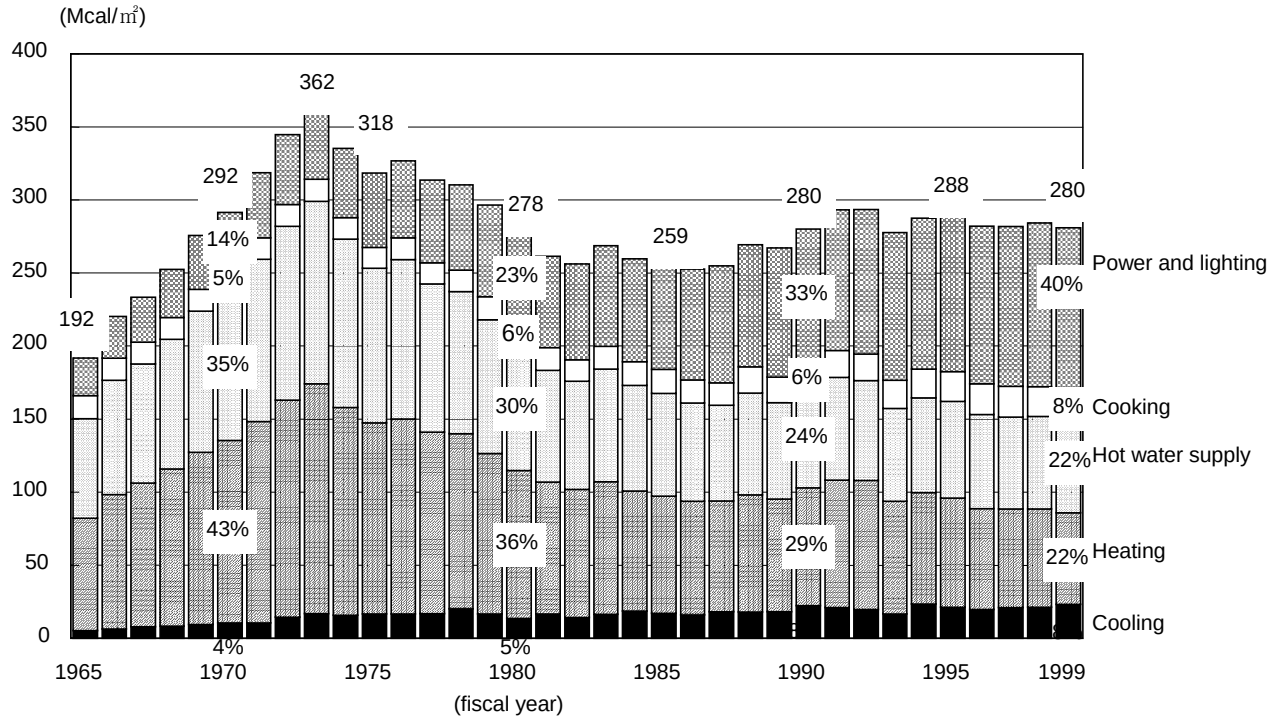
3. Energy Consumption by End-Use

Table 4-3 Energy Consumption by End-Use

	(Average growth rate, %)			(Share, %)			
	1965 to 1973	1973 to 1990	1990 to 1999	1965	1973	1990	1999
Cooling	22.9	5.5	3.1	2.8	4.7	7.9	8.2
Heating	16.1	- 0.1	- 0.1	40.2	43.5	28.8	22.4
Hot water supply	14.6	0.1	1.7	35.5	34.6	23.9	21.8
Cooking	5.8	4.9	4.7	8.0	4.1	6.4	7.6
Power and lighting	14.5	8.0	4.9	13.6	13.1	33.0	40.0
Total	15.0	2.3	2.7	100.0	100.0	100.0	100.0

Remark: The consumption for power and lighting has been steadily increasing in response to computerization of business transactions and increasing floor areas, as is the case with the household energy consumption. By contrast, the consumption by heating and hot water supply did not grow very much.

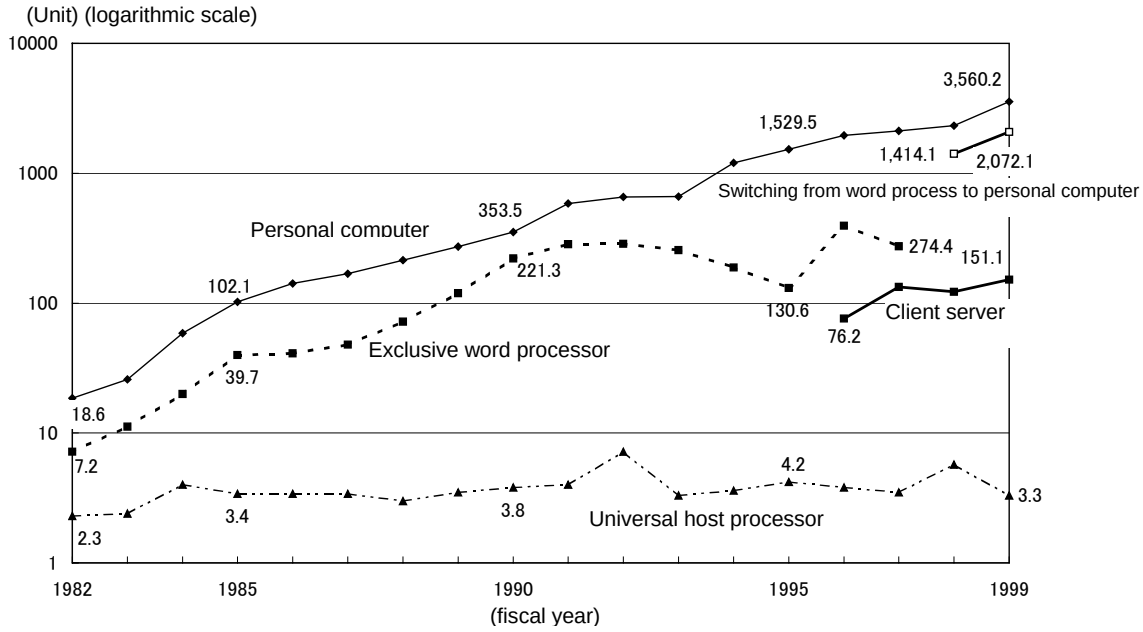
Figure 4-5 End-Use Energy Intensity in the Commercial Sector



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The energy intensity for power and lighting has steadily increased reflecting the computerization and increasing office floors, reaching 40 percent in fiscal 1999. By contrast, the energy intensity for heating and hot water supply has decreasing, as a result of advancement of energy conservation (use of more efficient equipment) and improving thermal insulation of buildings. The energy intensity of cooling increased at a rate exceeding 10 percent during the period around 1970. Since the first oil crisis, the energy intensity has remained almost unchanged, because of the progress of energy conservation and saturation of air-conditioning facilities. (The effect of atmospheric temperature is great.)

Figure 4-6 Average Number of OA Facilities Used by One Business



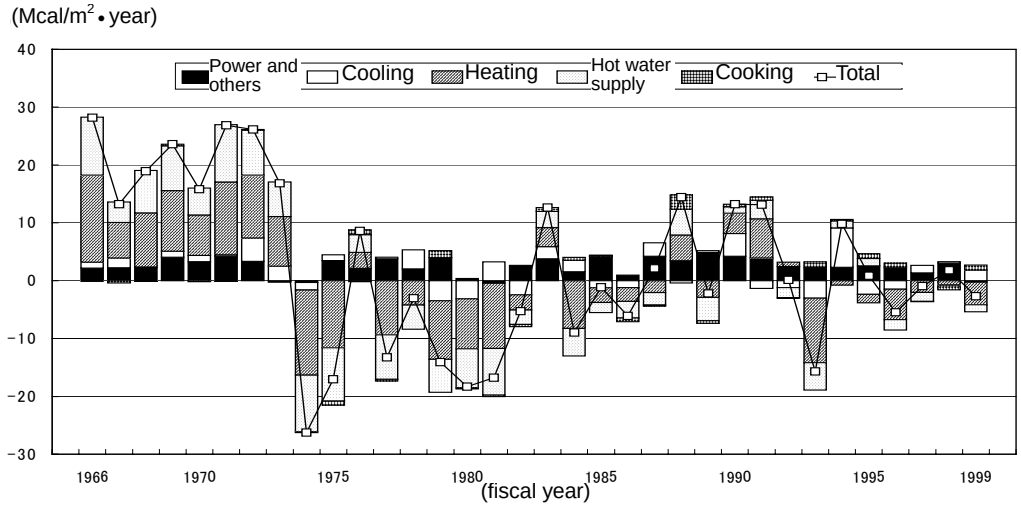
Note 1: The survey was done on 1,000 selected major listed and unlisted companies. In fiscal 1999, 98 companies responded to the questionnaire.

Note 2: Figure 4-6 was developed based on the data of the businesses using OA facilities.

Source: Japan Institute of Office Automation "Office Automation Research Report 2000"

Remark: Office automation is rapidly adopted by business companies, with personal computers playing the central roles. Large host computers are not increasing very much but client server systems are rapidly spreading.

Figure 4-7 Fluctuations of End-Use Energy Intensity in the Commercial Sector

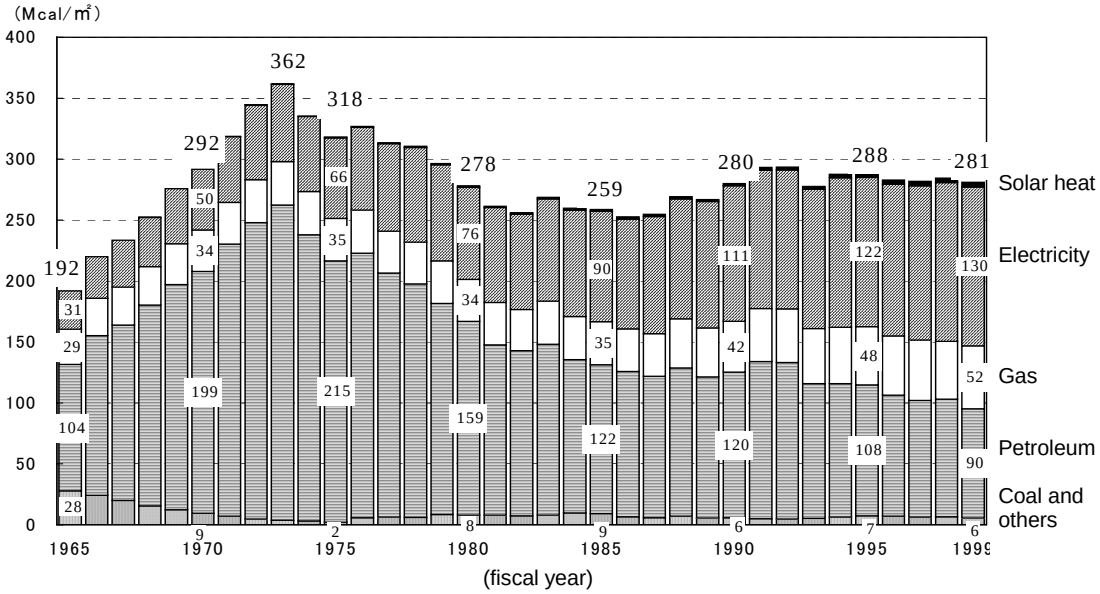


Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: Regarding the fluctuation of energy intensity, the consumption in the “power and others” category is stable compared with those of others which are susceptible to external conditions such as temperature.

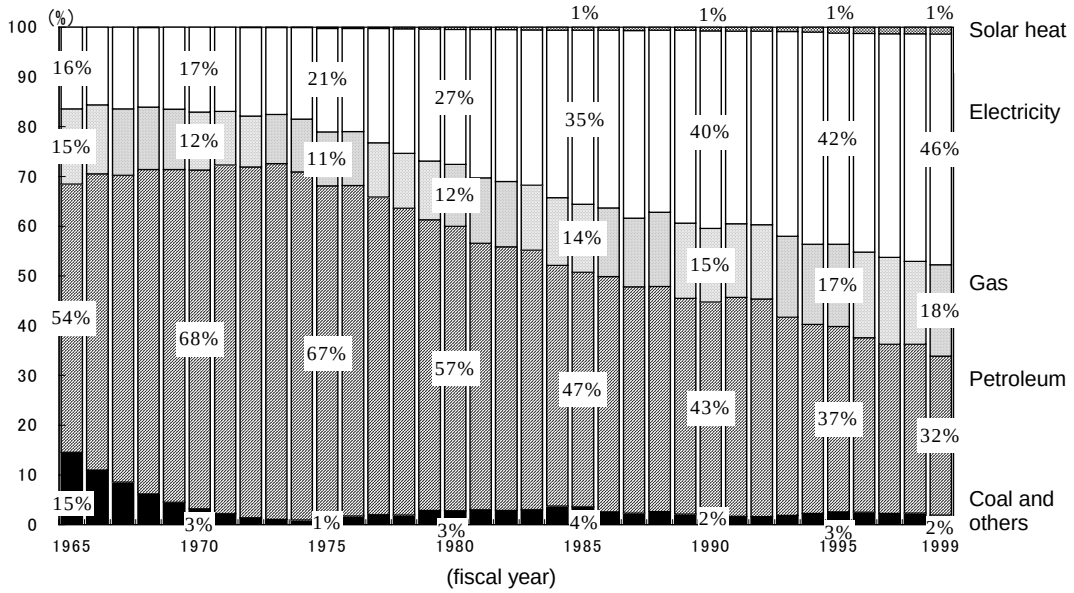
4. Energy Consumption by Energy Source

Figure 4-8 Energy Intensity in the Commercial Sector (by Energy Source)



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Figure 4-9 Energy Source Composition of Energy Intensity in the Commercial Sector

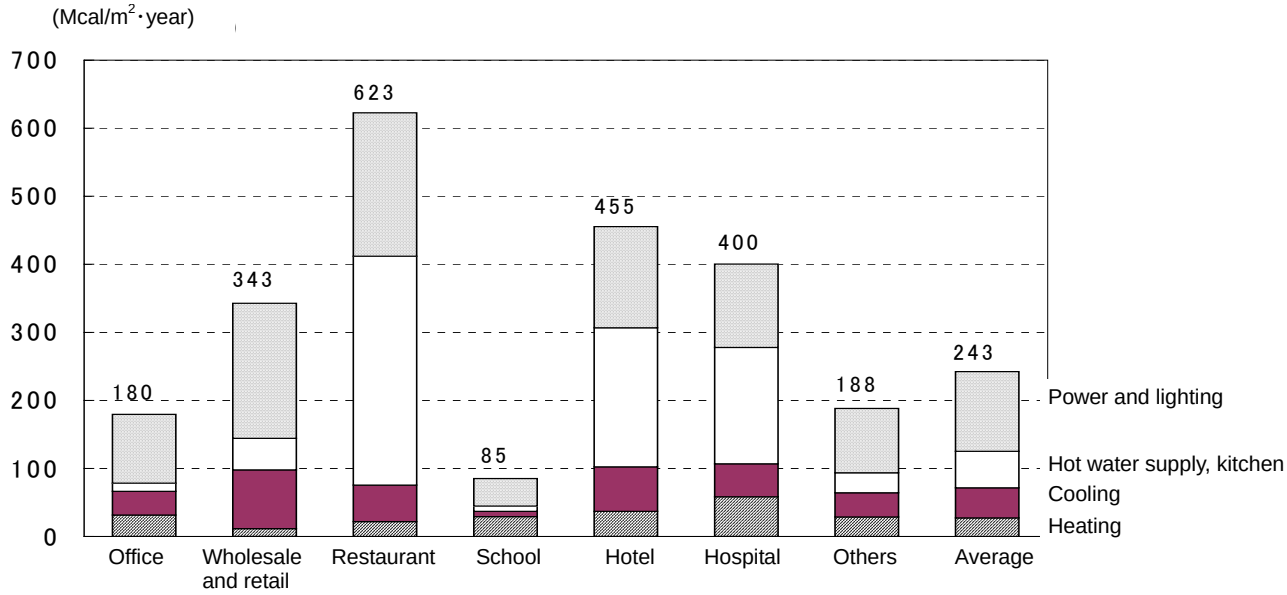


Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The consumption of electricity and gas has been steadily increasing, reflecting the increasing demand for power and lighting. The share of electricity has increased to 46 percent. The share of gas has increased to 18 percent, reflecting the demand for cooling. By contrast, the share of petroleum has declined to 32 percent, accompanying declining share of heating and hot water supply, and conversion of energy from petroleum to electricity and gas.

Figure 4-10 Results of Surveys on Energy Intensity in the Commercial Sector (fiscal 1995 and 1996 Surveys)

(by Business Type and by End-Use)

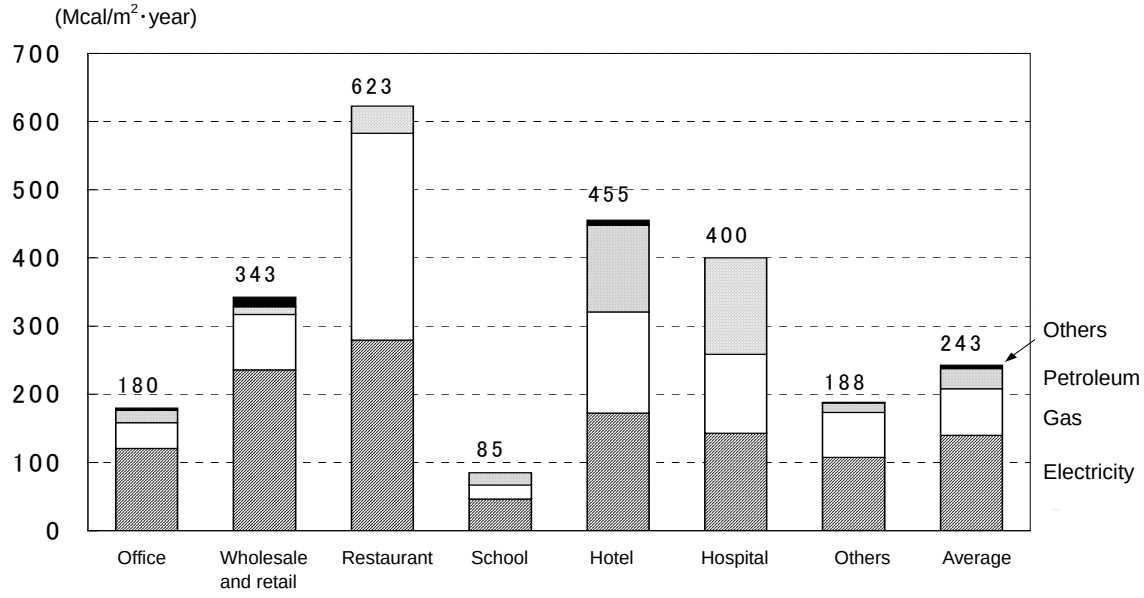


Note: The survey for the office, wholesale and retail, and restaurant was done in fiscal 1994, that for school, hotel, hospital and others was done in fiscal 1995.

Source: NEDO, EDMC "Report on Energy Consumption in the Residential & Commercial Sector of Japan" (Summary Version) (October 2000)

Remark: The total of the energy intensity was the greatest in the restaurant and smallest in the school. In the office and the wholesale and retail, the lighting accounts for more than half the consumption. The restaurant, hotel, hospital consume a large amount of energy for cooking and baths; therefore, the hot water supply and kitchen have high shares. The wholesale and retail has the highest unit consumption for cooling.

(by Business Type and by Energy Source)

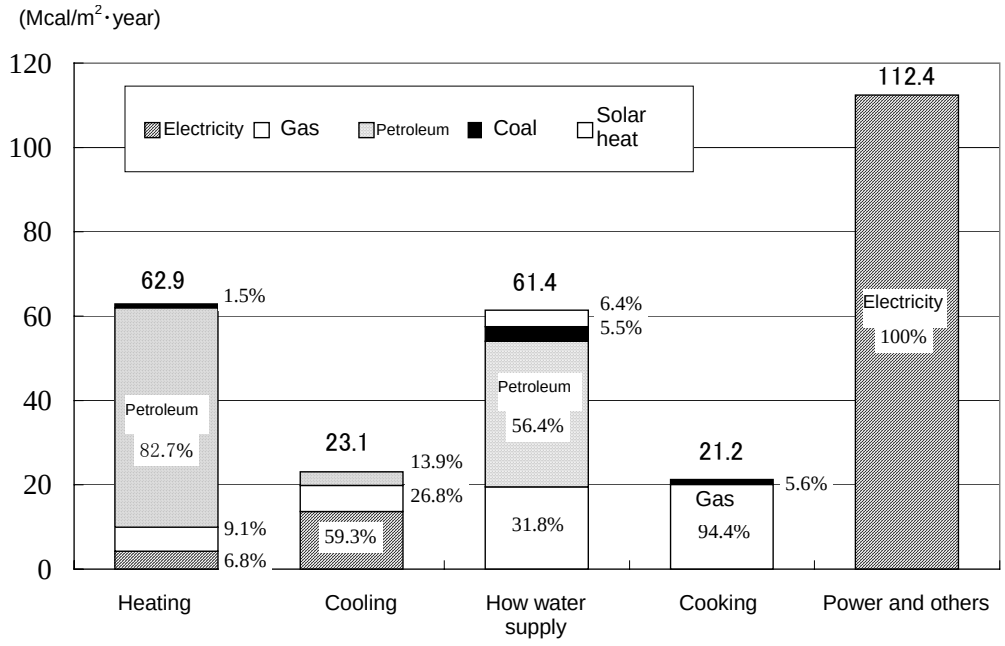


Note: The survey for the office, wholesale and retail, and restaurant was done in fiscal 1994, that for school, hotel, hospital and others was done in fiscal 1995.

Source: NEDO, EDMC "Report on Energy Consumption in the Residential & Commercial Sector of Japan" (Summary Version) (October 2000)

Remark: The office and wholesale and retail, in which the power and lighting use accounts for more than half the consumption, have high share of electricity, 67 percent for the office and 69 percent for the wholesale and retail. The restaurant, in which gas occupies a significant portion of energy consumption, has a high share of petroleum at 49 percent. The hotel and hospital have high shares of petroleum, at 28 percent and 35 percent, respectively.

Figure 4-11 End-Use Energy Consumption per floor space in the Commercial Sector by Energy Source (fiscal 1999)

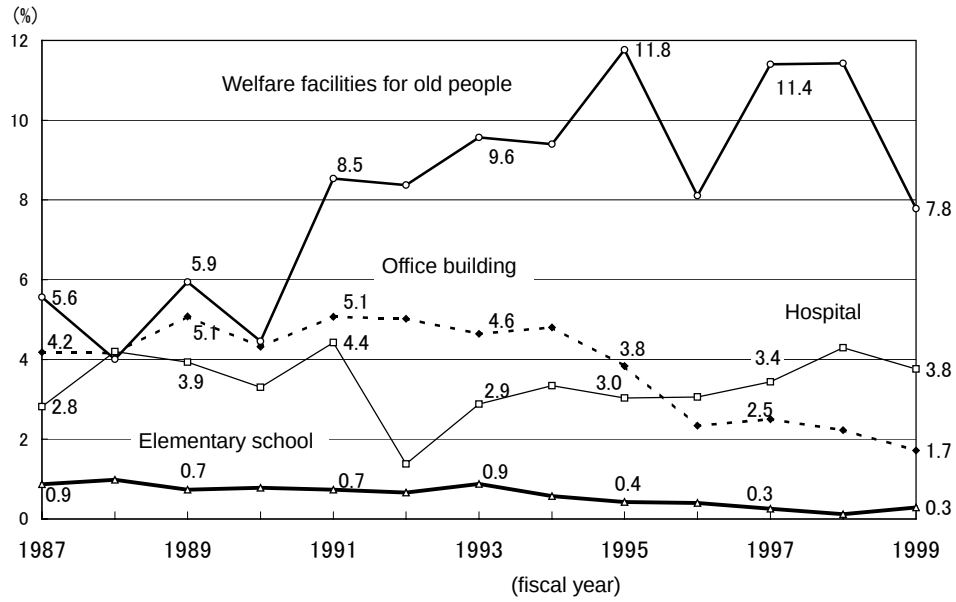


Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: Petroleum accounts for about 80 percent in the heating use and for about 60 percent in the hot water supply use. Electricity represents 100 percent in the power and lighting use, about 60 percent in the cooling use, and somewhat less than 10 percent in the heating use. Gas accounts for more than 90 percent in the cooking use and about 30 percent in the hot water supply and the cooling uses.

5. Declining Birth Rate, Aging Population and Energy Consumption

Figure 4-12 Growth Rate of Total Floor Space in the Commercial Sector (by Business Type)

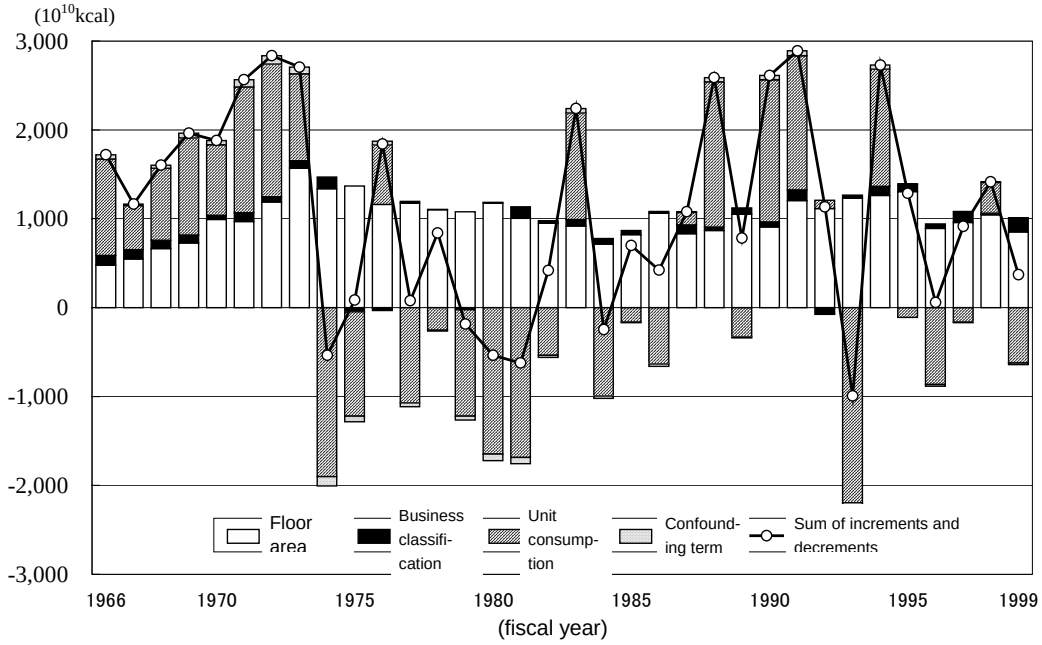


Source: EDMC, "Energy Trend (September 2000)"

Remark: The growth rate of elementary school floor space has declined to virtually zero level. While on the other hand, the floor space of facilities for old people grows at a rate close to 10 percent. The floor space of the office buildings, now with the greatest share among all business classifications, grows at only less than 2 percent. The floor space of the hospital now grows at a rate close to 4 percent.

6. Factors Analysis of Energy Consumption in the Commercial Sector

Figure 4-13 Factor Analysis of Changes in Energy Consumption in the Commercial Sector



Note: The factor analysis is done in the following manner.

$E = \Sigma\{(Ei/Si)\cdot(Si/S)\cdot S\}$

E: Energy consumption, (10^{10}kcal), S: floor space for business, i: business classification

$\Delta E = \Sigma\{\Delta(Ei/Si)\cdot(Si/S)\cdot S\}$ → Primary factor (intensity factor)

$+ \Sigma\{(Ei/Si)\cdot\Delta(Si/S)\cdot S\}$ → Secondary factor (structural factor)

$+ \Sigma\{(Ei/Si)\cdot(Si/S)\cdot\Delta S\}$ → Third factor (floor space factor)

+ confounding term

Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The floor space factor consistently contributes to increase in energy consumption. The intensity factor fluctuates very much every year; therefore, it may be considered to be the greatest factor determining fluctuations of energy consumption in the commercial sector. The structural factor has almost no effect on the fluctuation of energy consumption.

(Reference)

Table 4-4 Long-term Energy Supply Demand Forecast

(Unit: crude oil equivalent, million kiloliters)

	Fiscal 1999 record	Forecast for fiscal 2010		Annual growth rate from 1999 to 2010	
		Base case	Target case	Base case	Target case
Business sector	50	66	about 63	2.56%	about 2.12%
Final demand total	402	409	about 400	0.16%	about - 0.05%

Source: Advisory Committee on Natural Resources and Energy (July 2001)

Chapter 5 Energy Consumption in the Transportation Sector

Energy consumption in the transportation sector
= ∑(transportation demand × transportation share $_i$) × Energy intensity $_i$

1. Economic Activity and Transportation Demand, Energy Consumption

(1) Transportation Demand (Refer to Figure 5-1.)

Passenger: (person・kilometer (hereinafter referred to as person-km*)): This index has steadily increased at a rate of 3% per year even after the energy crises.

Freight: (ton・kilometer (hereinafter referred to as ton-km*)): This index is significantly affected by the state of economic activities. For some years after the first and second energy crises, this index declined and leveled off, respectively, but it has been increasing since 1985.

(2) Energy Consumption (Refer to Figure 5-2.)

Passenger: The energy consumption has been on increase at a rate exceeding the GDP growth rate.

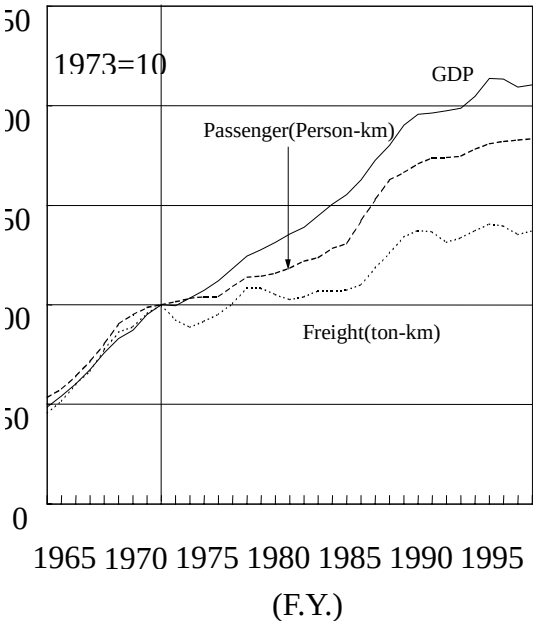
freight: The energy consumption declined and leveled off, respectively, for some years after the first and second energy crises. The energy consumption showed a trend for a decline because of the decrease in unit consumption, but it picked up again in 1985 and has been increasing since then.

Total: The total consumption has been increasing almost in parallel with the growth of GDP. The energy breakdown for fiscal 1999 is 51.7% for gasoline, 34.0% for diesel fuel, 5.6% for heavy fuel oil, 4.4% for jet fuel, LPG for 2.3% and electricity for 2.0%.

---

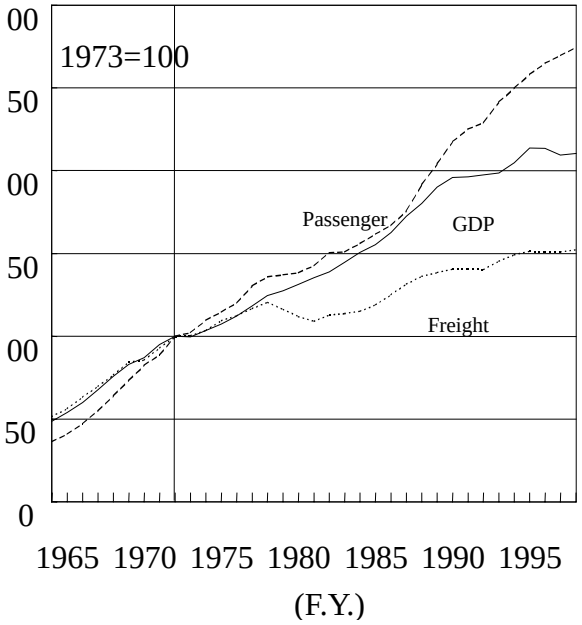
* The terms “tons transported” and “number of passengers transported” indicate freight weight and passenger number transported but do not indicate distances transported. To express the magnitudes of transportation activities, therefore, the terms “ton-km” and “person-km” are used. When 1 ton of cargoes (or 1 person) is transported for a distance of 10 kilometers, the magnitude of transportation work is 10 ton-kms (or 10 person-kms). When 5 tons of cargoes (or 5 persons) are transported over a distance of 1 kilometer, the magnitude of transportation work is 5 ton-kms (or 5 person-kms).

Figure 5-1 Trends of GDP and Demand for Transportation (1973 = 100)



Remark: The passenger transportation has been steadily growing. The freight transportation tends to be affected by business activities and changes in industrial structure.

Figure 5-2 GDP and Energy for Transportation (1973 = 100)



Remark: The energy consumption in the passenger transportation sector has increased at a rate outpacing the GDP growth rate.

Table 5-1 Transportation Demand and Energy Consumption (Average Annual Growth Rate)

(%)

	1965 to 1973	1973 to 1990	1990 to 1999	1973 to 1999
Transportation load				
Passenger (person-km), %	8.2	3.0	1.1	2.4
Freight (ton-km), %	10.3	1.7	0.2	1.2
Energy consumption (total), %	10.8	3.2	2.5	3.0
Passenger, %	13.4	4.3	3.1	4.0
Freight, %	8.7	1.9	1.1	1.6
Real GDP, %	9.4	3.9	1.1	2.9
Elasticity of passenger transportation to GDP	0.86	0.79	0.96	0.81
Elasticity of freight transportation to GDP	1.09	0.45	0.22	0.42

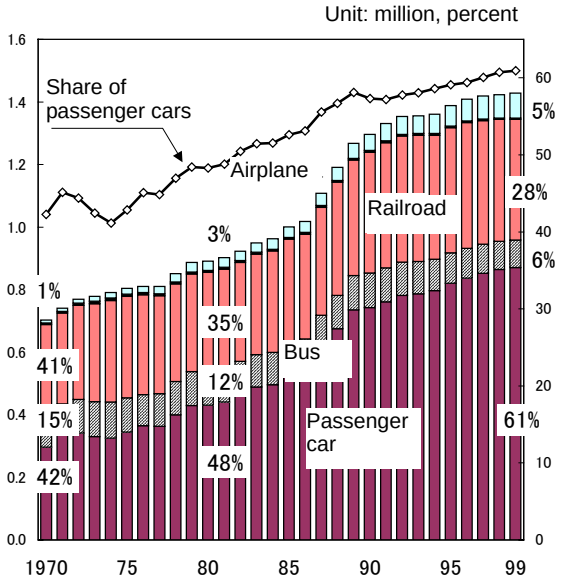
Remark: The elasticity of transportation to GDP (growth rate of transportation/GDP growth rate) varies with time. It may be noted that variation is greater in freight transportation.

2. Transportation Demand and Shares by Transportation Mode

Passenger (person-km): As the number of automobiles increased, the share of passenger cars increased and loads of the railroad and bus declined, and their shares declined.

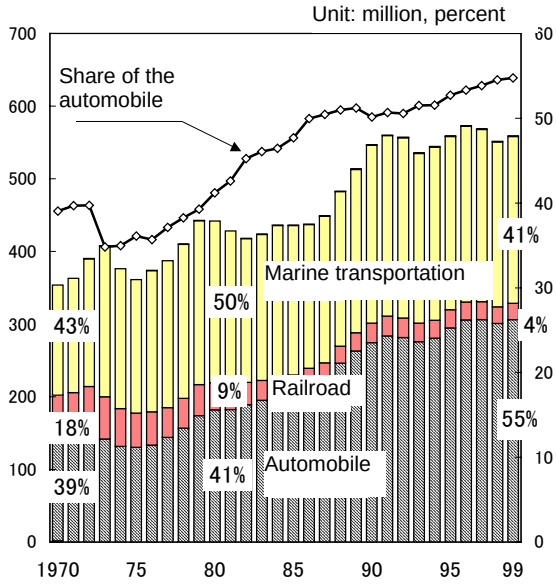
Freight (ton-km): As a result of modal shift, transportation by automobiles has firmly increased. The transportation by railroad has been declining gradually. The marine transportation has responded to the activity of material industries.

Figure 5-3 Trends of Passenger Transportation Demand (Passenger: person-km)



Remark: he demand for transportation by automobiles has steadily increased to over 60 percent of the total, while that for railroad has declined.

Figure 5-4 Trends of Freight Transportation Demand (Freight: ton-km)



Source: EDMC Handbook of Energy & Economic Statistics in Japan

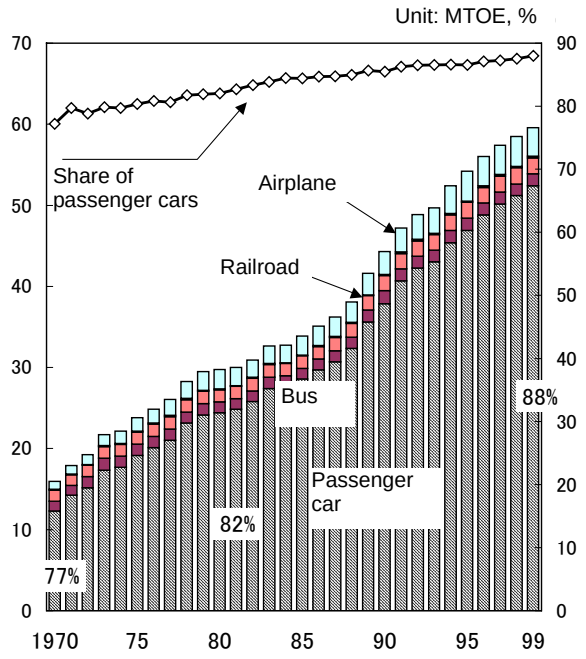
Remark: The demand for transportation by automobile and that for marine transportation jointly represent more than half the total demand. The demand for transportation by automobile has steadily increased. The demand for marine transportation responds to the demand by the material industries. The share of the railroad transportation has been declining.

3. Energy Demand and Shares by Transportation Mode

Passenger: The share of passenger cars has increased.

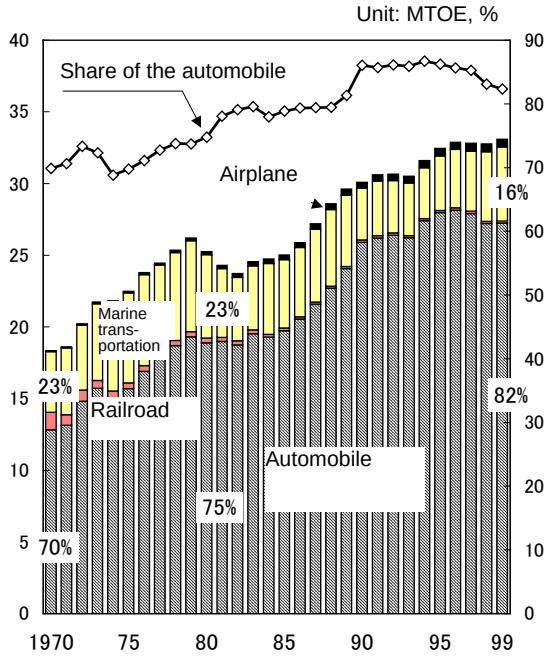
Freight: The energy for automobile transportation increased since 1985 until 1995, since then the share has remained almost unchanged. The share of automobile gradually increased until 1990, since then the share has remained almost unchanged. The energy demand for marine transportation decreased until 1990.

Figure 5-5 Trends for Energy Demand for Passenger Transportation



Remark: The energy demand for passenger cars has steadily increased to nearly 90 percent recently, along with the progress of motorization.

Figure 5-6 Trends of Energy Demand for Freight Transportation



Source: EDMC Handbook of Energy & Economic Statistics in Japan

Remark: The energy demand for automobiles has leveled off since 1990. Transportation by automobile and marine transportation jointly account for most of the energy demand.

4. Energy Intensity (Energy Consumption per Transportation Demand)

(1) Comparison in Energy Intensity among Transportation Mode (= Energy consumption/transportation demand)

Passenger: The energy intensity of the bus is a quarter of passenger cars' demand. That of railroad is one-twelfth of passenger cars' demand. Use of mass transportation means can save energy consumption per person-km.

Freight The energy intensity of railroad transportation per ton-km is 1/14 of that of automobiles, and that of marine transportation is a quarter of automobile transportation. The energy intensity by air is 6 times as large as that of automobiles.

(2) Trends of Energy Intensity

Passenger: The energy intensity of passenger cars has remained virtually unchanged. That for air transportation has declined as aircraft becomes larger.

Freight: The average for freight has remained almost unchanged. The energy intensity of automobiles shows a trend for decline. (This is because the share of more efficient business cars is increasing.)

Figure 5-7 Energy Intensity of Passenger Transportation by Transportation Mode (1999, Energy intensity of passenger cars = 100)

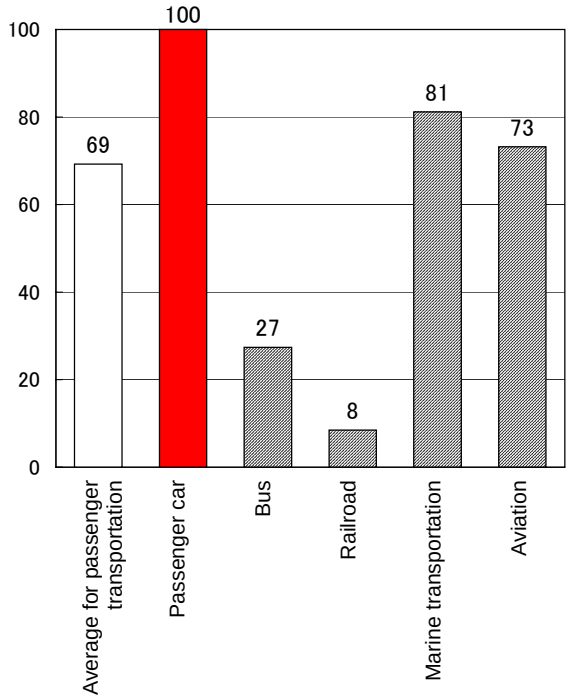
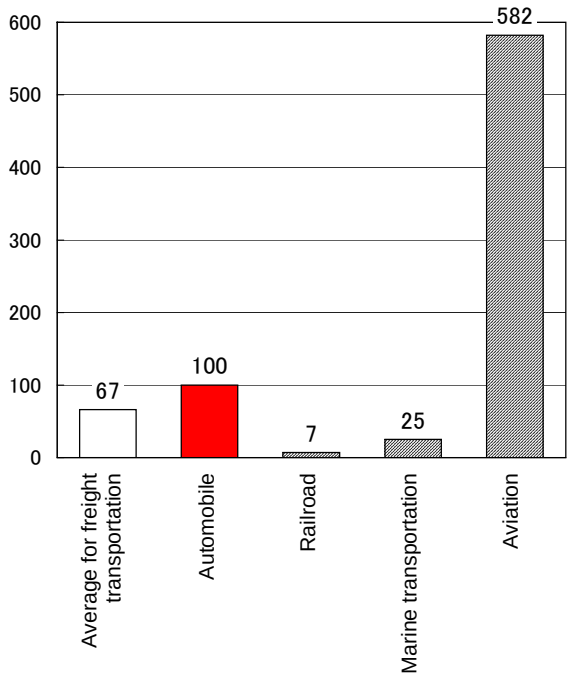


Figure 5-8 Energy Intensity of Freight Transportation by Transportation Mode (1999, Energy intensity of automobiles = 100)



Remark: The difference in energy intensity represents difference in energy efficiency. It may be noted from the figures that the energy intensity varies greatly among transportation means. In passenger transportation, the energy intensity of aircraft transportation is by far the largest, and that of railroad transportation is small. In the freight transportation, the aircraft transportation, which is the fastest, is by far the largest.

5. Factor Analysis of Energy Consumption in the Transportation Section

The changes in energy consumption were analyzed from such factors as transportation demand, distribution among transportation means, and energy intensity, with the following results.

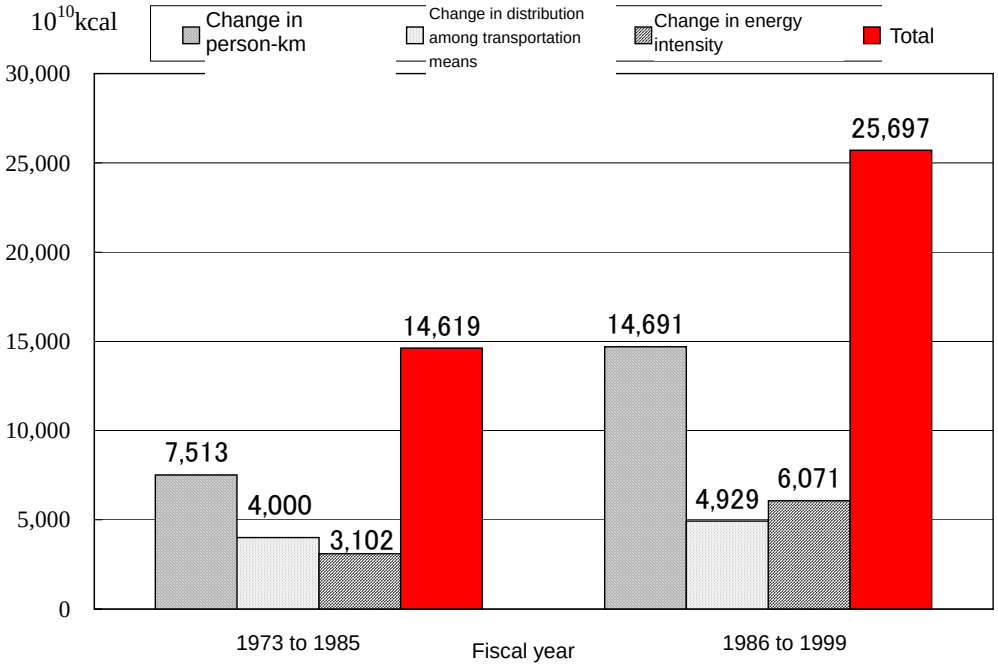
Passenger: The effect of transportation demand (person-km) is great. As the transportation is being shifted to automobiles, the effect of distribution among transportation means is gradually increasing.

Freight: All three factors -- namely, energy intensity, transportation demand (ton-km) and distribution among transportation means (shift to trucks) -- affect changes in energy consumption.

Table 5-2 Comparison of Factor Analyses for Fiscal 1999 versus Fiscal 1973

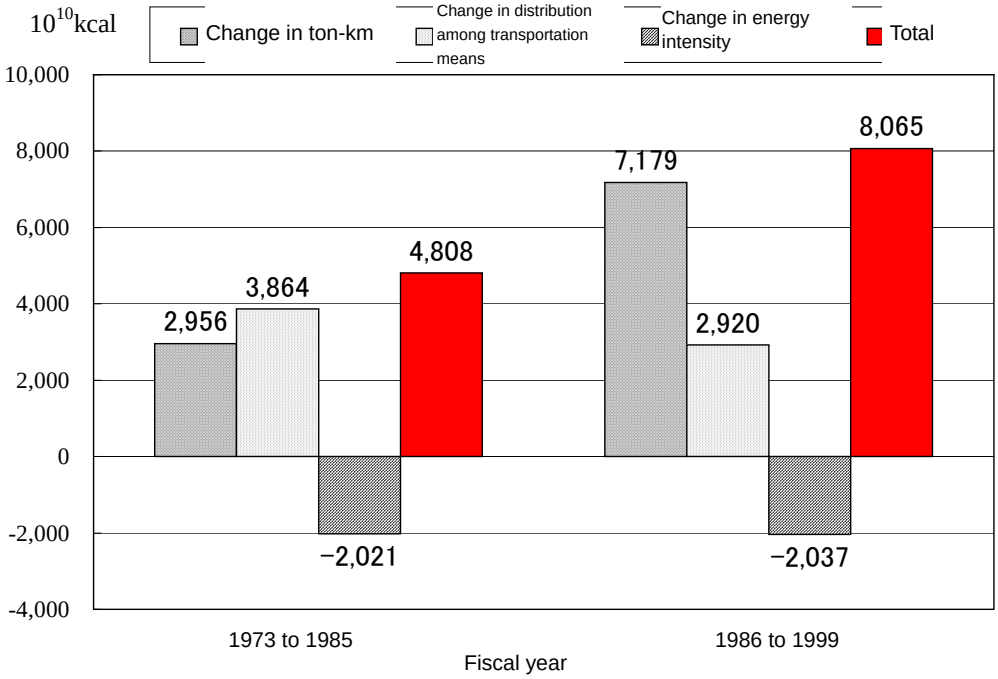
	Passenger		Freight		Total	
	Incremental consumption, ktoe	Ratio (%)	Incremental consumption, ktoe	Ratio (%)	Incremental consumption, ktoe	Ratio (%)
Recorded incremental energy consumption	40,306	(100)	12,862	(100)	53,168	(100)
Transportation demand factor	22,204	(55)	10,135	(79)	32,340	(61)
Distribution among transportation means factor	8,929	(22)	6,784	(53)	15,713	(30)
Energy intensity factor	9,173	(23)	-4,058	(-32)	5,115	(9)

Figure 5-9 Factors Analysis of Energy Consumption for Passenger Transportation



Remark: Positive and negative numbers of any factor respectively contribute to increase and decrease of energy consumption. The length of the bar in the figure indicates the magnitude of the concerned effect. It may be noted from the figure that the increase in energy consumption for passenger transportation is attributable more than 50 percent to the change in person-km.

Figure 5-10 Factors Analysis of Energy Consumption for Freight Transportation



Remark: Positive and negative numbers of any factor respectively contribute to increase and decrease of energy consumption. The length of the bar in the figure indicates the magnitude of the concerned effect. It may be noted from the figure that improvement in the energy intensity contributes to reduction of energy consumption; however, the effects of change in ton-kilometer and that in distribution among different transportation means to increase the energy consumption more than offset the effect of improvement in energy consumption.

6. Vehicle Stock

The Vehicle Stock in Japan is on the increase.

(1) Vehicle Stock by Type (Passenger car, Truck, Bus, Special-purpose Vehicle)

- Passenger cars occupy 70 percent of the vehicle stock. The vehicle stock is on the increase.
- Trucks represent somewhat less than 30 percent of the vehicle stock. The truck stock has been declining since fiscal 1991.

(2) Vehicle Stock by Fuel (Gasoline, Diesel fuel, LPG)

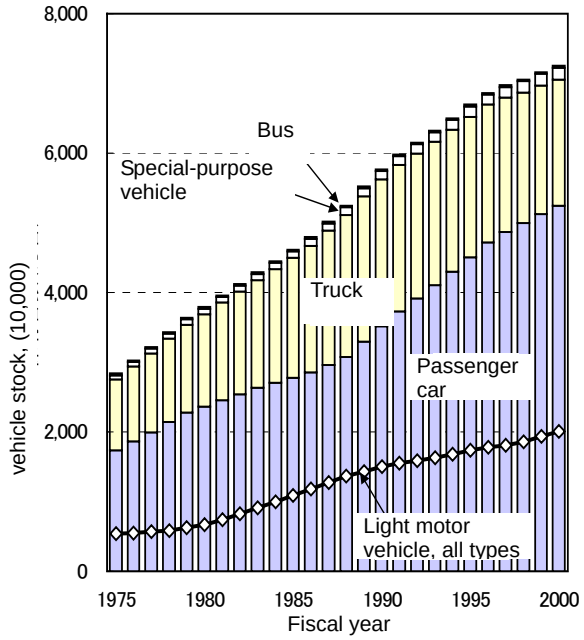
- Automobiles driven by gasoline account for more than 80 percent of the whole vehicle stock. The stock of this type of automobiles is on the increase.
- Automobiles driven by diesel fuel account for somewhat less than 20 percent of the

whole vehicle stock. The population of this type of automobiles increased from fiscal 1972 to fiscal 1995 at a rate faster than those driven by gasoline. In recent years, however, the growth rate is decreasing every year.

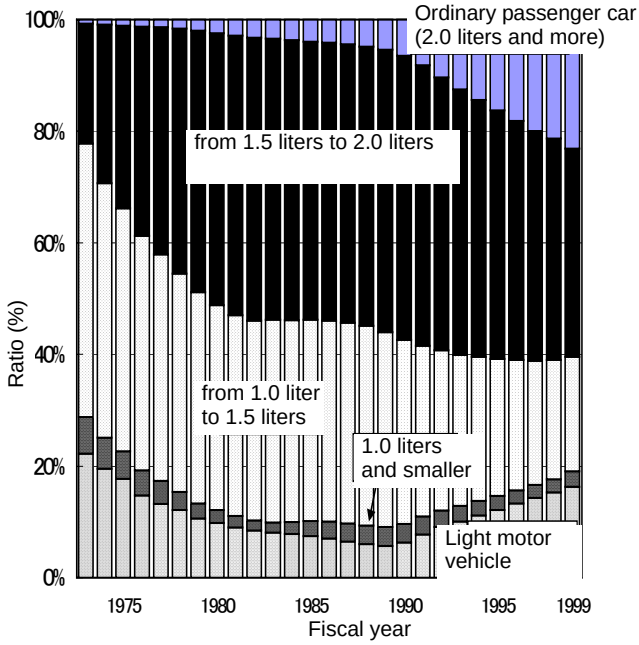
- Automobiles driven LPG are used mostly as taxi and account for 0.4 percent of the whole vehicle stock.

Figure 5-11 Vehicle Stock

(a) By type



(b) Passenger cars by size(displacement)



Source: Automobile Inspection & Registration Association, “Car Population”

Remark: The vehicle stock is on the increase. The numbers of passenger cars and automobiles driven by gasoline are steadily increasing. On the other hand, the numbers of trucks and automobiles driven by diesel fuel are decreasing recently. The light motor vehicles are divided into light motor passenger cars and light motor trucks.

Remark: It may be noted from the figure that the number of larger passenger cars became conspicuously more popular during the 1970s. In the 1990s, however, the number of light motor vehicles increased again reflecting the sluggish economy.

7. Energy Conservation in the Transportation Sector

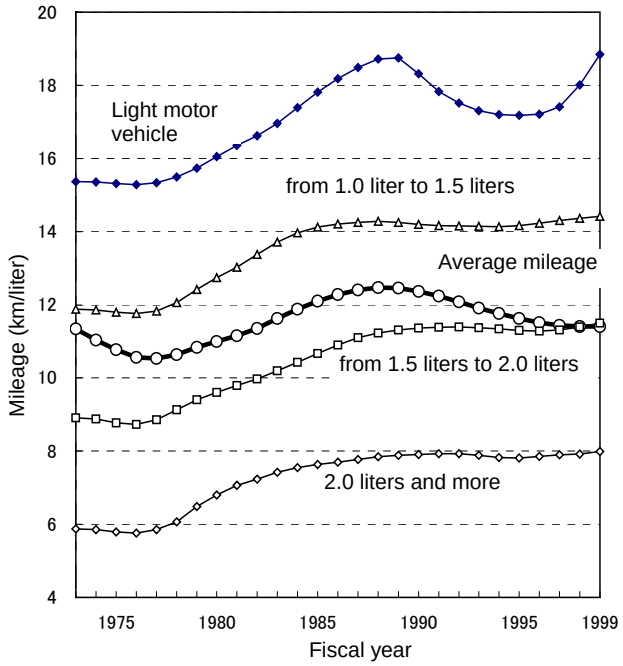
(1) Energy Conservation Factor

Increased transportation by mass transport systems (railroad, boat, etc.), industrial restructuring for reduction in size and in weight of products, improvement of fuel efficiency of automobiles, size reduction of automobiles, efficiency improvement of transportation (reduction of transportation distance) constitute the energy conservation factor.

(2) Factor for Increasing Energy Consumption

Motorization, deterioration of fuel efficiency (traffic congestion, pollution prevention measures, automobile size increase, multi-functionalization), longer transportation distance, diversification and higher added value of services (delivery in small size and chilled home delivery) constitute the factor for increasing energy consumption.

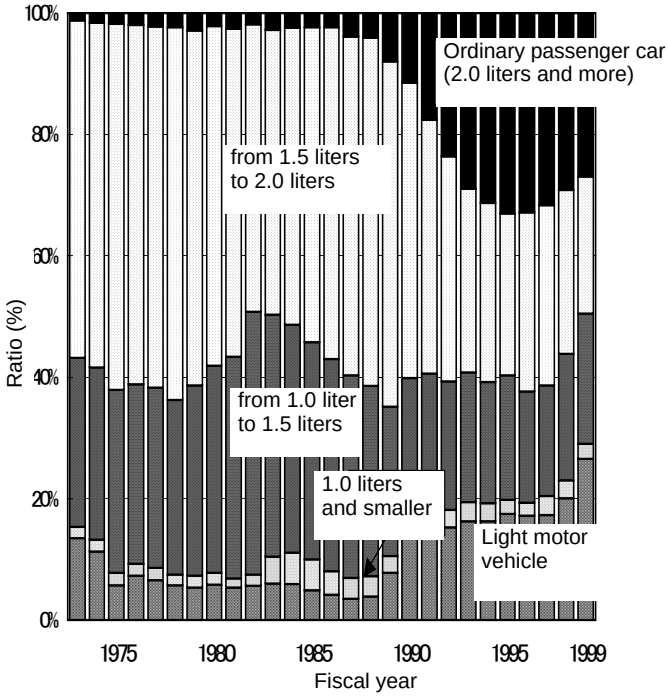
Figure 5-12 Trends of Fuel Efficiency of Automobiles (Stock Base) (10 modes)



Note: Estimation by EDMC (Since 1993 the 10-mode values have been used instead of the 10.15 mode values. (For light motor vehicles × 0.93 is used; for others × 0.9 is used.))

Remark: Recently, fuel mileage has been improved for automobiles of all sizes. However, the average mileage has recently declined because of the increase of the larger automobile population.

Figure 5-13 Sale of New Automobiles by Size

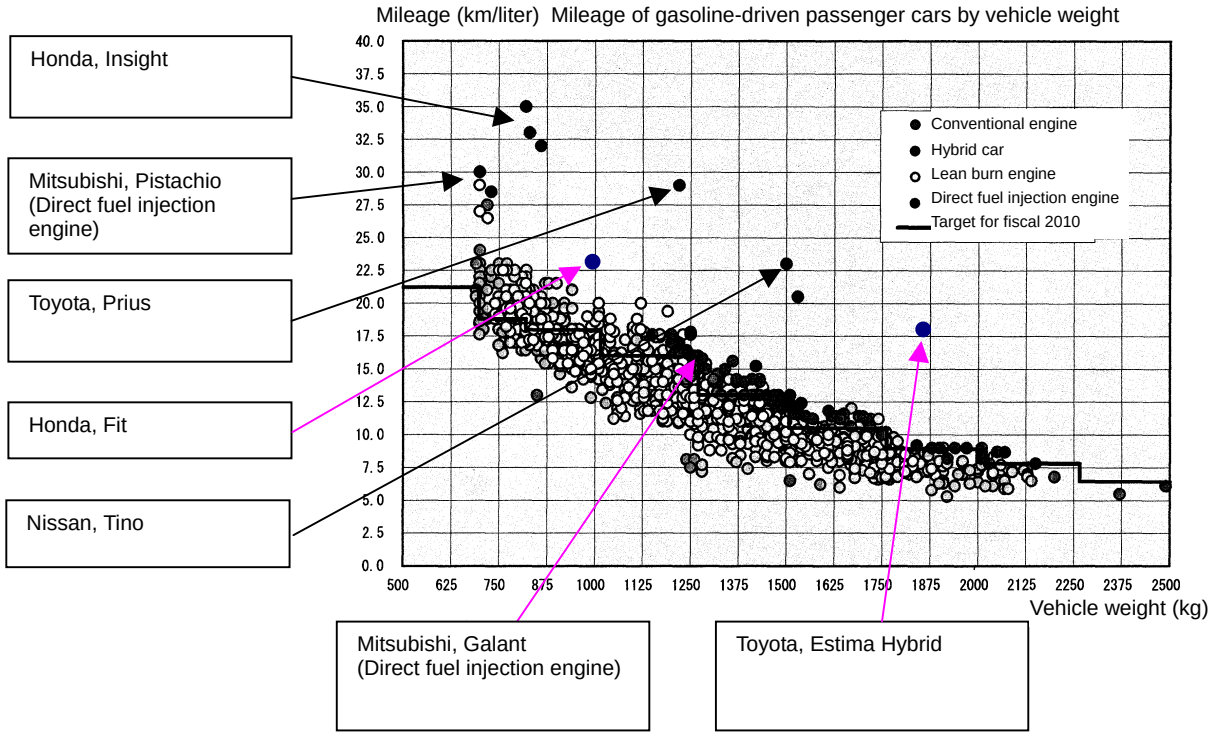


Remark: There was a trend to purchasing new ordinary passenger cars (with displacement at 2.0 liters and more) from fiscal 1988 to the first half of the fiscal 1990s. Presently, such a trend has subsided. The sale of light motor vehicles and automobiles with displacement at or smaller than 1.5 liters is increasing.

Table 5-3 Mileage Deterioration by Additional Functions

Function	Automatic transmission	Power steering	Air-conditioning
Detrimental effect on fuel efficiency, %	from 7 to 13%	from 2 to 3%	about 10%

Figure 5-14 Present Status of Automobile Mileage by Vehicle Weight (as of the End of March 2001)



Source: Ministry of Land, Infrastructure and Transport, the Road Transport Bureau, "List for Mileage of Passenger Cars (March 2001) with some additions

Remark: The mileage of Toyota Prius, 29 km/liter, is more than twice the average mileage, 14.1 km/liter, of the present passenger cars of the same weight class (at or heavier than 1,016 kg but lighter than 1,265 kg). The mileage of Honda Insight, 32 to 35 km/liter, permits the car to run 100 kilometers with only 3 liters of gasoline. The mileage of Mitsubishi Galant with a direct fuel inject engine, 13.0 to 14.2 km/liter, is 10 to 30 percent better than the average mileage of the present passenger cars. The pump-to-wheel vehicle efficiency is considered to increases in the order of gasoline engine, direct gasoline injection engine, direct-injection common rail diesel engine, hybrid engine, and fuel cell driven car (forecast). (Source: Materials from the Ministry of Economy, Trade and Industry, Advisory Committee on Natural Resources and Energy, the Petroleum Committee, the Development Subcommittee and Natural Gas Subcommittee)

Table 5-4 Recent Trends of High Mileage Cars

Toyota	Toyota is the first in the world to sell a hybrid mini-van, Estima Hybrid, with a displacement of 2.4 liters and a mileage of 18.0 km/liter (10.15 mode). Toyota has also developed a simpler version of the hybrid system called Toyota mild hybrid system, with an additional mileage improvement of about 15 percent.
Honda	Honda placed on the market the Honda Fit, of which the engine is designed to have each cylinder equipped with two spark plugs to improve fuel efficiency. (The displacement of Honda Fit is 1.3 liters and the mileage is 23 km/liter (10.15 mode)).
Fuel cell powered vehicle	Such automobile companies as DaimlerChrysler, Toyota, Honda, GM and Ford are scheduled to commercialize fuel cell powered vehicles around 2003 to 2004. Presently, the State of California of the Unites States and other organizations are conducting running tests. Toyota's FCHV-4 has scored a cruising distance of more than 250 kilometers on compressed hydrogen.

Source: Homepages of the Toyota Motor Corporation and Honda Motor Co., Ltd., Nihon Keizai Shimbun, Evening Issue of June 12, 2001 and Others

Table 5-5 Features and Trends of Clean Energy Vehicles

	Features	Development status and problems	Number of vehicles in use (Note 1)	Global environment, CO_2, (Note 2)	Power	Cruising distance
LPG vehicle	The vehicle runs on liquid fuels consisting mainly of such inexpensive components as propane or butane.	LPG vehicles have long been used as taxi. Recently, LPG vehicles are being used in place of diesel-engine driven vehicles with a specific objective to reduce NOx and particulate matter in the exhaust gas.	286,108	C	D	C to D
Natural gas vehicle	The vehicle runs on natural gas of which the main component is methane. The CNG car runs on compressed natural gas and the LNG car runs on liquefied natural gas. Except for fuel, the design of vehicles is basically the same as those of gasoline-driven and diesel-fuel-driven vehicles.	CNG vehicles are used mainly for urban route buses and collection and delivery vehicles for the benefits of reducing emission of CO_2 and NOx. Improvement of fuel efficiency and reduction of cost are required to replace diesel-engine driven vehicles. The LNG vehicle, which should have a longer cruising distance than the CNG vehicle, is still in the practical development stage.	5,252	B	D	D to E
Methanol vehicle	Methanol is a liquid fuel manufactured from natural gas and other fossil fuels. Methanol has advantages in storability and transportability. Methanol vehicles are broken down into Otto-engine-driven type and diesel-engine-driven type.	The methanol vehicle of an Otto cycle engine attains cleanness of exhaust gas comparable to gasoline-driven vehicles. Those with a diesel engine emit lesser amounts of NOx and dark exhaust gas. However, they still need to resolve such problems as durability of fuel system parts, cold startability, reduction of aldehyde emission during engine start.	224 (estimated)	C	C to D	D
Hybrid vehicle	The hybrid vehicle is designed to combine the benefits of the engine power, electric power, pressure to realize a higher efficiency. The parallel-type hybrid vehicle converts the energy of braking and deceleration into electricity or pressure to use as auxiliary power for startup and acceleration. The series-type hybrid vehicle stores in a battery electricity generated by the	The hybrid vehicle has many advantages: realization of resource saving by higher performance and such environmental benefits as reduction of CO_2 emission, cleaner exhaust gas. Development of higher-performance low-cost batteries is desired.	37,719	A to B	C to D	A to C

	Features	Development status and problems	Number of vehicles in use (Note 1)	Global environment, CO_2, (Note 2)	Power	Cruising distance
	engine and runs by the motor only. The series-parallel-type vehicle uses the above two systems depending upon the running conditions.					
Electric vehicle	The electric vehicle carries a battery, motor, system controller instead of the fuel tank, engine-controlling system, engine, exhaust gas system. The electric vehicle has advantages that it does not emit exhaust gas, generate little noise and vibration.	Use of the electric vehicle is limited because of the constraints on the power system and cruising distance. If high-performance and low-cost batteries are developed and such infrastructure as filling stations and recycling of batteries is established, use of the electric vehicle is expected to expand.	2,400 (estimated)	A	C to D	D to E
Fuel cell powered electric vehicle	The fuel cell powered electric vehicle is the electric vehicle equipped with a fuel cell to generate electricity by reacting hydrogen and oxygen. The fuel cell powered electric vehicle does not require electric charging. Drivers can use this type of cars just as vehicles with an internal combustion engine requiring feeding of fuel.	Researches are underway on fuels, infrastructure and various other concerned matters. The automobile makers intend to commercialize them around 2003 to 2005.	Not applicable	A	C to D	C to D

Note 1 The numbers for natural gas vehicles, methanol vehicles, hybrid vehicles and electric vehicles are the values as of the end of March 2001. That for LPG vehicles is the value as of the end of March 2001.

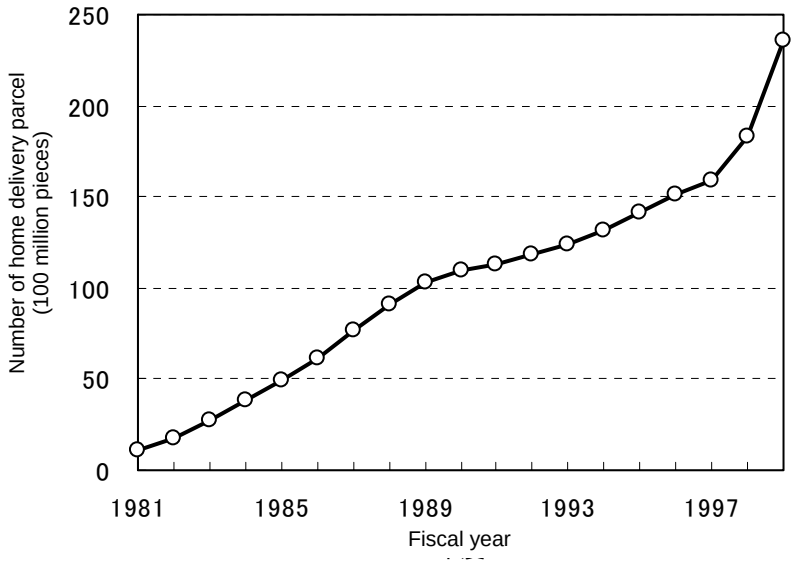
Note 2 Comparison among various types of vehicle is made with the gasoline-driven vehicle as being the standard, or C, and the performance excels in the order of (inferior) E → D → C → B →A (superior). The evaluation of exhaust gas does not include emission in the process of fuel manufacturing.

Reference

Nobuo Iwai, “Automobile Energy conservation” Energy and Resource, 341-351(1998)
Japan Automobile Manufacturers Association, “2001 THE MOTOR INDUSTRY OF JAPAN”
Automobile Inspection & Registration Association, “Monthly Car Population” March 2001
Toshiharu Sato, “Features and Problems with Penetration of Natural Gas Vehicles as Low Pollution Car” Industry and Environment, No. 6 pp37 to pp40 (1999)
Toshiyuki Seko, “Present Status and Future of Development of Alternate Fuel Cars”, Journal of Society of Automotive Engineers of Japan, Vol.53, No.5, pp15 to pp20 (1999)
Homepage of the Japan Electric Vehicle Association, http//www.jeva.or.jp
K. K. SEKIYU TSUSHINSHA, “SEKIYU TSUSHIN” Friday June 2, 2000
The Daily Automotive News, “Automotive Industry Handbook 2001”
Homepages of Automobile Manufacturers and others

Remark: Various efforts are being made to cope with environmental and energy problems caused by automobiles. These efforts may be broken down into the following approaches. The development target of these approaches is improvement of conventional automobiles (mounting of the direct gasoline injection engine, hybrid car), CNG vehicle, electric vehicle, methanol vehicle, hydrogen vehicle, fuel cell powered electric vehicle. Newly developed automobiles based on the conventional one have advantages in that they can rely on the existing infrastructure; therefore, they may have better chance of market penetration. Other types of automobiles have their respective problems; namely, cost, cruising distance, energy supply infrastructure. Each type will be developed in a manner to realize its particular advantages.

Figure 5-15 Trends of Number of Home Delivery Parcels



Source: Ministry of Land, Infrastructure and Transport, "Domestic Transportation Statistics Handbook"

Remark: The number of home delivery parcels is steadily increasing as the service becomes more diversified.

(Reference)

Table 5-6 Long-term Energy Supply Demand Forecast

(Unit: crude oil equivalent, million kiloliters)

	Fiscal 1999 record	Forecast for fiscal 2010		Annual growth rate from 1999 to 2010	
		Base case	Target case	Base case	Target case
Transportation sector	100	96	about 94	- 0.37%	about - 0.56%
Passenger cars	53	51	about 50	- 0.35%	about - 0.53%
Freight cars and others	47	45	about 45	- 0.39%	about - 0.39%
Final demand total	402	409	about 400	0.16%	about - 0.05%

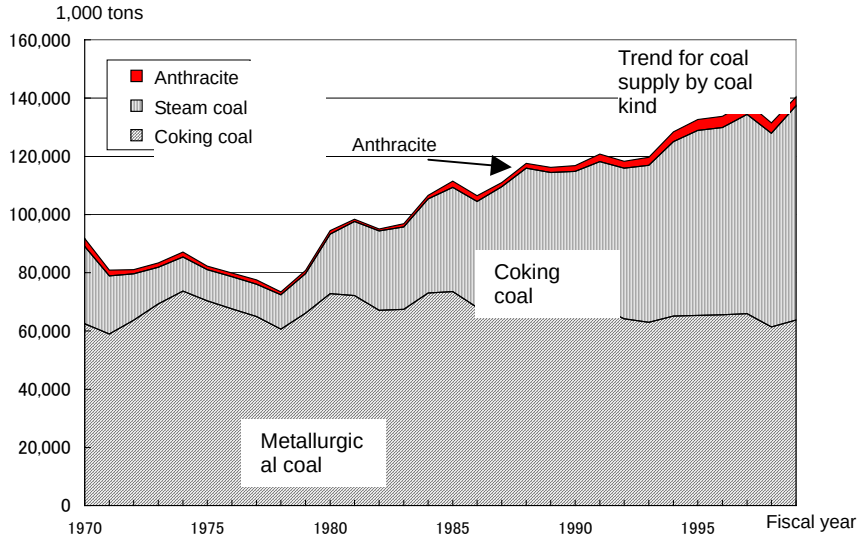
Source: Advisory Committee on Natural Resources and Energy (July 2001)

* The terms “tons transported” and “number of passengers transported” indicate freight weight and passenger number transported but do not indicate distances transported. To express the magnitudes of transportation activities, therefore, the terms “ton-km” and “person-km” are used. When 1 ton of cargoes (or 1 person) is transported for a distance of 10 kilometers, the magnitude of transportation work is 10 ton-kms (or 10 person-kms). When 5 tons of cargoes (or 5 persons) are transported over a distance of 1 kilometer, the magnitude of transportation work is 5 ton-kms (or 5 person-kms).

Chapter 6 Energy Supply and Demand by Source

1. Supply and Demand of Coal

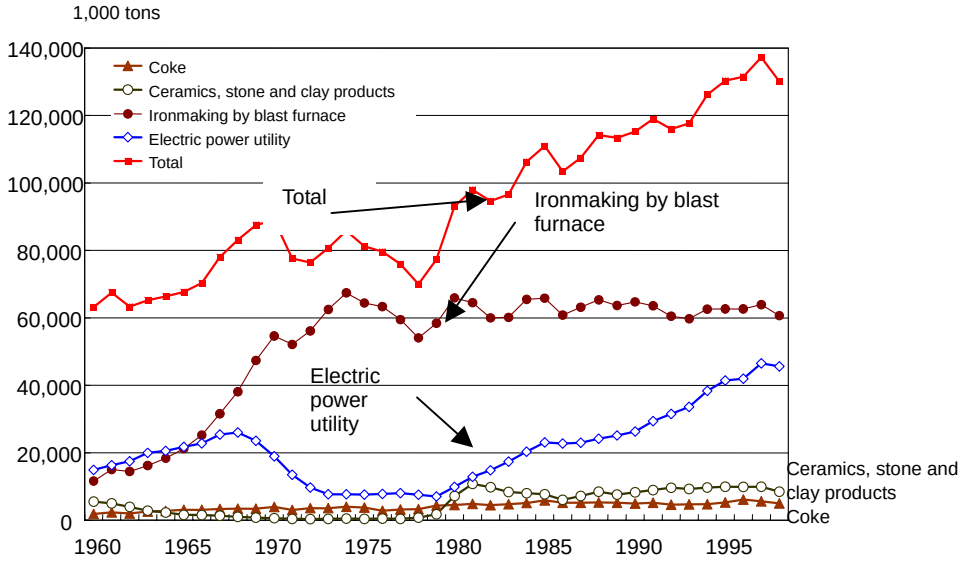
Figure 6-1 Coal Supply by Coal Kind



Source: Institute of Energy Economics, Japan, Database

Remark: The supply of coking coal has remained unchanged for recent several years. The supply of steam coal has been increasing. Though very little in total supply, the supply of anthracite has been increasing. Domestic production of coal peaked in 1961 at 55,410 thousand tons. Those days, domestic coal accounted for about 80 percent of the total supply. Now, the domestic coal accounts only for about 3 percent of the supply.

Figure 6-2 Coal Demand by Major Coal Consumer

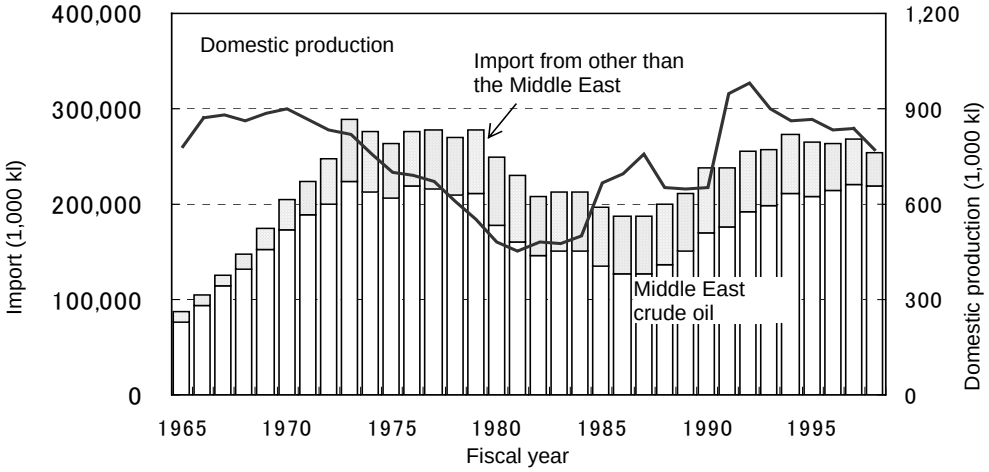


Source: Agency of Natural Resources and Energy, Coal and New Energy Department, "Coal Note 2000"

Remark: Consumption of coal in Japan has been increasing since fiscal 1978 and came close to 140 million tons in fiscal 1997. The consumption by the iron and steel industry, the largest consumer, has remained almost unchanged recently; however, there is a conspicuous increase in the demand by the electric power utility industry.

2. Supply and Demand of Oil

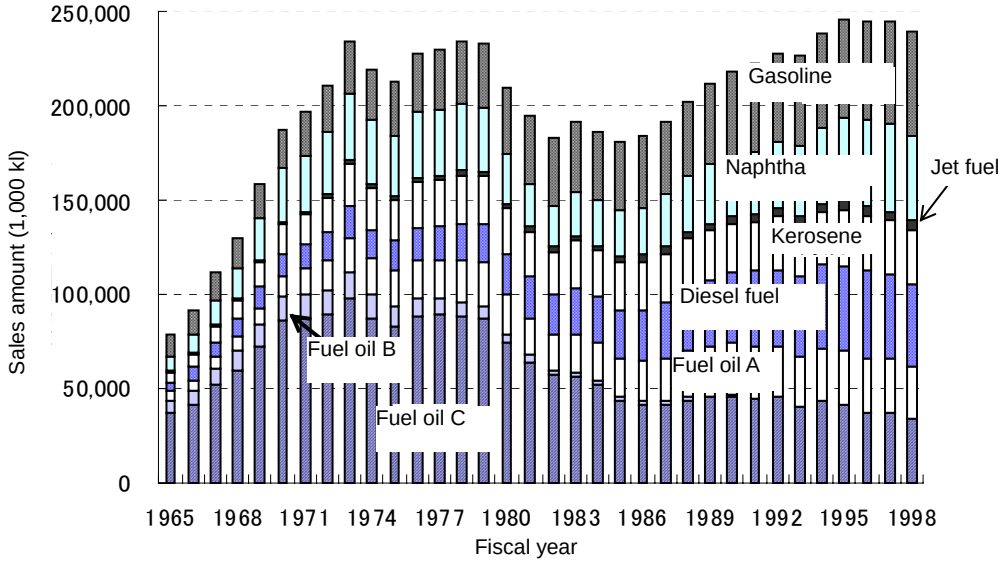
Figure 6-3 Domestic Production and Import of Crude Oil



Source: Ministry of International Trade and Industry (MITI), "Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke", MITI, "Yearbook of Petroleum Statistics"

Remark: The rate of self-sufficiency of petroleum supply of Japan is 0.3 percent in fiscal 1998. Japan depends on import from the Middle East to the extent of 70 to 80 percent.

Figure 6-4 Sales of Petroleum Products by Fuel



Source: MITI, "Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke", MITI, "Yearbook of Petroleum Statistics"

Remark: Since the latter half of the 1980s, use of alternate energy and energy conservation have been promoted. As a result, sale of heavy fuel oil has declined and that of such distillate fuels as gasoline, kerosene and diesel fuel has increased.

(Supply of Petroleum Products in Japan)

Principle of consuming area refining: To transport crude oil to the consuming area and to refine the crude oil there as necessary

(Advantage): Crude oil is cheaper than petroleum products; this can moderate the effects of international affairs; this system can better adapt to changes in demand structure; there are other advantages.

Refining capacity: about 5 million barrels/day by 38 refineries, operation rate at about 80 percent

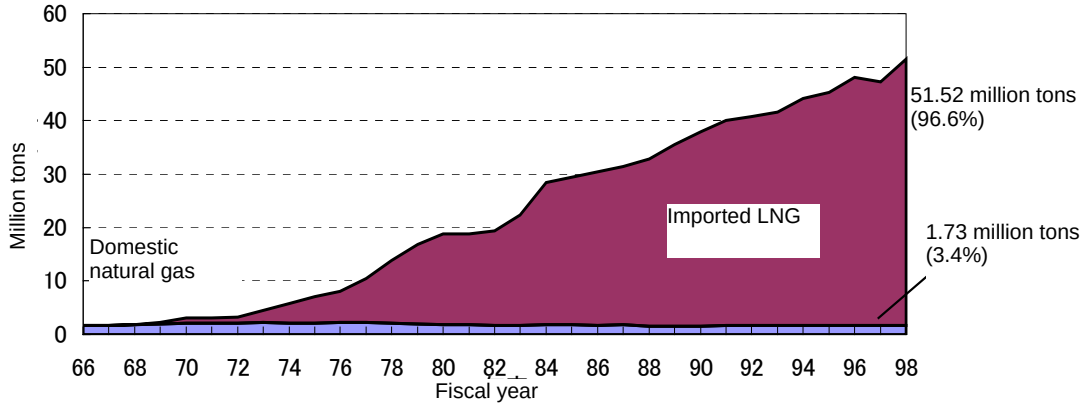
Regulation of petroleum product import: the Provisional Measures Law on the Importation of Specific Petroleum Refined Products, from 1986 to 1996

(Storage of Petroleum in Japan)

Japan has established the system of petroleum storage, both the government storage and private storage, through two energy crises and the Gulf Crises. As of end of March 2000, Japan had a government storage and private storage equivalent to 84 day's demand and 72 day's demand, respectively, or a total of 156 day's demand.

3. Supply and Demand of Town Gas and LNG

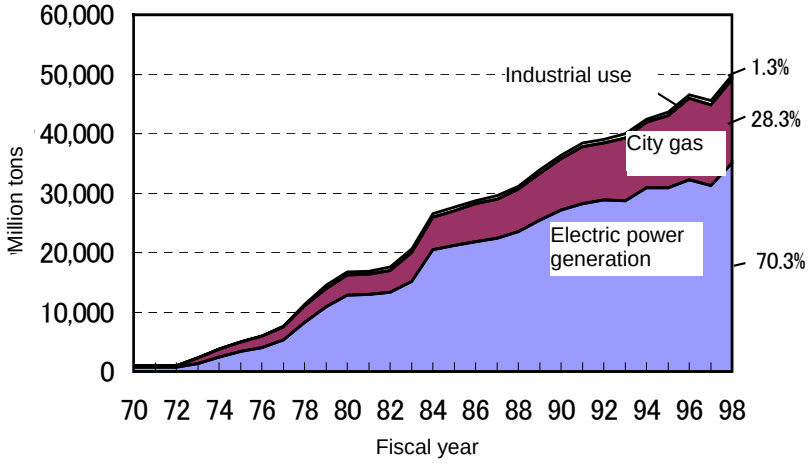
Figure 6-5 Supply of Natural Gas



Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: The demand for natural gas in Japan is met almost entirely by the imported LNG. About 70 percent of imported natural gas comes from Indonesia, Malaysia and Brunei, accounting respectively for 36.4, 19.8 and 10.8 percent.

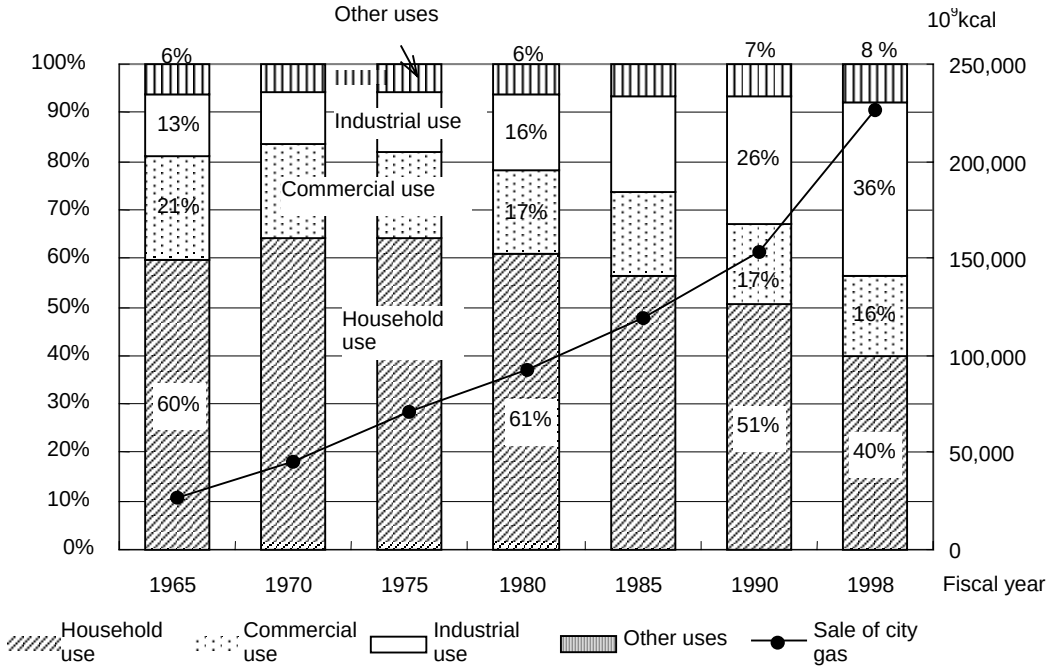
Figure 6-6 LNG Demand by Use



Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: The imported LNG is consumed almost entirely for electric power generation, about 70 percent, and for city gas, about 30 percent.

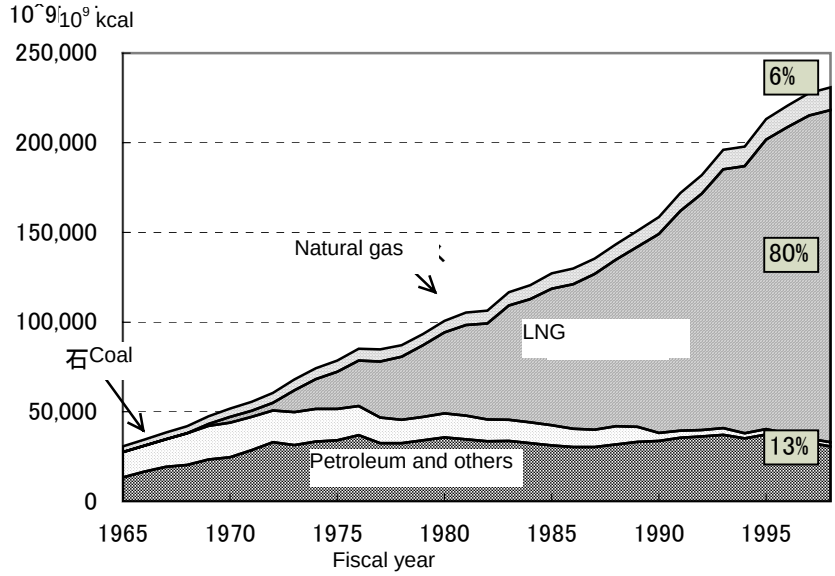
Figure 6-7 Sale of Town Gas by Use



Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: Regarding the ratios of sales by use, the industrial consumption has increased to close to 40 percent while that for household use has decreased in relative terms to less than 40 percent. There are 244 city gas enterprises operating in Japan. Of these gas enterprises, the major four companies jointly occupy 78 percent of the sale and 68 percent of the consumer households. Regarding area, city gas supply covers only 5 percent of the entire area of Japan.

Figure 6-8 Production and Purchase of Town Gas by Sources



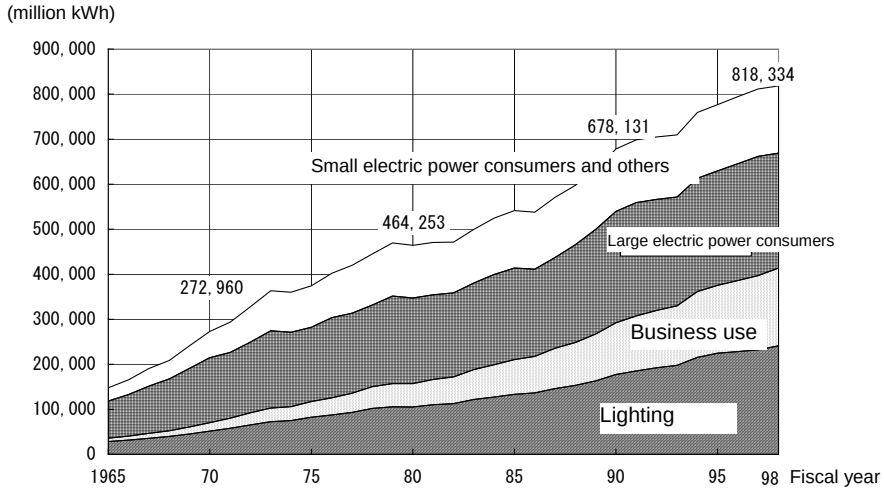
Note: The percentage numbers on the figure show ratios in fiscal 1998.

Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: The raw material for the production of city gas has shifted at first from coal to petroleum and then from petroleum to LNG. Now, LNG accounts for 80 percent of the raw material.

4. Supply and Demand of Electric Power

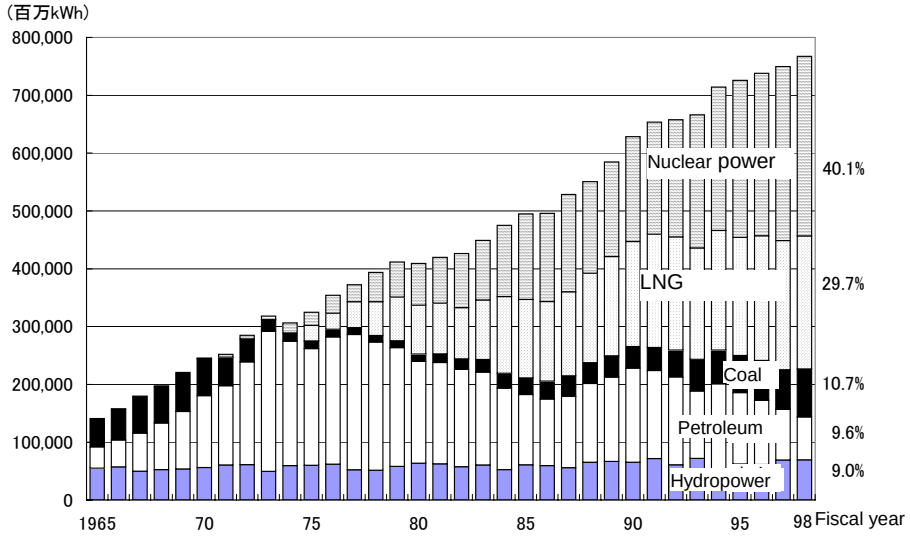
Figure 6-8 Electric Power Demand by Sector (Electric Power Utility Enterprise)



Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: The demand for electricity has grown steadily at a rate greater than that of final total energy consumption. The demand in fiscal 1998 was 796 trillion kcal (3,332 trillion kJ or 925.6 billion kWh), accounting for about 22 percent of the total final energy consumption. (This figure was about 13 percent in 1973.) While energy conservation has been promoted and efficiencies of electricity-using facilities have been improved, further penetration of household electric appliances and office automation equipment have contributed to the growth of electric power demand.

Figure 6-9 Electric Power Generation
(Top 9 Electric Utility Companies)

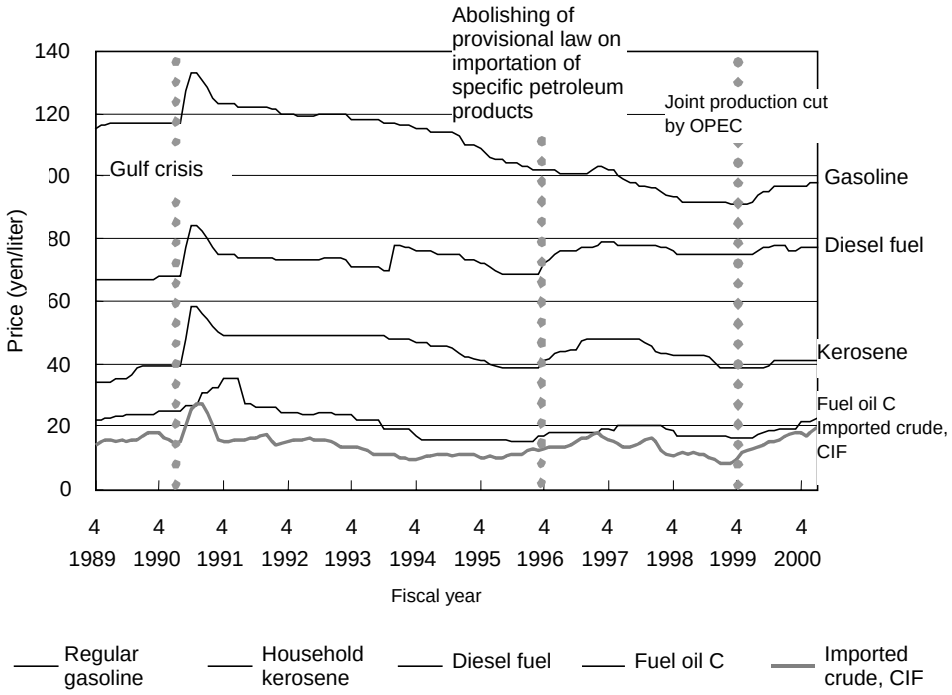


Source: Denki Jigyo Binran

Remark: The total electric power generated by the top nine electric utility companies indicates that the oil-burning power generation had increased in ratio until fiscal 1973 when the first energy crisis occurred. (The share of the oil-burning electric power generation in fiscal 1973 was 74 percent.) Since the first energy crisis, the oil-burning power generation has been steadily declining. By contrast, nuclear power generation and LNG-burning power generation have been increasing since then. The sources for power generation in fiscal 1998 were nuclear power at 40 percent, LNG at 30 percent, coal at 11 percent, petroleum at 10 percent and hydropower at 9 percent.

5. Energy Prices

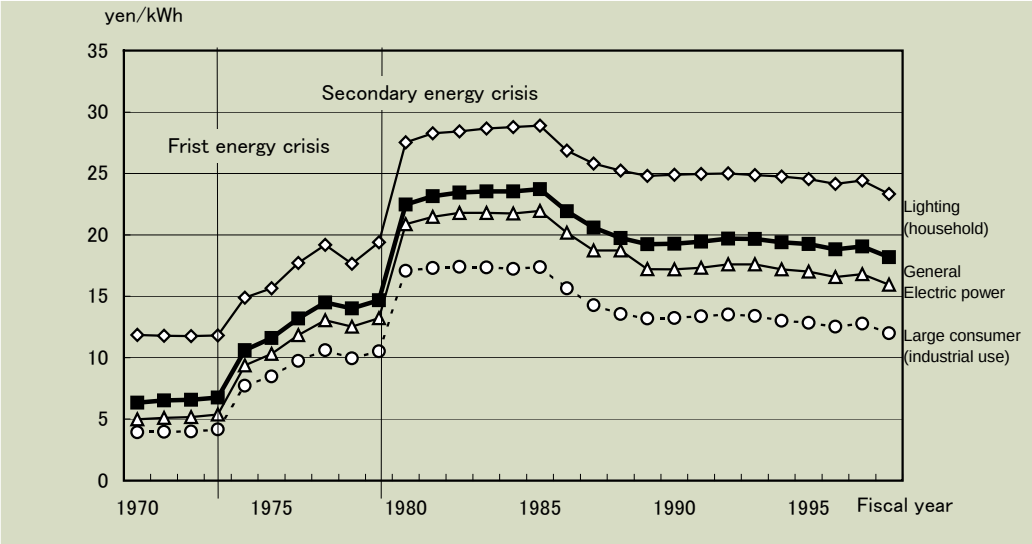
Figure 6-10 Trends of Petroleum Product Price
(End-of-month Average in Tokyo, Osaka and Nagoya)



Source: “Materials on Petroleum”

Remark: The differences in distribution system and taxes are one of the causes of difference in petroleum prices. Gasoline

Figure 6-11 Trends of Unit Electric Power Price for Lighting



Source: Institute of Energy Economics, Japan, Energy Data & Modeling Center, "EDMC Handbook of Energy & Economic Statistics in Japan"

Remark: The price of electric power is determined by overall cost plus profit system. Depending upon degree of installation of transmission and transmission facilities, the price differs by customer.

Chapter 7 Energy Supply and Demand Forecast

Regarding future prospects such terms as those given below are often used.

- Forecast
- Outlook
- Scenario analysis

The figures obtained by these methods have their respective characters (political consideration, elements of wishful thinking, etc.). These terms may differ in connotation, but the purposes of their processes are basically the same in that they all attempt to quantitatively prospect the future.

Given below are key factors important in prospecting the future.

1. Key factors for the future

- Economic growth, final demand structure, industrial structure (international trade structure, technical structure), IT revolution

The economic growth is one of the most important factors determining energy demand. It is also important to view what kinds of structural changes of economy the economic growth will bring about. In the case of Japan, for example, energy consumption per GDP decreased by 30 percent after the first energy crisis (energy conservation in broader meaning). This reduction of energy consumption is considered to be attributable to the extent of about 60 percent to structural changes and about 40 percent to technical energy conservation.

- Social factor (aging population, privatism, social advancement of women, increase of nuclear family households, etc.)

Such factors as trends of population, number of households, aging population, and changes in people's sense of value are important in the study of energy in the residential sector and transportation sector.

- Saturation

As economy matures, supplies can become close to the demands in various aspects. In other words, it is possible that demands for goods do not necessarily increase in association with economic growth. Energy is an absolute necessity in various aspects; therefore, demands may be overestimated if such factors as those mentioned above are not well considered, depending upon the sector.

- Energy conservation technology (technological advancement, economic incentive)

The demand for energy has two aspects, one determined by market mechanism and the

other that could be greatly affected by technological development in the future. In forecasting energy demand in the latter aspect, proper assessment of possibility of future technological developments and their applications is very important.

- Energy price

Typically, the estimate of future price of crude oil, the most important of energy price, is important. The price elasticity of energy is generally considered to be small. Nevertheless, the energy price is an important factor determining commodity prices through the market. The relative prices among different energy sources are an important factor promoting substitution among different energy sources.

- Energy policy (promotion of energy conservation, tax system, deregulation, environmental regulation)

Energy is one of the most important basic materials supporting people's living. There are such issues to energy as securing of stable supply, promotion of energy conservation, environmental problems that cannot be satisfactorily settled if left to market mechanism alone. Such energy policies as promotion of energy conservation, official subsidy to introduction of new energy, policy measures to control price (carbon tax for example), development of domestic energy and diversification of sources (nuclear power, electric power development) for securing energy supply, deregulation to stimulate market can be very effective. How one considers these policy measures and integrates them is very important in energy forecasting.

2. Methods for Forecasting

There are following methods for forecasting supply and demand of energy.

- Use of models (Optimization type, simulation type)
- Cumulative method
- Step-wise approach

These methods have their own advantages and disadvantages. Making effective use of these methods will lead to a good forecast. Figure 6-1 outlines the structure of the supply demand forecast model of the Institute of Energy Economics, Japan.

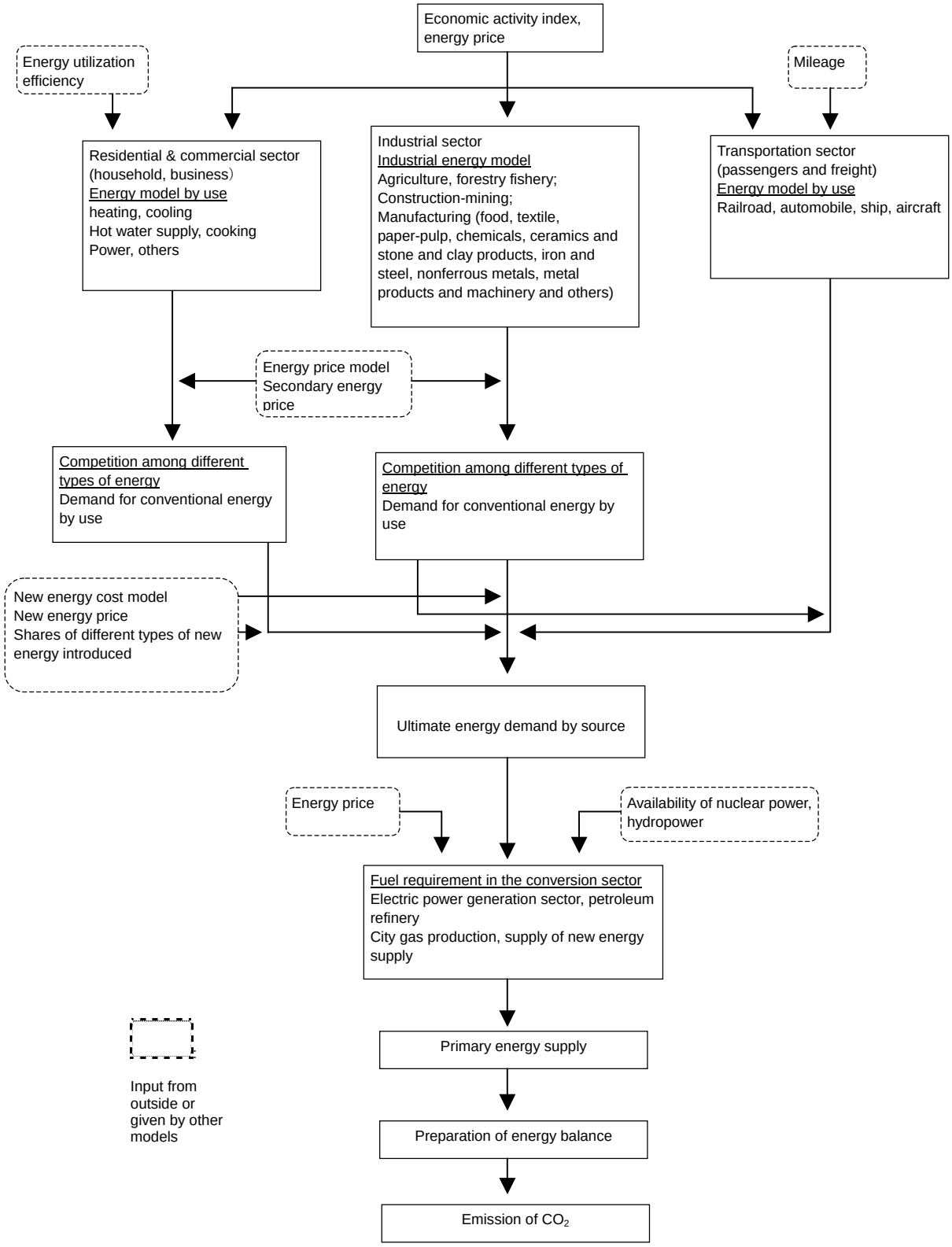
3. Examples of Long-term Energy Supply and Demand Forecast

The following three long-range energy supply and demand forecasts are attached as example.

(1) Long-range Energy Supply Demand Forecast (Advisory Committee on Natural Resources and Energy (July 2001))
(2) Extra-long-term Energy Supply and Demand Outlook (2030) (the Institute of Energy Economics, Japan, the Energy Data and Modeling Center, 1998)
(3) Japan's Long-term Energy Supply and Demand Outlook and Problems (the Institute of Energy Economics, Japan, 1998)

Figure 7-1 Structure of Extra-long-term Energy Supply and Demand Model

(Institute of Energy Economics, Japan, the Energy Data and Modeling Center, 1998)



(Example of forecast - 1) Long-term Energy Supply Demand Forecast (Advisory Committee on Natural Resources and Energy (July 2001)

Premises of the base case

Macro frame

Fiscal year	1999	2005	2010	(2020)	
Population (thousand persons)	12,669	12,768	12,762	12,413	Forecast by the National Institute of Population and Social Security Research (medium case forecast), January 1997
Number of households (10,000 households)	4,669	4,823	4,914	4,885	Forecast of the number of households by the above organization, October 1998
Working population (10,000)	6,779	6,988	6,953	6,552	Estimate by the Ministry of Economy, Trade and Industry, considering social advancement of women and other factors
Exchange rate (\/$)	110	110	110	110	Estimation by the Ministry of Economy, Trade and Industry based on the past five-year-or-so record
Nominal CIF price					
Crude oil price ($/bbl)	21	24	30	48	Assumption referring to IEA's long-term outlook
LNG price ($/ton)	183	214	248	350	Linkage with crude oil price is assumed.
Steam coal price ($/ton)	35	42	45	72	Estimation by the Ministry of Economy, Trade and Industry

Demand side

The Voluntary Action Plan of the Japan Federation of Economic Organizations (Keidanren)
Top-runner standard
Incorporation of such factors as improvement of distribution efficiency, traffic control measure, promotion of teleworking

Supply side

Supply of domestic energy, export of energy:
Estimation by the Ministry of Economy, Trade and Industry based on past supplies and introduction for the past about 10 years

Ratio of electric power generation by source:
Estimation by the Electric Power Source Model of the Central Research Institute of Electric Power Industry

Share of inhouse electric power generation (inhouse consumption) in the total electric power generation:

Fiscal year	1999	2005	2010	(2020)	
Share of inhouse electric power generation (%)	12.7	11.9	10.2	7.9	Estimation by the Central Research Institute of Electric Power Industry

Operation ratio of nuclear power stations:
Estimation by the Ministry of Economy, Trade and Industry based on records of recent years, (80%)

Amount of hydroelectric power and geothermal power generation:
Estimation by the Ministry of Economy, Trade and Industry based on records of recent years (Electric power generation by the electric power utility companies: 84.0 billion kWh)

New energy:
8.78 million kiloliters crude oil equivalent, an estimate by the New-Energy Division, the Japan Institute of Energy assuming that the present measures will be maintained, is employed.

	Photovoltaic power	Windpower	Solar heat utilization	Unused energy	Waste power generation	Waste heat utilization	Black liquor, waste wood	Total
Crude oil equivalent (10,000 kl)	62	32	72	9.3	220	4.4	479	878
Power generation facility (10,000 kW)	254	78	-	-	190	-	-	521

Case

Base case: The present policy measures will be maintained.

Target case: Additional policy measures will be implemented for “energy conservation,” “new energy,” and “fuel conversion to electricity and others.”

Table 7-1 Trends and Outlook of Total Primary Energy Supply

Crude oil equivalent, million kiloliters

Fiscal year / Item	Fiscal 1990		Fiscal 1999		Fiscal 2010				Fiscal 2010 previous countermeasure case	
					Base case		Target case			
Primary energy supply	526		593		622		about 602		616	
Type of energy	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)
Oil	307	58.3	308	52.0	280	45.0	about 271	about 45	291	47.2
Coal	87	16.6	103	17.4	136	21.9	about 114	about 19	92	14.9
Natural gas	53	10.1	75	12.7	82	13.2	about 83	about 14	80	13.0
Nuclear power	49	9.4	77	13.0	93	15.0	93	about 15	107	17.4
Hydropower	22	4.2	21	3.6	20	3.2	20	about 3	23	3.8
Geothermal energy	1	0.1	1	0.2	1	0.2	1	about 0.2	4	0.6
New energy and others	7	1.3	7	1.1	10	1.6	20	about 3	19	3.1
Renewable energy	29	5.6	29	4.9	30	4.8	40	about 7	-	-

Renewable energy includes new energy, hydropower and geothermal energy.

Table 7-2 Trends and Outlook of Final Energy Demand

Crude oil equivalent, million kiloliters

Item \ Fiscal year	Fiscal 1990		Fiscal 1999		Fiscal 2010				Fiscal 2010 previous countermeasure case	
					Base case		Target case			
	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)
Industry	183	52.5	197	49.0	187	45.8	about 185	about 46	192	48.0
Residential	85	24.4	105	26.1	126	30.8	about 120	about 30	113	28.2
Household	46	13.3	55	13.8	60	14.7	about 58	about 14	-	-
Commercial	39	11.2	50	12.3	66	16.1	about 63	about 16	-	-
Transportation	80	23.0	100	24.9	96	23.4	about 94	about 24	95	23.7
Passenger car	39	11.0	53	13.2	51	12.5	about 50	about 12	-	-
Freight and other	42	12.0	47	11.7	45	10.9	about 45	about 11	-	-
Total	349	100.0	402	100.0	409	100.0	about 400	100.0	400	100.0

Table 7-3 Trends and Outlook of Emission of Energy-derived CO_2

Carbon equivalent, million tons

Item \ Fiscal year	Fiscal 1990	Fiscal 1999	Fiscal 2010		Fiscal 2010 previous countermeasure case
			Base case	Target case	
Emission of energy-derived CO_2	287	313	307	about 287	287
Rate of increase over fiscal 1990		8.9%	6.9%		

Table 7-4 Trends and Outlook of Facility Capacity at Fiscal Year End (Electric Power Utility Company)

(10,000 kW)

Item \ Fiscal year	Fiscal 1990		Fiscal 1999		Fiscal 2010			
					Base case		Target case	
Capacity of power generation facilities at fiscal year end (electric power utility company)	17,212		22,410		26,657		25,288 - 27,229	
Electric power generation by energy source	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)
Thermal	10,408	60.5	13,434	59,9	15,343	57.6	14,670 - 16,220	57.0 - 59.6
Coal	1,223	7.1	2,488	11.1	44,101	6.5	3,155 - 4,413	12.3 - 16.2
LNG	3,839	22.3	5,677	25.3	6,702	25.1	6,606 - 6,696	24.6 - 26.1
Petroleum and others	5,347	31.1	5,270	23.5	4,231	15.9	4,908 - 5,111	18.8 - 19.4
Nuclear power	3,148	18.3	4,492	20.0	6,185	23.2	5,755 - 6,185	22.7 - 24.1
Hydropower	3,632	21.1	4,433	19.8	5,071	19.0	4,810	17.7 - 19.0
Conventional hydroelectric power	1,931	11.2	2,002	8.9	2,070	7.8	2,069	7.6 - 8.2
Pumped storage hydroelectric power	1,701	9.9	2,431	10.8	3,001	11.3	2,741	10.1 - 10.8
Geothermal energy	24	0.1	52	0.2	59	0.2	54	0.2

Table 7-5 Trends and Outlook of Electric Power Generation (Electric Power Utility Company)

100 million kWh

Item \ Fiscal year	Fiscal 1990		Fiscal 1999		Fiscal 2010			
					Base case		Target case	
Amount of power generated (electric power utility company)	7,376		9,176		10,292		about 9,970	
Electric power generation by energy source	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)	Supply	Ratio (%)
Thermal	4,466	60.5	5,063	55.2	5,074	49.3	about 4,680	about 47
Coal	719	9.7	1,529	16.7	2,351	22.8	about 1,599	about 16
LNG	1,639	22.2	2,405	26.2	2,341	22.7	about 2,549	about 26
Petroleum and others	2,108	28.6	1,129	12.3	383	3.7	about 533	about 5
Nuclear power	2,014	27.3	3,165	34.5	4,186	40.7	4,186	about 42
Hydropower	881	11.9	893	9.7	966	9.4	952	about 10
Conventional hydropower generation	788	10.7	769	8.4	803	7.8	803	about 8
Pumped storage hydroelectric power	93	1.3	123	1.3	163	1.6	149	about 1
Geothermal energy	15	0.2	34	0.4	37	0.4	37	about 0.4
New energy	-	-	21	0.2	29	0.3	115	about 1
		101.9		89.9		82.6		about 73.6

Figure 7-2 Long-term Energy Supply Demand Forecast (Advisory Committee on Natural Resources and Energy)

Trend and Outlook of Total Primary Energy Supply

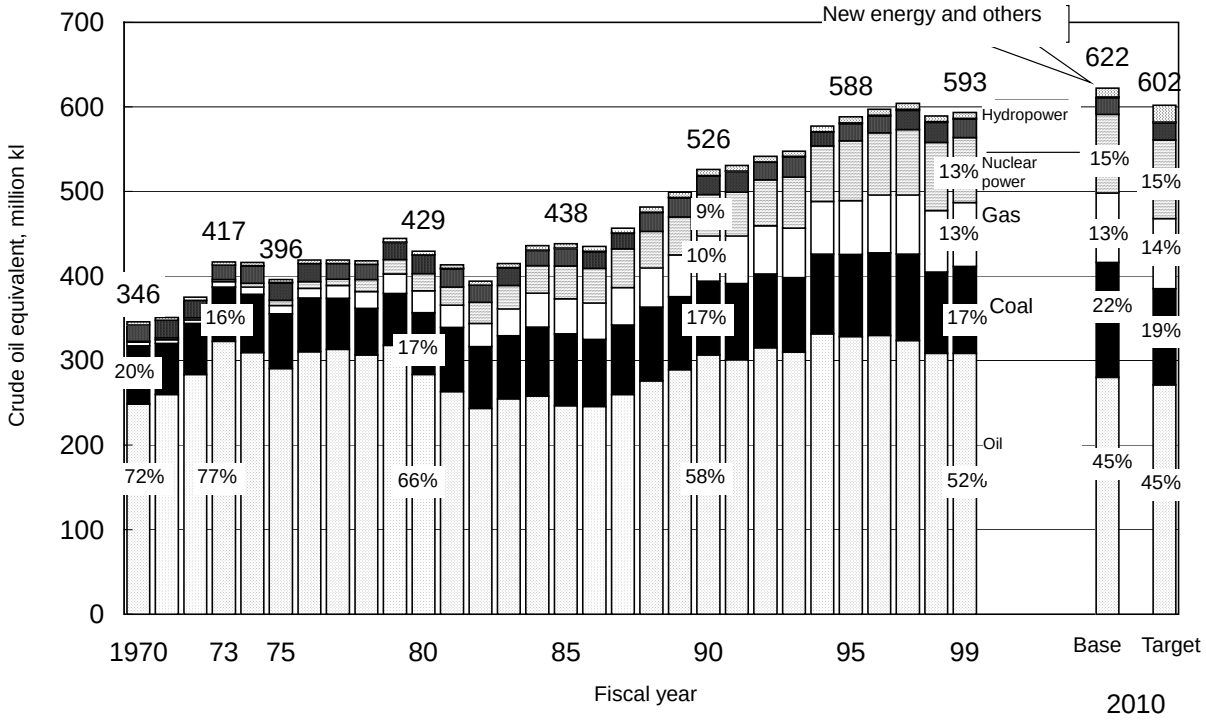


Figure 7-3 Trends and Outlook of Final Energy Consumption

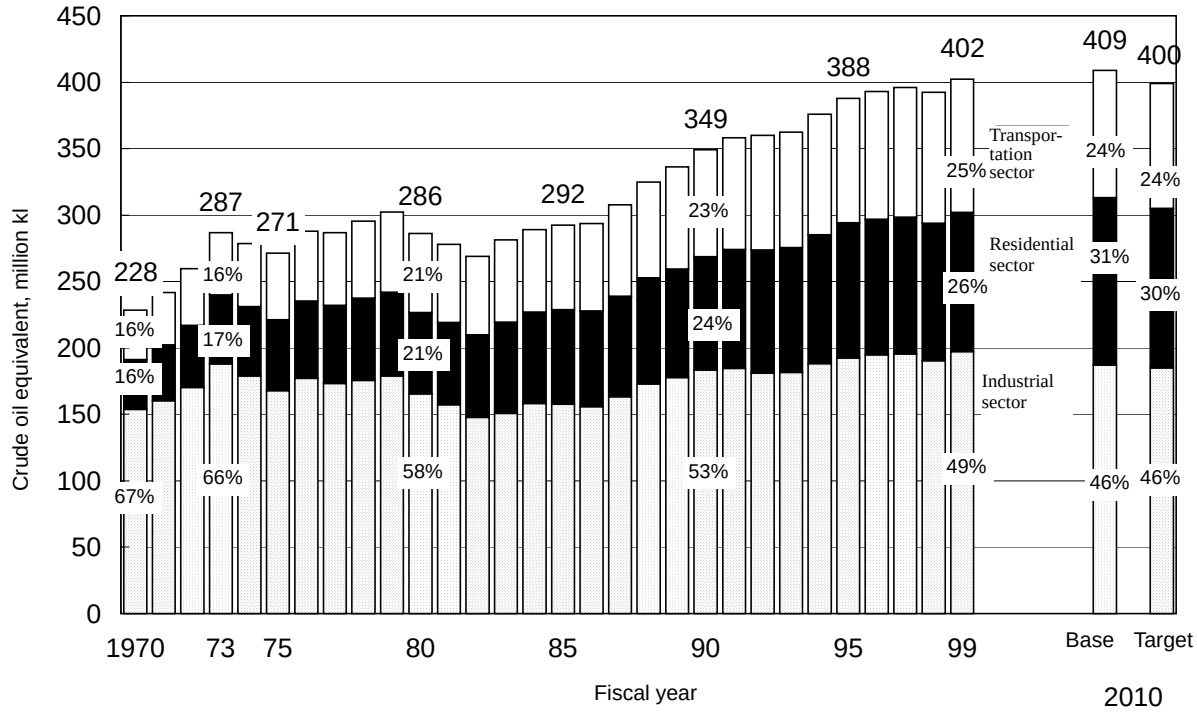
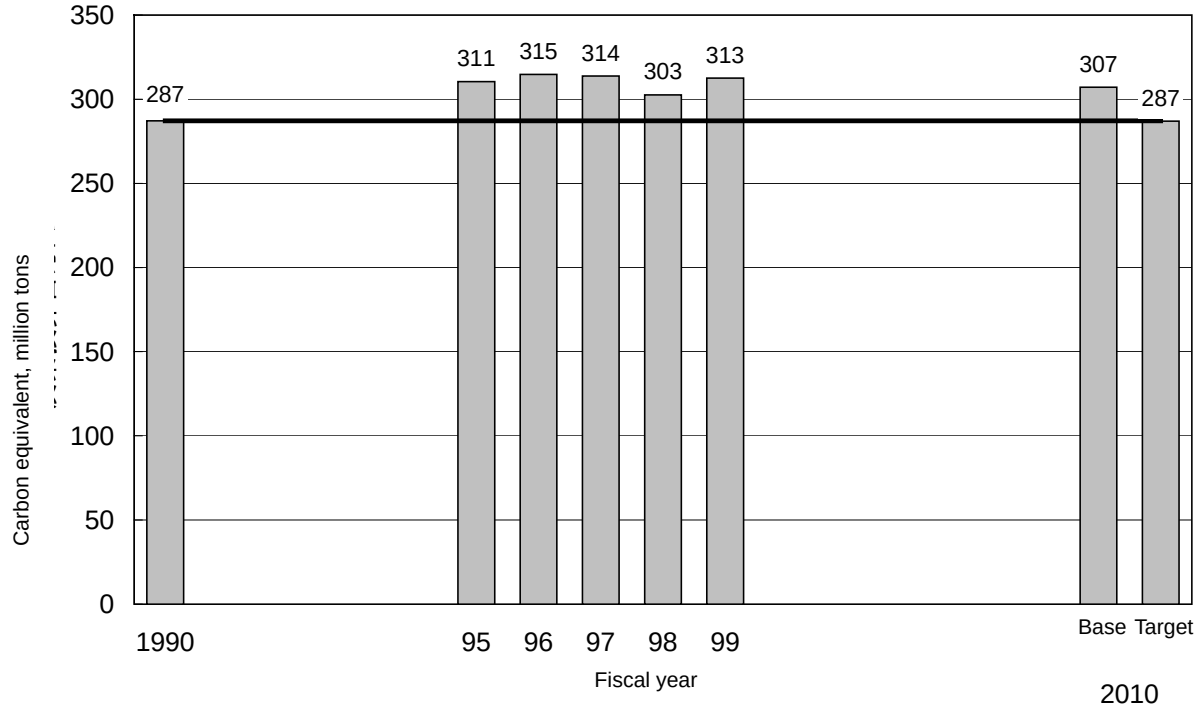


Figure 7-4 Trends and Outlook of Energy-derived Carbon Dioxide Emission



The past data were excerpts from the Agency of Natural Resources and Energy, "Final Report on Energy Supply and Demand for Fiscal 1999 (March 30, 2001)."

Factor analysis of variation in CO_2 emission

$$C = \frac{C}{E} \times \frac{E}{GDP} \times GDP$$

C: CO_2,

E: Energy

↓

$$\Delta C = \Delta\frac{C}{E} + \Delta\frac{E}{GDP} + \Delta GDP$$

$\Delta\frac{C}{E}$: Reduction of carbon emission

$\Delta\frac{E}{GDP}$: Energy conservation

ΔGDP: Economic growth

(Annual average growth rate, %)

	from 1973 to 1990	from 1990 to 1999	from 1999 to 2010	
			Base case	Target case
CO_2 Emission as C	0.8	1.0	- 0.2	- 0.8
Carbon emission reduction, *C/E*	- 0.5	- 0.4	- 0.6	- 1.0
Energy conservation*E/GDP*	- 2.2	0.4	- 1.9	- 2.0
Economic growth, GDP	3.9	1.1	2.0	2.0

(Example of forecast - 2) Extra-long-term Energy Supply and Demand Outlook (2030) (the Institute of Energy Economics, Japan, the Energy Data and Modeling Center, 1998)

Figure 7-5 Comparison of Primary Energy Supply

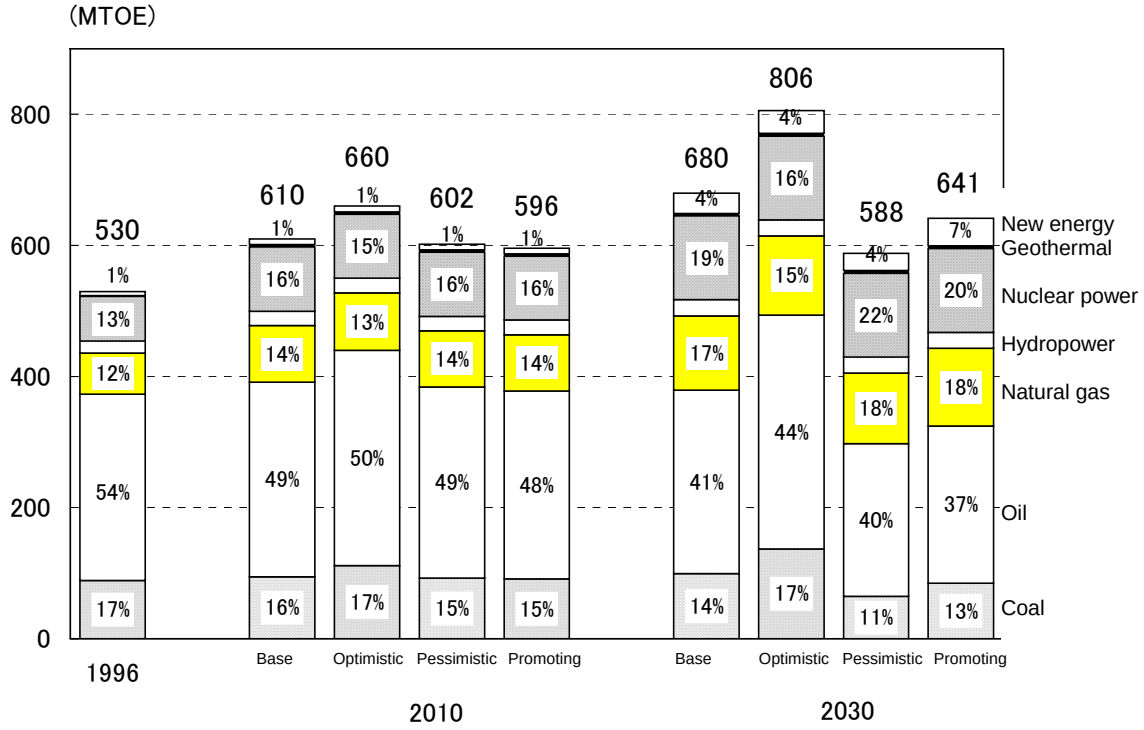


Figure 7-6 Comparison of Final Energy Demand

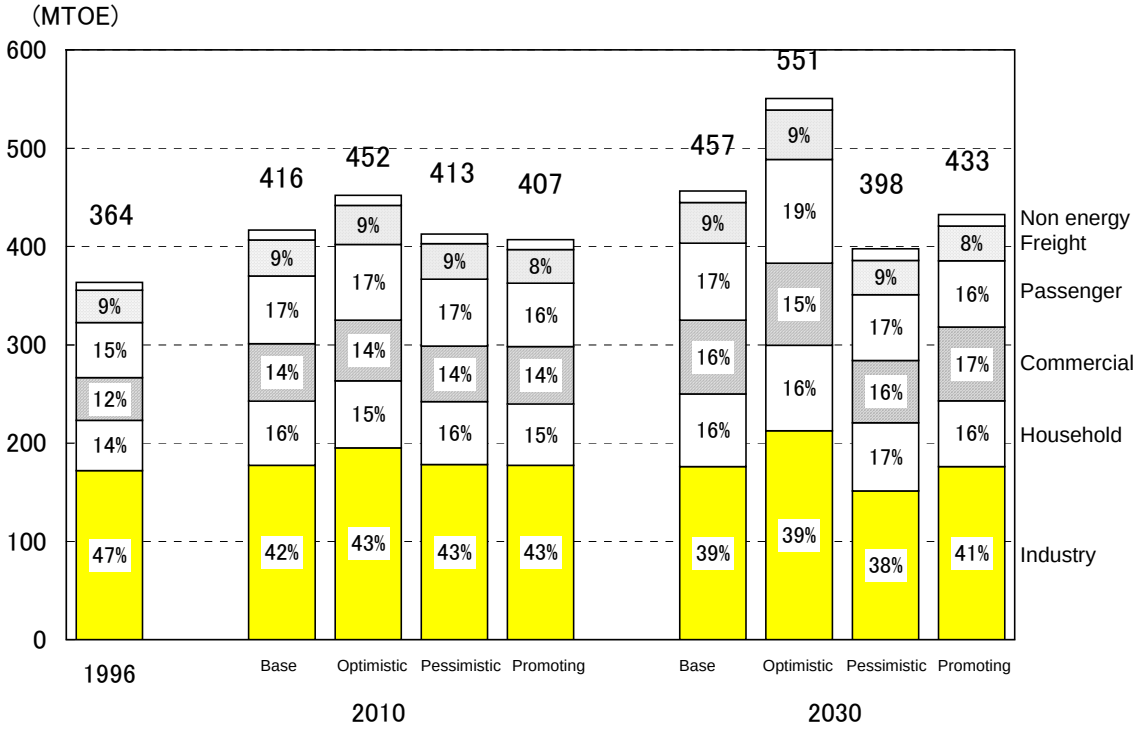


Table 7-6 Comparison among Different Cases (Base Case, Optimistic Case, Pessimistic Case, Promoting Case)

Case	Item	1996	2000	2010	2020	2030	Annual average growth rate (%) 2000/1996	2010/2000	2020/2010	2030/2020
Base case	Domestic supply of primary energy (Unit: MTOE)	530	556	610	652	680	1.2	0.9	0.7	0.4
Optimistic case		530	561	660	742	806	1.4	1.6	1.2	0.8
Pessimistic case		530	556	602	611	588	1.2	0.8	-2	-0.4
Promoting case		530	553	596	627	641	1.1	0.7	0.5	0.2
Base case	Total emission of CO_2 (Unit: million tons) The numbers in parentheses are indices with the 1990 figure, 288.1, as base, or 100.	315.2 (109.4)	333.8 (115.9)	343.2 (119.1)	359.1 (124.6)	350.8 (121.8)	1.4	0.3	0.5	-0.2
Optimistic case		315.2 (109.4)	337.3 (117.1)	383.2 (133.0)	430.6 (149.5)	448.3 (155.6)	1.7	1.3	1.1	0.4
Pessimistic case		315.2 (109.4)	333.6 (115.8)	336.1 (116.7)	325.7 (113.0)	278.0 (96.5)	1.4	0.1	-0.3	-1.6
Promoting case		315.2 (109.4)	331.5 (115.0)	331.7 (115.1)	336.2 (116.7)	307.2 (106.6)	1.3	0.0	0.1	-0.9
Base case	GDP (trillion yen)	480.7	522.4	618.3	703.6	769.5	2.1	1.7	1.3	0.9
	Elasticity to GDP		0.587	0.545	0.515	0.463				
	Primary energy/GDP	11.0	10.6	9.9	9.3	8.8	-0.8	-0.8	-0.6	-0.5
	CO_2/E	0.595	0.600	0.563	0.551	0.516	0.2	-0.6	-0.2	-0.6
Optimistic case	GDP (trillion yen)	480.7	524.5	698.0	859.3	987.4	2.2	2.9	2.1	1.4
	Elasticity to GDP		0.656	0.568	0.559	0.590				
	Primary energy/GDP	11.0	10.7	9.5	8.6	8.2	-0.7	-1.2	-0.9	-0.6
	CO_2/E	0.595	0.601	0.580	0.580	0.557	0.3	-0.4	0.0	-0.4
Pessimistic case	GDP (trillion yen)	480.7	522.4	606.3	637.3	612.2	2.1	1.5	0.5	-0.4
	Elasticity to GDP		0.581	0.532	0.308	0.969				
	Primary energy/GDP	11.0	10.6	9.9	9.6	9.6	-0.9	-0.7	-0.3	0.0
	CO_2/E	0.595	0.600	0.559	0.533	0.473	0.2	-0.7	-0.5	-1.2
Promoting case	GDP (trillion yen)	480.7	522.4	618.3	703.6	769.5	2.1	1.7	1.3	0.9
	Elasticity to GDP		0.525	0.439	0.388	0.258				
	Primary energy/GDP	11.0	10.6	9.6	8.9	8.3	-1.0	-0.9	-0.8	-0.7
	CO_2/E	0.595	0.599	0.556	0.536	0.479	0.2	-0.7	-0.4	-1.1
Base case	Total final energy demand (Unit: MTOE)	364	385	416	440	457	1.4	0.8	0.5	0.4
Optimistic case		364	388	452	505	551	1.7	1.5	1.1	0.9
Pessimistic case		364	385	413	415	398	1.4	0.7	0.0	-0.4
Promoting case		364	382	407	422	433	1.3	0.6	0.4	0.2
	(Ratio, %)									
Base case	Industrial	47.3	46.2	42.5	39.8	38.5				
	Residential	25.9	27.2	29.8	31.7	32.7				
	Transportation	24.5	24.3	25.3	26.0	26.2				
	Non-energy	2.3	2.3	2.4	2.5	2.6				
Optimistic case	Industrial	47.3	46.6	43.2	40.2	38.6				
	Residential	25.9	26.9	28.8	30.0	30.9				
	Transportation	24.5	24.2	25.8	27.7	28.3				
	Non-energy	2.3	2.3	2.2	2.2	2.1				
Pessimistic case	Industrial	47.3	46.2	43.1	39.7	38.1				
	Residential	25.9	27.1	29.2	31.6	33.3				
	Transportation	24.5	24.3	25.2	26.0	25.6				
	Non-energy	2.3	2.3	2.4	2.6	3.0				
Promoting case	Industrial	47.3	46.5	43.5	41.4	40.7				
	Residential	25.9	27.2	29.8	31.7	32.9				
	Transportation	24.5	24.0	24.3	24.2	23.7				
	Non-energy	2.3	2.3	2.5	2.6	2.7				

(Example of forecast -3) Japan's Long-term Energy Supply and Demand Outlook (the Institute of Energy Economics, Japan, 1998)

The purpose of this study was to identify problems with the long-term supply and demand of energy in Japan to 2020, while viewing Japan's supply and demand of energy, with due consideration given to socioeconomic changes taking place presently and in the future. A number of uncertainties were foreseen both at home and abroad that should affect a long-term energy forecast extending as far away as more than 20 years. Therefore, two scenarios were assumed to cover such uncertainties; namely, status quo case and structural reform case. A forecast energy supply and development was developed for each case while indicating premises for each case.

Scenario

	Status quo case	Structural reform case
Image	Conservative	Liberal and innovating
	Large government	Small government
	Declining birth rate and aging population (low level estimate)	Declining birth rate and aging population (middle level estimate)
	Low and declining economic growth	Recovery of economic growth after the structural reform
	Little room for energy conservation and environmental conservation	Increasing room for energy conservation and environmental conservation (after 2010)
Growth of world economy	Slow growth	Slow growth
Crude oil price	Gradual rise in and after 2000 16.8 $/bbl in 2000 (1977 price) 17.5 $/bbl in 2010 (ibid.) 18.9 $/bbl in 2020 (ibid.)	Same as left
Exchange rate	Gradual decline of yen price 130 yen/$ in 2000, 140 yen/$ in 2010 150 yen/$ in 2020	Gradual rise of yen price since 2010 135 yen/$ in 2010, 125 yen/$ in 2020
Japan's population	Low level estimate 127 million in 2000, 126 million in 2010 121 million in 2020	Middle level estimate 128 million in 2000, 128 million in 2010 124 million in 2020
Growth rate of Japan's economy	Entire period (1997 to 2020): 1.0% 1997 to 2010: 1.3%/year 2010 to 2020: 0.6%/year	Entire period (1997 to 2020): 1.5% 1997 to 2010: 1.0%/year 2010 to 2020: 2.0%/year
Policy measure	Depending upon fiscal investment and loan programs to boost economy	Administrative reform and deregulation Private activities expected to boost economy
Industrial structure	Large portion of material industries will survive.	Technology intensive small and light products are main.
Concern on the environment	Priority given to economy than to environment	More consideration and investment in environmental conservation (after 2010)

	Status quo case	Structural reform case
Energy conservation	Moderate	Introduction of energy conservation technologies promoted (after 2010)
Introduction of new energy	Slow	Positively introduced (after 2010)

Macroeconomic assumption

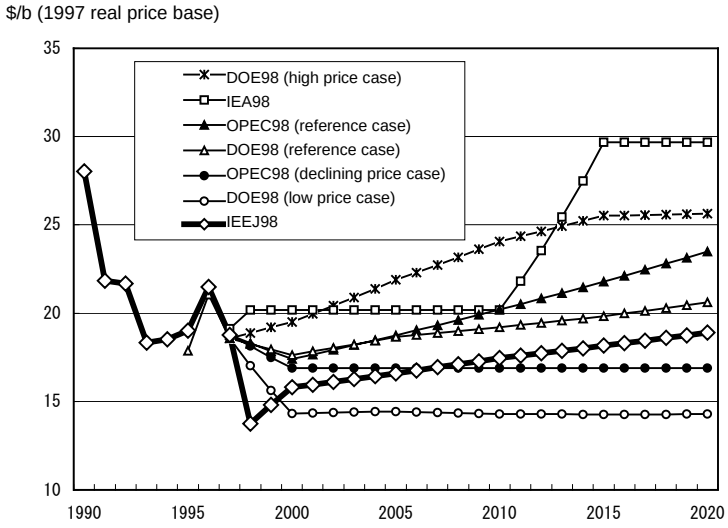
The status quo case assumed that the roles of the government and industrial structure would not significantly change from the present and Japan would have an aging society in the 21st century. The structural reform case assumes that Japan would promote the administrative reform and deregulation in the beginning of the 21st century and thereafter Japan's economy would revive. Therefore, in the structural reform case, economic growth rates are lower than those of the status quo case up to 2010, but thereafter, economic growth rates overtake those of the status quo case.

Table 7-7 Macroeconomic Assumption

(Unit: billion yen (1990 price))

		Status qua case				Structural reform case			
	Fiscal 1997	Fiscal 2010		Fiscal 2020		Fiscal 2010		Fiscal 2020	
	(record)	1997/1990	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997
Gross domestic expenditure (GDP)	479,835	1.4	564,865	1.3	601,950	0.6	1.0	548,693	1.0	668,671	2.0	1.5
Private sector demand	387,691	0.9	456,444	1.3	494,878	0.8	1.1	482,772	1.7	596,206	2.1	1.9
Private sector final consumption expenditure	282,153	1.7	337,918	1.4	365,170	0.8	1.1	325,187	1.1	375,614	1.5	1.3
Private sector housing investment	20,439	-3.2	26,207	1.9	28,266	0.8	1.4	25,251	1.6	28,259	1.1	1.4
Private sector capital investment	83,901	-0.3	91,418	0.7	100,957	1.0	0.8	131,661	3.5	191,038	3.8	3.6
Public sector demand	82,861	3.0	90,297	0.7	74,412	-1.9	-0.5	51.866	-3.5	47,125	-1.0	-2.4
Public sector final consumption expenditure	44,355	1.8	43,782	-0.1	38,606	-1.3	-0.6	38,019	-1.2	32,686	-1.5	-1.3
Public sector fixed asset formation	38,407	4.4	46,415	1.5	35,707	-2.6	-0.3	13,747	-7.6	14,339	0.4	-4.2
Net export of goods and service	9,426	12.3	18,124	5.2	32,660	6.1	5.6	14,055	3.1	25,339	6.1	4.4
Export of goods and service	65,600	5.0	90,590	2.5	118,668	2.7	2.6	86,332	2.1	116,222	3.0	2.5
Import of goods and service	56,174	4.1	72,466	2.0	86,008	1.7	1.9	72,277	2.0	90,883	2.3	2.1
[Reference] Gross national expenditure (GNP)	486,073	1.5	576,422	1.3	619,556	0.7	1.1	561,094	1.1	684,360	2.0	1.5
Consumer price index, (1995 = 100)	102.3	1.2	130.9	1.9	157.2	1.8	1.9	120.3	1.3	160.1	2.9	2.0
Wholesale price index, (1995 = 100)	101.5	-1.0	123.5	1.5	143.0	1.5	1.5	110.1	0.6	129.3	1.6	1.1
Exchange rate, (yen/US Dollars)	122.6	-2.0	140.0	1.0	150.0	0.7	0.9	135.0	0.7	125.0	-0.8	0.1
Crude oil price, CIF, (US Dollars/barrel)	18.8	-3.1	25.6	2.4	37.3	3.8	3.0	25.6	2.4	37.3	3.8	3.0
Index of industrial production, (1995 = 100)	104.9	-0.1	120.0	1.0	132.1	1.0	1.0	124.0	1.3	165.0	2.9	.2.0
Crude steel production, (1,000 tons)	102,800	-1.2	100,295	-0.2	95,487	-0.5	-0.3	82,665	-1.7	84,417	0.2	-0.9
Ethylene production, (1,000 tons)	7,338	3.0	7,327	0.0	7,218	-0.2	-0.1	6,633	-0.8	6,875	0.4	-0.3
Cement production, (1,000 tons)	89,445	0.4	90,210	0.1	88,156	-0.2	-0.1	74,593	-1.4	80,062	0.7	-0.5
Paper production, (1,000 tons)	31,007	1.2	33,852	0.7	34,777	0.3	0.5	30,696	-0.1	32,979	0.7	0.3
Pulp production, (1,000 tons)	11,522	0.0	12,736	0.8	13,085	0.3	0.6	11,549	0.0	12,408	0.7	0.3

Figure 7-7 Outlook of Crude of Prices by Various Organizations



(Source): DOE98: DOE/EIA (April 1998), "International Energy Outlook 1998"
OPEC98: OPEC Secretariat (January 1998), "Oil & Energy Outlook to 2020"
IEA98 (October 1998), "World Energy Outlook 1998 edition"
Ministry of Finance of Japan, "Japan export & import", for records up to 1997

Outlook

Table 7-8 Outlook of Final Energy Consumption

(Unit: 10^{10}kcal=1,000 TOE)

				Status qua case					Structural reform case				
		Fiscal 1997		Fiscal 2010		Fiscal 2020			Fiscal 2010		Fiscal 2020		
		(record)	1997/1990	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997
Breakdown by sector	Industrial sector	172,592	1.0	177,329	0.2	178,273	0.1	0.1	159,936	-0.6	167,538	9,5	-0.1
		(47.1)		(43.7)		(43.1)			(41.6)		(40.9)		
	Residential sector	95,157	2.7	122,972	2.0	130,626	0.6	1.4	121,980	1.9	135,702	1.1	1.6
		(26.0)		(30.3)		(31.5)			(31.7)		(33.1)		
	Household sector	50,952	2.5	62,701	1.6	64,865	0.3	1.1	63,141	1.7	66,649	0.5	1.2
		(13.9)		(15.4)		(15.7)			(16.4)		(16.3)		
	Business sector	44,205	3.0	60,271	2.4	65,761	0.9	1.7	58,839	2.2	69,053	1.6	2.0
		(12.1)		(14.8)		(15.9)			(15.3)		(16.9)		
	Transportation sector	90,236	2.8	98.098	0.6	97,328	-0.1	0.3	94,855	0.4	98,466	0.4	0.4
		(24.6)		(24.1)		(23.5)			(24.7)		(24.0)		
	Passenger	57,426	3.8	63,322	0.8	61,834	-0.2	0.3	62,551	0.7	64,379	0.3	0.5
		(15.7)		(15.6)		(14.9)			(16.3)		(15.7)		
	Freight	32,808	1.2	34,776	0.4	35,494	0.2	0.3	32,304	-0.1	34,087	0.5	0.2
		(9.0)		(8.6)		(8.6)			(8.4)		(8.3)		
	Non-energy	8,149	-1.0	7,807	-0.3	7,839	0.0	-0.2	7,796	-0.3	8,044	0.3	0.1
		(2.2)		(1.9)		(1.9)			(2.0)		(2.0)		
Breakdown by energy source	Coal and others	40,621	-0.4	37,601	-0.6	35,755	-0.5	-0.6	32,609	-1.7	31,711	-0.3	-1.1
		(11.1)		(9.3)		(8.6)			(8.5)		(7.7)		
	Petroleum	220,334	1.7	230,903	0.4	226,658	-0.2	0.1	217,149	-0.1	218,978	0.1	-0.0
		(60.2)		(56.8)		(54.7)			(56.5)		(53.4)		
	City gas	22,165	5.5	31,106	2.6	35,791	1.4	2.1	30,368	2.5	36,690	1.9	2.2
		(6.1)		(7.7)		(8.6)			(7.9)		(9.0)		
	Electricity	78,524	2.7	100,530	1.9	108,801	0.8	1.4	98,597	1.8	113,993	1.5	1.6
		(21.4)		(24.7)		(26.3)			(25.6)		(27.8)		
	New energy	3,793	-1.9	5,330	2.7	6,262	1.6	2.2	5,108	2.3	7,567	4.0	3.0
		(1.0)		(1.3)		(1.5)			(1.3)		(1.8)		
	Others	695	-1.7	736	0.4	799	0.8	0.6	736	0.4	811	1.0	0.7
		(0.2)		(0.2)		(0.2)			(0.2)		(0.2)		
Total		366,134	1.8	406,206	0.8	414,066	0.2	0.5	384,567	0.4	409,750	0.6	0.5
		(100.0)		(100.0)		(100.0)		(100.0)			(100.0)		

Notes: 1. The numbers in parentheses indicate percentage ratios.
2. “Coal and others” includes coke, coke oven gas, blast furnace gas, bee-nest and round coal briquettes.
3. “City gas” includes consumption by natural-gas-driven vehicles.
4. “Electricity” includes consumption in the new energy and newly introduced co-generation.
5. “New energy” includes black liquor, photovoltaic energy, heat from co-generation and from fuel cells.
6. “Others” includes natural gas and geothermal energy.

Table 7-9 Total Primary Energy Supply Outlook

				Status qua case					Structural reform case				
		Fiscal 1997		Fiscal 2010		Fiscal 2020			Fiscal 2010		Fiscal 2020		
	Unit	(record)	1997/1990	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997	(forecast)	2010/1997	(forecast)	2020/2010	2020/1997
Coal	Million tons	137	2.5	154	0.9	154	0.0	0.5	143	0.3	147	0.3	0.3
		(16.9)		(16.6)		(16.2)			(16.0)		(15.3)		
Oil	Million kL	324	0.8	336	0.3	331	-0.1	0.1	316	-0.2	320	0.1	-0.1
		(53.6)		(49.6)		(47.7)			(48.7)		(46.1)		
Natural gas	100 million m^3	659	3.9	865	2.1	943	0.9	1.6	867	2.1	1,062	2.1	2.1
		(11.6)		(13.6)		(14.4)			(14.2)		(16.2)		
Hydropower	100 million kWh	931	0.3	1,123	1.4	1,134	0.1	0.9	1,123	1.4	1,291	1.4	1.4
		(3.8)		(4.0)		(4.0)			(4.2)		(4.5)		
Nuclear energy	10,000 kW	4,508	5.2	5,740	1.9	6,478	1.2	1.6	5,740	1.9	6,478	1.2	1.6
		(12.9)		(14.5)		(15.6)			(15.1)		(15.6)		
Geothermal energy	10,000 kL	119	14.3	132	0.8	156	1.7	1.2	132	0.8	157	1.8	1.2
		(0.2)		(0.2)		(0.2)			(0.2)		(0.2)		
New energy	10,000 kL	689	1.5	1,023	3.1	1,328	2.6	2.9	965	2.6	1,441	4.1	3.3
		(1.1)		(1.5)		(1.9)			(1.5)		(2.1)		
Total	Million kL	604	3.1	676	0.9	693	0.3	0.6	648	0.5	694	0.7	0.6
		(100.0)		(100.0)		(100.0)			(100.0)		(100.0)		
Real gross domestic expenditure (billion yen 1990 price)		479,835	1.4	564,865	1.3	601,950	0.6	1.0	548,693	1.0	668,671	2.0	1.5
Unit consumption per GDP (fiscal 1997 = 100)		100.0		95.1		91.5			93.8		82.5		
Energy/GDP elasticity			2.3		0.7		0.4	0.6		0.5		0.3	0.4
Emission of CO_2 (million tons carbon equivalent)		313	1.2	345	0.7	346	0.0	0.4	326	0.3	341	0.5	0.4
Emission of CO_2 (fiscal 1990 = 100)		109		120		121			113		119		

Notes: 1. The numbers in parentheses indicate percentage ratios.

2. "New energy" includes photovoltaic energy, windpower, black liquor and others.

3. Since exported coke is not included, the summation of figures in a column does not agree with that in "Total."

4. Japan's Energy Conservation Policies

Present Measures and History

The Conference of Parties of the United Nations Framework Convention on Climate Change (COP3) held in December 1997 in Kyoto, the government of Japan agreed to reduce emission of greenhouse-effect gases during the target period, 2008 to 2012, by 6 percent from the level of 1990.

To achieve this objective, the government of Japan is now executing various energy conservation policies, including the Voluntary Action Plan of the Japan Federation of Economic Organizations (Keidanren) and the top-runner standards (see note). The expected reduction of energy consumption by these measures, about 50 million kiloliters, amounts as much as the total

annual household energy consumption excluding passenger car use of energy. The breakdown by sector of saving of about 50 million kiloliters is to be achieved 40.2 percent by the industrial sector (20.10 million kl), 28.0 percent by the residential sector (14.00 million kl), 31.8 percent by the transportation sector (15.90 million kl). This saving of energy consumption corresponds to a carbon emission of 43 million tons.

Note: This system intends to make the mileage of automobiles and the energy conservation standards of household equipment (home appliances and OA equipment) better than the most efficient commercial product in each line of products.

Future energy conservation policy

The Advisory Committee on Natural Resources and Energy, General Department and Supply Demand Department, issued a report in July 2001 a report entitled "About Future Energy Policies." The report mentioned necessity of additional policy measures for energy conservation to realize further energy conservation. The recommendation is focused on energy conservation of about 7 million kiloliters in the residential & commercial sector and service sector including passenger cars, to the extent possible within the limit of not reducing their utility. Specifically, the recommendation mentions the following. (For outline of present and future policy measures, reference should be made to the attachment.)

Industrial sector (about 900 thousand kl)

- Introduction of high-performance industrial furnaces (medium- and small-scale industries)
- High-performance laser/boiler (technology development), etc.

Residential sector (about 5.1 million kl)

- Extension of top runner facilities in the areas of oil and gas appliances
- Intensive extension of high-performance appliances in the area of hot water supply
- Extension of energy management systems for households and businesses, etc.

Transportation sector (about 1 million kl)

- Intensive extension of automobiles meeting the top runner standards
- Promotion of diversification of automobiles including hybrid cars, etc.

The above additional energy conservation measures (about 7 million kl) will reduce carbon dioxide emission by about 6 million tons carbon equivalent.

(Attachment) Outline of the Present and Future Energy Conservation Policy Measures

Sector	Measure	Energy conservation (crude oil equivalent, 1,000 kl)
Industrial	**(Present measure)**	20,100
	○ Measures based on the Voluntary Action Plan of the Japan Federation of Economic Organizations (Keidanren) ○ Energy conservation measure for medium- and small-scale industries	(by both measures) 20,100
	(New measure)	400
	◎ High-performance industrial furnace (medium- and small-scale industries)	400
	Subtotal	20,500
Residential	**(Present measure)**	14,000
	○ Improvement of equipment efficiency by the top-runner standards	5,400
	○ Improvement of energy conservation performance of houses and buildings	8,600
	(New measure)	4,600
	◎ Extension of top-runner appliances	1,200
	◎ Intensive extension of high-efficiency appliances	500
	◎ Reduction of standby electric power	400
	◎ Extension of the home energy management system (HEMS)	900
	◎ Extension of the office building energy management system (BEMS)	1,600
	Subtotal	18,600
Transportation	**(Present measure)**	15,900
	○ Improvement of equipment efficiency by the top-runner standards	5,400
	○ Extension of clean energy automobiles	800
	○ Energy conservation measures in the traffic system	9,700
	(New measure)	1,000
	◎ Intensive extension of automobiles meeting the top-runner standards	500
	◎ Promotion of diversification of automobile types including hybrid vehicles	500
	Subtotal	16,900
Intersectoral	○ Technological development	1,000

Sector	Measure	Energy conservation (crude oil equivalent, 1,000 kl)
	・ High-performance boiler (industry related technology) ・ High-performance laser (industry related technology) ・ High-efficiency lighting (living related technology) ・ Performance improvement of clean energy automobiles (transportation related technology) Note: Saving of energy in this item is included in "Promotion of diversification of automobile types including hybrid vehicles."	400 100 500
	Subtotal	1,000
Total	**(Present measure)** **(New measure)**	50,000 7,000
	Total	57,000

Source: The Advisory Committee on Natural Resources and Energy, General Department and Supply Demand Department, "About Future Energy Policies." (July 2001)

Remark: The past policy measures for energy conservation concentrated on measures on behaviors of business enterprises mainly from the viewpoint of applicability. The new policy measures, in addition to measures aimed at business enterprises, introduce sure and practical measures to create an environment where people's behaviors are directed more toward environmental conservation.