An Analysis of Major Countries' Energy Security Policies and Conditions◆

– Quantitative Assessment of Energy Security Policies –

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Summary

In this research, we divided the concept of energy security into seven elements -- (1) the primary energy self-sufficiency rate, (2) the degree of diversification of energy import source countries, (3) the degree of diversification of energy sources, (4) the degree of transportation risk management, (5) the degree of domestic risk management, (6) the degree of demand conservation and (7) the degree of supply interruption risk management. Using these elements, we attempted to analyze chronological energy security policy changes and energy situations between the 1970s and 2000s in seven major countries (the United States, the United Kingdom, Germany, France, China, South Korea and Japan) and to quantitatively assess policy conditions.

Among the countries investigated in this research, Japan has had a persistently low energy self-sufficiency rate and has used the conservation of energy consumption and the dispersion of overseas energy resources securement risks (the diversification of energy sources) to make up for this weak point. Its energy security policy has supported the Japanese economy featuring the world's second largest gross domestic product despite the lowest energy self-sufficiency rate among the major countries, and can be appreciated as successful so far.

It will be important for Japan to secure domestic or quasi-domestic energy sources in order to maintain and improve its energy security. This means that Japan should steadily expand nuclear energy use and develop and diffuse renewable energies while striving to acquire stakes in overseas energy resources. Next, Japan will have to continue efforts to diversify energy sources and energy import source countries, enhance diplomacy and strengthen Japanese companies' competitiveness for exploration of new overseas resources in order to secure overseas energy sources and manage transportation risks. From the viewpoint of domestic risk management, the government is required to provide appropriate guidance and support for the private sector's continuous capital investment under a competitive environment.

Furthermore, Japan should transfer energy-saving technologies to developing countries for their conservation of energy demand in a bid to maintain and expand its potential for the acquisition of energy resources and stabilize energy prices, as far as energy conservation is harmonized with global

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warming measures and Japanese technologies for these measures are selected and diffused.

Introduction – Objective and Significance of This Research

The world energy situation has dramatically changed since the late 20th century. In line with remarkable economic growth in emerging countries since the early 2000s, global energy demand has rapidly increased with the supply/demand balance multi-polarized. New geopolitical risks have begun to be pointed out. Furthermore, we have seen growing "resource nationalism" under which resource-rich countries attempt to take strategic advantage of their resources for expanding their presence. As a result, it has become difficult to get access to interests in resources. These changes have been combined to frequently cause resource price spikes.

The objective of this research is to make contributions to Japan's future energy security policy planning by extracting characteristics of major countries' energy security policies and analyzing whether the policies adopted by them have been effective. In this process, an important point is that we have taken note of not only factors that directly affect the energy supply/demand balance, geopolitical risks and energy security but also indirect factors including constraints under global warming prevention measures, progress in various low-carbon technologies and major countries' energy industry structures.

1. Energy Security Assessment Model Development and Assessment Method

This chapter specifies the definition of energy security and explains how to extract energy security components, how to select assessment indicators meeting components and how to quantify indicators into scores.

1-1 Definition and Components of Energy Security

If energy security is defined as "securing the amount of energy required for people's life, economic and social activities, defense and other purposes for acceptable prices," we can consider a supply chain (on the supply side) from the obtainment of resources or energy production sites to demand sites and how to use energy efficiently (on the demand side) as basic components of energy security. Therefore, we have decided that this research should consider key supply chain points and efficient energy uses as energy security policy components.

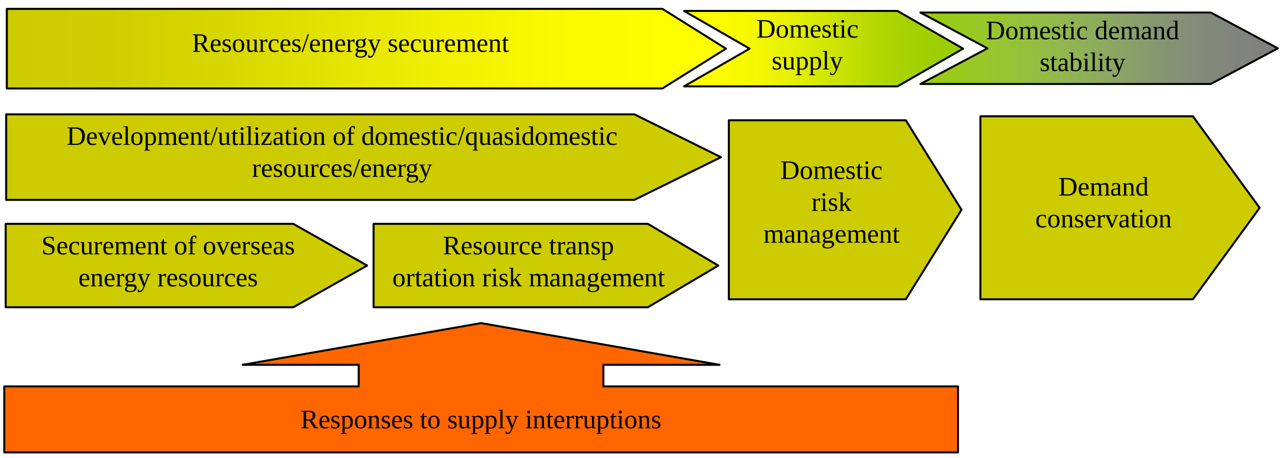
Fig. 1-1 indicates energy security components (major items) involving key supply chain points.

Basic principles are the management of risks and the improvement of energy security. The management of risks includes the dispersion of risks (including the diversification of energy sources), the absorption of risks (including sufficient margins) and the preparation against risks (including reserves). The improvement of energy security includes the development of domestic and quasidomestic energy sources, the expansion of overseas resources development and imports and the positive development of an energy procurement environment. We would like to discuss their components below.

The energy supply chain consists of three stages – "resources/energy securement," "domestic supply" and "domestic demand stability." A generally conceivable resources/energy securement method is to discover or secure resources at home or abroad and transport them to consumption points. Therefore, “the development and utilization of domestic and quasidomestic energy resources,” “the securement of overseas energy resources” and “the management of resources transportation risks” are deemed major items constituting this stage. “Domestic risk management” is required for sustaining “domestic supply” stably and is deemed a major item for this stage. “Demand conservation” is cited as a major item indicating the “domestic demand stability.”

If any of these factors is dropped, it may be structurally difficult for the supply chain to sustain the stable securement of energy. Therefore, whether responses to supply interruptions are prepared for each major item is adopted as a major item for energy security components.

Fig. 1-1 Energy Security Components (Major Items) Involving Key Supply Chain Points



1-2 Building Energy Security Assessment Model

This section discusses how we conducted the quantitative assessment of energy security.

We extracted several indicators of characteristics of the four major items cited in the previous section. Of these indicators, apparently important ones are treated as “key indicators” subject to quantitative assessment. The others are classified as “supplementary indicators” subject to referential assessment. The following table indicates relations between major items, key indicators and supplementary indicators :

Major item	Key indicator	Supplementary indicator
Securement of domestic/quasidomestic energy	1. Primary energy self-sufficiency rate (covering nuclear)	S-1 Power supply facility capacity utilization rate S-2 Life of domestic resources
Securement of overseas energy resources and Transportation risk management	2. HI[1] for degree of diversification of energy import source countries 3. HI for degree of diversification of energy sources 4. Degree of dependence on choke points for crude oil transportation	S-3 Direct investment in resource-producing countries as a percentage of GDP

[1] HI (Hirschmann-Herfindahl Index): The HI is defined as the sum of the squares of the individual market shares of every firm in the market. An HI of 1 would mean there is just one firm in the market, a monopoly structure. The HI comes closer to 0 as competition spreads. It is also called the oligopoly index. If two companies oligopolize a market with equal market shares at 50%, the HI is “2×（0.5^2）=0.5.” If 100 companies each have a 1% market share, the HI is “100×（0.01^2）=0.01.”

Domestic risk management	5. Electricity supply reliability (reserve supply rate)	S-4 Power outage frequency S-5 Energy R&D government budget S-6 Power generation capacity utilization rate
Conservation of demand	6. Energy consumption per GDP	S-7 Energy consumption per GDP by sector
Responses to supply interruptions	7. Number of days of on-land oil reserves	

The following procedure was used to assess energy security in each country and decade:

1-2-1 Selection of Research Target Countries

Comprehensive data over dozens of years must be collected and analyzed to assess energy security. Considering that a detailed analysis of several countries whose data are useful for Japan would be more appropriate than a shallow analysis of dozens of countries, we selected seven countries – France, Germany, the United Kingdom, the United States, China, South Korea and Japan. For some items for assessment, China or South Korea is excluded because of limited data availability.

1-2-2 Selection of Statistics and Other Materials

We decided to use statistics and other materials that have been published by domestic or overseas organizations and used widely and generally.

1-2-3 Computing Assessment Values

Data such as the primary energy self-sufficiency rate and the life of domestic resources were collected from statistics and other materials as given in 1-2-2 above and 10-year averages were adopted for the 1970s, 1980s, 1990s and 2000s (e.g., Japan's primary energy self-sufficiency rate came to 10.5% in the 1970s). These data were indexed based on 100 for the OECD average in each decade (e.g., Japan's primary energy self-sufficiency rate index stood at 16 against 100 for the OECD average in the 1970s). A score of 10 points is given to a country with the highest index for each indicator. For other countries, ratios of their indicators to the highest-index country's indicator were computed as scores of points (e.g., when China with the highest primary energy self-sufficiency rate index at 152 in the 1970s was given a score of 10 points, the score for Japan stood at 1.0 point).

The statistics we have used do not necessarily cover data for the 30 OECD countries for all assessment items. For some assessment items for which data do not cover all of the 30 OECD countries, we selected OECD countries with available data and used their averages as OECD averages.

2. Assessment Results by Key Indicator

This chapter overviews the results of energy security assessment by key indicator for each decade and each country, using the assessment model built through the 1-2 process.

2-1 Primary Energy Self-sufficiency Rate (Covering Nuclear Energy)

2-1-1 Adopted Statistics/Materials and Research Target Periods

・IEA "Energy Balances of OECD, Non-OECD Countries" 1971-2007

2-1-2 Basic Concept of Assessment

As the statistics treats nuclear energy as domestically produced energy, we included nuclear energy into domestic and quasidomestic energy. Although higher self-sufficiency rates lead to higher scores as a matter of course, crude oil, coal and natural gas self-sufficiency rates depend heavily on domestic resources. Even if domestic crude oil, coal or natural gas resources are limited, nuclear energy's higher share of total primary energy supply may result in a high primary energy self-sufficiency rate.

2-1-3 Details of Computation Method

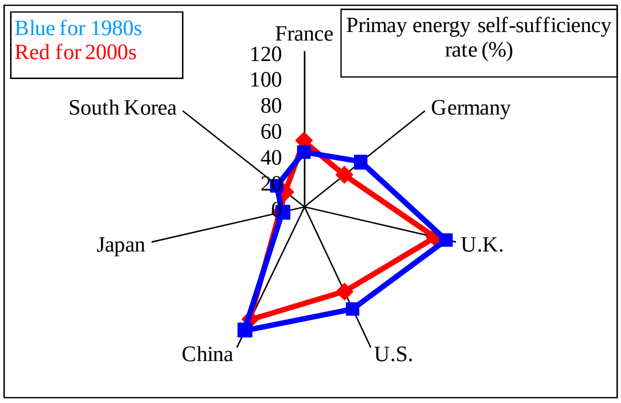
Primary energy self-sufficiency rate = Total domestic energy output / Total primary energy supply * 100

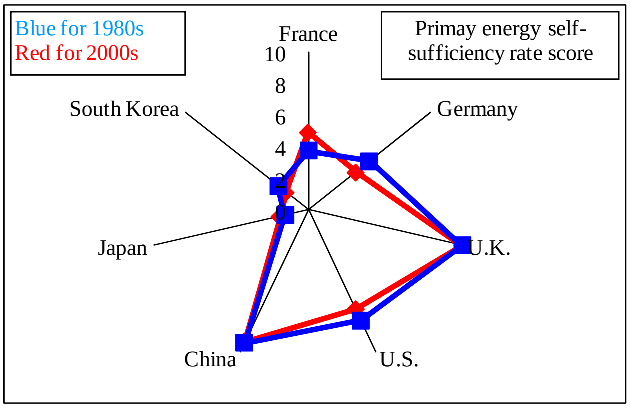
Based on this definition and the statistics in 2-1-1, we computed primary energy self-sufficiency rates for the seven research target countries in each decade and divided these rates by an OECD average for each decade to compute their respective ratios to the OECD average.

2-1-4 Computation Results

Following are decade-by-decade and country-by-country assessment results. The graphs below compare energy self-sufficient rates (%) in the 1980s after the second oil crisis and in the 2000s when energy price prices spiked.

Country	1970s			1980s			1990s			2000s		
	Self-sufficiency rate	Ratio to OECD average	Score	Self-sufficiency rate	Ratio to OECD average	Score	Self-sufficiency rate	Ratio to OECD average	Score	Self-sufficiency rate	Ratio to OECD average	Score
France	25.7	38	2.5	42.5	55	3.8	52.2	69	4.6	51.3	72	4.9
Germany	52.4	78	5.1	56.2	73	5.0	44.5	59	3.9	40.0	56	3.9
U.K.	62.7	93	6.1	112.5	146	10.0	112.9	149	10.0	103.7	145	10.0
U.S.	83.3	124	8.2	87.2	113	7.7	80.6	107	7.1	72.3	101	7.0
China	101.9	152	10.0	104.9	136	9.3	101.2	134	9.0	95.9	134	9.2
Japan	10.5	16	1.0	16.6	22	1.5	19.5	26	1.7	18.9	26	1.8
South Korea	29.0	43	2.8	27.1	35	2.4	16.7	22	1.5	18.6	26	1.8
OECD average	67.1			76.9			75.5			71.5		





The graph area size for the 2000s is smaller than for the 1980s, indicating that the seven countries' energy self-sufficiency rates declined.

The assessment score has remained high in all decades for China that is rich with fossil fuel resources. The score for the United Kingdom with the North Sea oilfields in addition to coal resources has soared since the 1980s. The United States with fossil fuel resources gained the third highest score after China and the United Kingdom. The score for Germany with coal resources ranked fourth in the 1970s and 1980s before falling to fifth place in the 1990s.

Among the three other countries that have little fossil fuel resources, France logged the fifth highest score in the 1970s and 1980s before getting the fourth highest score in place of Germany in the 1990s. Japan's score remained the lowest for all of the decades. South Korea's score in the 2000s was the same as Japan's. France's energy self-sufficiency rate gaps with Japan and South Korea indicate its greater nuclear power generation.

For reference, the self-sufficiency rates (%) for energy sources excluding nuclear are given below :

Country	1970s	1980s	1990s	2000s
France	22.8	17.3	12.3	8.2
Germany	50.4	47.9	32.5	27.4
U.K.	58.5	105.5	102.5	94.1
U.S.	80.7	81.4	72	63.2
China	101.9	104.9	100.9	95.2
Japan	8.1	6.5	4.7	4.2
South Korea	28.4	17.6	3.6	2.2
OECD average	64.7	69.7	64.7	60.3

2-2 HI for Degree of Diversification of Energy Import Source Countries

The HI was computed each for crude oil, natural gas and coal and converted into a score. Finally, a simple average of scores for crude oil, natural gas and coal was computed for each decade and country.

2-2-1 Adopted Statistics/Materials

- IEA "Oil Information," "Natural Gas Information," "Coal Information"

Research target periods differ from country to country.

- For China, we used its import statistics.
- OECD Country Risk Classifications of the Participants to the Arrangement on Officially Supported Export Credits (October 23, 2009)

2-2-2 Basic Concept of Assessment

(a) Import source country risk

For stable resources imports, the degree of political stability in import source countries is also an important factor. We attempted to quantify the factor as country risks. Specifically, we adopted OECD export credit data as country risk data. The OECD publishes eight country risk classifications ranging from 0 to 7 based on export credits. According to the above-cited OECD data, country risk classifications for major resources producing countries are as follows :

7	Iraq, Sudan, Venezuela, etc.
6	Angola, Iran, Libya, Nigeria, etc.
5	Kazakhstan, Papua New Guinea, Vietnam, etc.
4	Egypt, Indonesia, Russia, etc.
3	Brazil, Mexico, South Africa, Tunisia, UAE, etc.
2	China, Kuwait, Malaysia, Oman, Qatar, Saudi Arabia, etc.
0	Australia, Canada, Netherlands, Norway, U.K., etc.

For the sake of computation convenience, we here deemed the OECD export credit data plus 1 as a country risk value. But countries classified as "others" are excluded from our computation as their country risk values cannot be computed. Data for the former Soviet Union are represented by Russia.

The country risk indicator here is defined as the volume of imports from each country multiplied by its country risk value.

(b) Details of assessment methods

We computed the HI by multiplying the country risk indicator with a share for each import source country in each decade. Each HI was divided by the OECD average to calculate the ratio of each HI to the OECD average. For each country, the ratio in each decade was multiplied by primary energy supply shares for coal, crude oil and natural gas to compute a value for assessment here. One reason we adopted this computation procedure is that a heavy dependence on one country for supply of some energy source may not be any serious threat to security if the source's share of total primary energy supply is small. The reverse may also be true. Based on this assessment method, oligopoly assessments are interpreted as follows:

(1) A lower HI is represented by a higher assessment score.

(2) Relations between an assessment score and a combination of each fuel's HI and primary energy supply share are as follows :

HI for crude oil, natural gas or coal	Share for crude oil, natural gas or coal	Assessment score
High	High	Low
High	Low	Medium to High
Low	High	Medium to High
Low	Low	High

(3) When a high-risk country's share of imports increases, the HI may rise (the assessment score may decline) further than in a case where an import volume share is simply used for computation. This result is reasonable because a heavy dependence on a high-risk country poses a greater threat to security than that on a low-risk country.

(4) When a certain fuel's share of total primary energy supply is conspicuously large, the HI assessment score may be low even if an import source country for the fuel has a low country risk.

2-2-3 Fuel-by-fuel Assessment Results

(a) HIs for crude oil import source countries

The period for the assessment is between 1978 and 2008. For China, however, the period is between 1990 and 2008. For South Korea, the period between 1994 and 2008 is adopted because country-by-country import data have been available since 1994. For each country, crude oil import source countries' shares were computed and multiplied by country risk values to determine the HIs.

For reference, the three largest crude import source countries for each major country in each decade are indicated below :

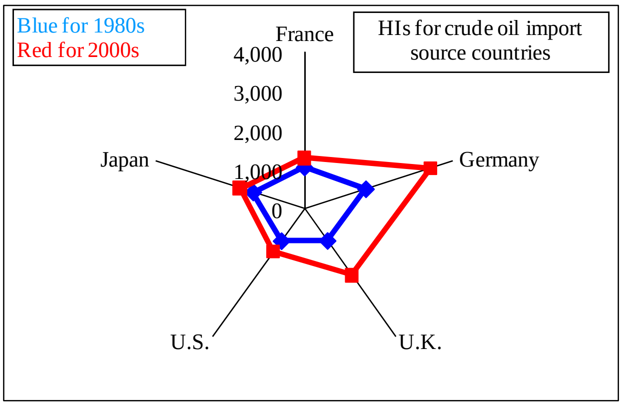
Country	Rank	1970s		1980s		1990s		2000s	
France	1	Saudi Arabia	35%	Saudi Arabia	25%	Saudi Arabia	24%	Former USSR	21%
	2	Iraq	19%	U.K.	11%	Norway	15%	Norway	19%
	3	UAE, Iran, Nigeria	7-8%	Nigeria	9%	U.K., Iran	11%	Saudi Arabia	13%
Germany	1	Saudi Arabia	13%	U.K.	18%	Former USSR	23%	Former USSR	39%
	2	Libya	13%	Saudi Arabia	11%	Norway	18%	Norway	18%
	3	Iran	12%	Libya	11%	U.K.	16%	U.K.	12%
U.K.	1	Saudi Arabia	28%	Norway	32%	Norway	60%	Norway	63%
	2	Kuwait	20%	Saudi Arabia	21%	Saudi Arabia	11%	Former USSR	9%
	3	Iran	14%	Iraq	7%	Former USSR	4%	Saudi Arabia	3%
U.S.	1	Saudi Arabia	18%	Saudi Arabia	15%	Saudi Arabia	19%	Canada	16%
	2	Nigeria	15%	Mexico	15%	Venezuela	16%	Venezuela	15%
	3	Libya	11%	Tunisia	11%	Mexico	14%	Saudi Arabia	15%
China	1	-	-	-	-	Oman	23%	Saudi Arabia	16%
	2	-	-	-	-	Indonesia	23%	Angola	14%
	3	-	-	-	-	Iran	8%	Iran	12%
Japan	1	Saudi Arabia	30%	Saudi Arabia	26%	UAE	26%	Saudi Arabia	28%
	2	UAE	16%	UAE	18%	Saudi Arabia	23%	UAE	25%
	3	Iran, Indonesia	14%	Indonesia	13%	Iran	10%	Iran	13%
South Korea	1	-	-	-	-	Saudi Arabia	32%	Saudi Arabia	30%
	2	-	-	-	-	UAE	14%	UAE	16%
	3	-	-	-	-	Iran	9%	Iran	8%

Computation results are as follows :

Country	1970s						1980s					
	HI	Ratio to OECD average	Crude oil Share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Crude oil share	Assess-ment value	Inverse of assessment value	Score
France	1,831	173	72.7	126	0.0079	4.4	1,065	138	63.4	87	0.0115	6.5
Germany	1,499	142	42.3	60	0.0167	9.2	1,656	214	34.1	73	0.0137	7.7
U.K.	1,646	156	50.3	78	0.0128	7.1	1,003	130	43.6	56	0.0177	10.0
U.S.	1,211	114	48.4	55	0.0181	10.0	1,009	130	46.9	61	0.0164	9.2
China	-	-	-	-	-	-	-	-	-	-	-	-
Japan	1,763	167	78.1	130	0.0077	4.3	1,386	179	65	116	0.0086	4.9
South Korea	-	-	-	-	-	-	-	-	-	-	-	-
OECD average	1,058						774					

Country	1990s						2000s					
	HI	Ratio to OECD average	Crude oil share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Crude oil share	Assess-ment value	Inverse of assessment value	Score
France	1,203	154	63.7	98	0.0102	5.5	1,306	157	61.8	97	0.0103	4.1
Germany	1,755	225	39.2	88	0.0114	6.1	3,401	409	41.1	168	0.0059	2.4
U.K.	1,384	177	46.4	82	0.0122	6.5	2,085	251	42.3	106	0.0094	3.8
U.S.	1,432	183	45.8	84	0.0119	6.4	1,347	162	45.9	74	0.0134	5.4
China	2,147	275	19.6	54	0.0186	10.0	1,487	179	22.3	40	0.0251	10.0
Japan	1,521	195	62.4	122	0.0082	4.4	1,733	209	54.5	114	0.0088	3.5
South Korea	1,424	182	71	129	0.0077	4.2	1,411	170	62.1	105	0.0095	3.8
OECD average	781						831					

The right figure compares HIs for crude oil import source countries for France, Germany, the United Kingdom, the United States and Japan in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. The graph area size for the 2000s is larger than that for the 1980s, indicating that crude oil import source countries for the five research target countries have been going in the direction of oligopoly.



(b) HIs for natural gas import source countries

The period for the assessment is between 1978 and 2008. For China, however, the period is two years between 2006 and 2008. For South Korea, the period is between 1986 and 2008. For each country, natural gas import source countries' shares were computed and multiplied by country risk values to determine the HIs.

For reference, the three largest natural gas import source countries for each major country in each decade are indicated below :

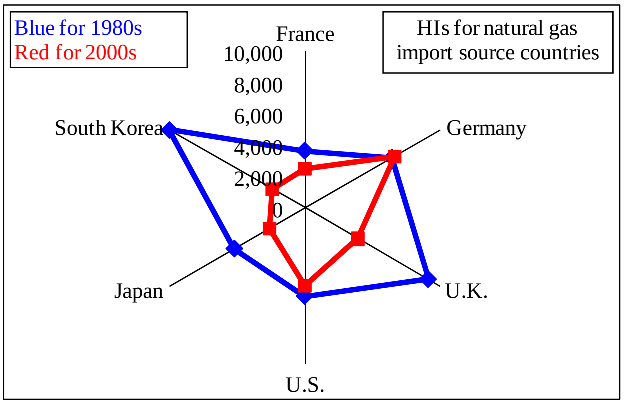
Country	Rank	1970s		1980s		1990s		2000s	
France	1	Netherlands	60%	Algeria	30%	Former USSR	33%	Norway	28%
	2	Algeria	17%	Netherlands	29%	Algeria	26%	Former USSR	21%
	3	Norway	13%	Former USSR	25%	Norway	25%	Algeria	18%
Germany	1	Netherlands	77%	Former USSR	43%	Former USSR	43%	Former USSR	43%
	2	Former USSR	17%	Netherlands	41%	Netherlands	36%	Norway	28%
	3	Norway	6%	Norway	16%	Norway	19%	Netherlands	25%
U.K.	1	Norway	58%	Norway	99%	Norway	98%	Norway	68%
	2	Algeria	42%	Algeria	1%	Others	2%	Netherlands	12%
	3	-	-	-	-	Algeria	-	Belgium	12%
U.S.	1	Canada	96%	Canada	91%	Canada	97%	Canada	88%
	2	Algeria	4%	Mexico	4%	Algeria	2%	Trinidad & Tobago	7%
	3	Mexico	1%	Algeria	4%	Mexico	-	Algeria	1%
China	1	-	-	-	-	-	-	Australia	85%
	2	-	-	-	-	-	-	Algeria	6%
	3	-	-	-	-	-	-	Nigeria	3%
Japan	1	Brunei	54%	Indonesia	52%	Indonesia	42%	Indonesia	26%
	2	Indonesia	20%	Brunei	21%	Malaysia	19%	Malaysia	21%
	3	U.S.	10%	Malaysia	13%	Australia	13%	Australia	16%
South Korea	1	-	-	Indonesia	100%	Indonesia	73%	Qatar	29%
	2	-	-	-	-	Malaysia	21%	Indonesia	23%
	3	-	-	-	-	Brunei	5%	Oman, Malaysia	19-20%

Computation results are as follows :

Country	1970s						1980s					
	HI	Ratio to OECD average	Gas share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Gas share	Assess-ment value	Inverse of assessment value	Score
France	2,951	130	9.2	12	0.083	4.9	3,683	134	17.7	24	0.0423	2.1
Germany	4,688	207	12.2	25	0.0397	2.3	6,463	234	17.4	41	0.0246	1.2
U.K.	6,182	273	14.7	40	0.025	1.5	9,120	331	23.1	76	0.0131	0.6
U.S.	7,271	321	31	100	0.01	0.6	5,638	205	27.1	55	0.0181	0.9
China	-	-	-	-	-	-	-	-		-	-	-
Japan	4,311	190	3.1	6	0.1709	**10**	5,200	189	11	21	0.0482	2.3
South Korea	-	-	-	-	-	-	10,000	363	1.3	5	0.21	**10**
OECD average	2,264						2,757					

Country	1990s						2000s					
	HI	Ratio to OECD average	Gas share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Gas share	Assess-ment value	Inverse of assessment value	Score
France	4,082	159	23.2	37	0.0272	5.1	2,518	138	28.2	39	0.0257	1.3
Germany	6,487	253	24.3	61	0.0163	3.1	6,654	365	28.1	103	0.0097	0.5
U.K.	9,502	370	30.4	112	0.0089	1.7	3,896	214	39.8	85	0.0117	0.6
U.S.	7,991	311	27.1	84	0.0118	2.2	4,972	273	26.5	72	0.0139	0.7
China	-		-	-	-	-	3,272	180	2.9	5	0.1952	**10**
Japan	4,407	172	14.9	26	0.0392	7.4	2,613	143	18.3	26	0.038	1.9
South Korea	7,284	284	6.6	19	0.0531	**10**	2,418	133	12.5	17	0.0601	3.1
OECD average	2,568						1,823					

The right figure compares HIs for natural gas import source countries for France, Germany, the United Kingdom, the United States, Japan and South Korea in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. The graph area size for the 2000s is smaller than that for the 1980s, indicating that natural gas import source countries for the six research target countries have been going in the direction of diversification, instead of the oligopoly seen for crude oil.



As Japan in the 1970s, South Korea in the 1980s and 1990s and China in the 2000s had very small shares for natural gas, these countries were given high assessment scores. This may be the reason scores for Europe and the United States were relatively lower.

(c) HIs for coal import source countries

The period for the assessment is between 1978 and 2008. For China, however, the period is between 1997 and 2008. For each country, coal import source countries' shares were computed and multiplied by country risk values to determine the HIs.

For reference, the three largest coal import source countries for each major country in each decade are indicated below :

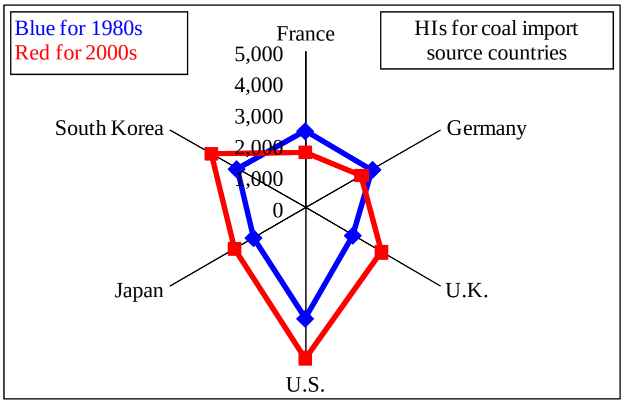
Country	Rank	1970s		1980s		1990s		2000s	
France	1	South Africa	30%	U.S.	28%	U.S.	29%	Australia	27%
	2	Germany	27%	South Africa	21%	Australia	20%	South Africa	22%
	3	Poland	18%	Germany	16%	South Africa	15%	U.S.	13%
Germany	1	Poland	11%	Czech Republic	15%	South Africa	29%	South Africa	21%
	2	Czech Republic	9%	South Africa	15%	Poland	22%	Poland	19%
	3	South Africa	6%	Poland	12%	Czech Republic	15%	Russia	14%
		Unknown/others	53%	Unknown/others	33%	Unknown/others	1%	Unknown/others	10%
U.K.	1	Australia	48%	U.S.	36%	U.S.	31%	Russia	14%
	2	U.S.	22%	Australia	33%	Australia	23%	South Africa	11%
	3	Poland	16%	Poland	10%	Colombia	16%	Australia	6%
U.S.	1	South Africa	44%	South Africa	34%	Colombia	45%	Colombia	66%
	2	Poland	28%	Colombia	33%	Venezuela	21%	Venezuela	13%
	3	Australia	24%	Canada	23%	Canada	17%	Indonesia、Canada	8%台
China	1	-	-	-	-	Australia	66%	Vietnam	43%
	2	-	-	-	-	New Zealand	7%	Australia	19%
	3	-	-	-	-	South Africa	6%	Indonesia	17%
Japan	1	Australia	47%	Australia	47%	Australia	54%	Australia	59%
	2	U.S.	21%	U.S.	19%	Canada	14%	Indonesia	14%
	3	Canada	19%	Canada	17%	China、U.S.	7-8%	China	13%
South Korea	1	Australia	50%	Australia	43%	Australia	42%	Australia	37%
	2	Canada	19%	Canada	22%	China	17%	China	30%
	3	U.S.	18%	U.S.	19%	Canada	13%	Indonesia	18%

Computation results are as follows :

Country	1970s						1980s					
	HI	Ratio to OECD average	Coal share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Coal share	Assess-ment value	Inverse of assessment value	Score
France	3,249	190	18.1	34	0.0291	6.7	2,469	153	18.9	29	0.0345	9.7
Germany	2,242	131	45.5	60	0.0167	3.9	2,472	153	48.5	74	0.0134	3.8
U.K.	2,559	150	35	52	0.0191	4.4	1,747	108	33.3	36	0.0277	7.8
U.S.	4,725	277	20.6	57	0.0175	4.1	3,532	219	26	57	0.0175	4.9
China	-	-	-	-	-	-	-	-	-	-	-	-
Japan	2,101	123	18.8	23	0.0431	10	1,897	118	24	28	0.0354	10
South Korea	4227	248	33.7	84	0.012	2.8	2,516	156	40.4	63	0.0159	4.5
OECD average	1,707						1,612					

Country	1990s						2000s					
	HI	Ratio to OECD average	Coal share	Assess-ment value	Inverse of assessment value	Score	HI	Ratio to OECD average	Coal share	Assess-ment value	Inverse of assessment value	Score
France	1,447	125	13.1	16	0.061	10	1,776	131	10.1	13	0.0759	10
Germany	2,509	217	36.5	79	0.0126	2.1	2,079	153	30.8	47	0.0212	2.8
U.K.	1,961	169	23.2	39	0.0255	4.2	2,816	208	17.8	37	0.027	3.6
U.S.	3,494	302	27	82	0.0122	2	4,807	355	27.7	98	0.0102	1.3
China	3,985	344	78.4	270	0.0037	0.6	4,938	364	74.9	273	0.0037	0.5
Japan	1,776	153	22.7	35	0.0287	4.7	2,601	192	27.1	52	0.0192	2.5
South Korea	2,037	176	22.4	39	0.0254	4.2	3,475	256	25.4	65	0.0154	2
OECD average	1,157						1,355					

The right figure compares HIs for coal import source countries for France, Germany, the United Kingdom, the United States, Japan and South Korea in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. HIs rose for the United Kingdom, the United States, Japan and South Korea from the 1980s to the 2000s while falling for France and Germany. Changes during the period are described in Chapter 3.



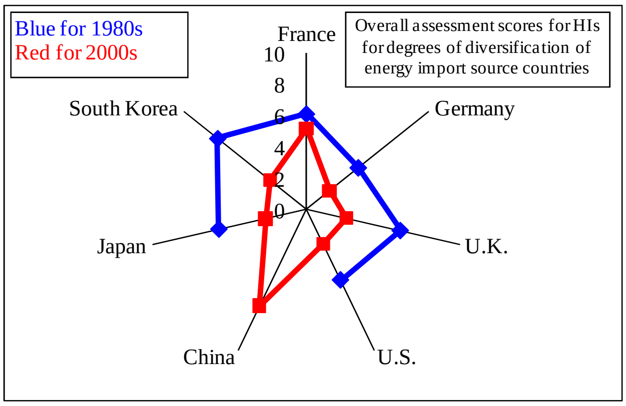
(d) Overall assessment scores for HIs for degrees of diversification of energy import source countries

The overall assessment of HIs for degrees of diversification of energy import source countries is as follows :

Country	1970s average score				1980s average score				1990s average score				2000s average score			
	Crude oil	Gas	Coal	Average	Crude oil	Gas	Coal	Average	Crude oil	Gas	Coal	Average	Crude oil	Gas	Coal	Average
France	4.4	4.9	6.7	5.3	6.5	2.1	9.7	6.1	5.5	5.1	10.0	6.9	4.1	1.3	10.0	5.1
Germany	9.2	2.3	3.9	5.1	7.7	1.2	3.8	4.2	6.1	3.1	2.1	3.7	2.4	0.5	2.8	1.9
U.K.	7.1	1.5	4.4	4.3	10.0	0.6	7.8	6.2	6.5	1.7	4.2	4.1	3.8	0.6	3.6	2.6
U.S.	10.0	0.6	4.1	4.9	9.2	0.9	4.9	5.0	6.4	2.2	2.0	3.5	5.4	0.7	1.3	2.5
China	-	-	-	-	-	-	-	-	10.0	-	0.6	5.3	10.0	10.0	0.5	6.8
Japan	4.3	10.0	10.0	8.1	4.9	2.3	10.0	5.7	4.4	7.4	4.7	5.5	3.5	1.9	2.5	2.7
South Korea			2.8	2.8		10.0	4.5	7.2	4.2	10.0	4.2	6.1	3.8	3.1	2.0	3.0

The right figure compares overall assessment scores in the 1980s and 2000s. No score is given for China for the 1980s.

Natural gas's share of total primary energy supply greatly affected assessment scores in each decade. The natural gas share was extremely small in Japan in the 1970s, in South Korea in the 1980s and 1990s, and in China in the 2000s, allowing these countries to log very high scores in these decades. As a result, scores for the other countries were relatively lower.



Among the seven research target countries, China has a unique energy mix including a very high share for coal and a very low share for natural gas. China has thus heavily depended on coal for which its self-sufficiency rate has been very high, allowing it to record a good overall assessment score. Among the six countries excluding China, France registered the highest score and Germany the lowest. The United Kingdom, the United States, Japan and South Korea logged scores in a medium range between the highest and lowest ones.

2-3 HIs for Degrees of Diversification of Energy Sources

This section assesses HIs for degrees of diversification of both primary energy supply and electricity generation.

2-3-1 Adopted Statistics/Materials and Research Target Periods

・IEA "Energy Balances of OECD, Non-OECD Countries," 1971-2007

2-3-2 Details of Computation Procedure

Based on the above statistics, we computed each energy source's percentage share of primary energy supply and electricity generation and HIs in the seven research target countries. Then, we computed each HI's ratio to the OECD average HI for each country and each decade by dividing each HI by the OECD average. Primary energy supply and electricity generation were divided into seven energy source categories – (1) coal, (2) crude oil, (3) natural gas, (4) nuclear, (5) hydraulic, (6) geothermal, solar and other new energies, and (7) combustible renewables.

Although no limit existed on the number of import source countries for the computation of HIs indicating degrees of oligopoly among resource import source countries, the number of primary energy sources or electricity sources is fixed at seven for the computation of HIs for degrees of diversification of energy sources. Therefore, a key assessment point is whether a country has diversified energy sources instead of depending heavily on some sources. In an ideal case, a country that has even primary energy or electricity generation shares for the seven categories of energy sources may have the highest assessment score. Under this assessment method, a lower value indicates a better condition. Therefore, we adopted inverses of assessment values as scores. Below are assessment results for primary energy supply and electricity generation sources.

(a) Primary energy supply

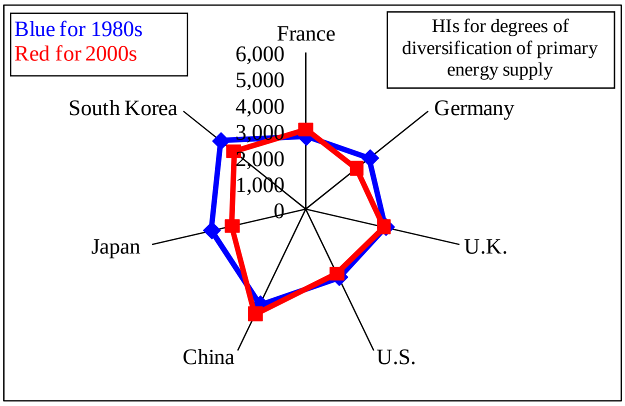
Following is a source-by-source breakdown of primary energy supply (%) for each country as a precondition for the assessment :

Country	Primary energy source	1970s	1980s	1990s	2000s
France	Coal	17.3	12.5	7.1	5.2
	Oil	62.7	43.6	34.9	32.4
	Natural gas	8.8	11.7	12.6	14.6
	Nuclear	2.9	25.2	39.9	43.1
	Hydraulic, etc.	8.2	7.0	5.5	4.7
U.K.	Coal	34.6	32.1	22.7	17.3
	Oil	46.6	38.2	35.7	32.5
	Natural gas	14.5	22.2	29.8	38.6
	Nuclear	4.2	7.0	10.4	9.6
	Hydraulic, etc.	0.2	0.4	1.4	2.0
China	Coal	49.4	56.1	60.4	61.9
	Oil	14.0	13.8	15.8	19.4
	Natural gas	1.6	1.6	1.5	2.4
	Nuclear	-	-	0.2	0.7
	Hydraulic, etc.	35.0	28.5	22.0	15.6
South Korea	Coal	33.9	36.7	20.1	23.5
	Oil	65.0	52.0	60.0	47.2
	Natural gas	0.0	1.2	6.0	11.6
	Nuclear	0.6	9.5	13.1	16.5
	Hydraulic, etc.	0.5	0.5	0.8	1.1

Country	Primary energy source	1970s	1980s	1990s	2000s
Germany	Coal	40.5	40.1	28.6	24.9
	Oil	45.0	35.4	38.1	35.0
	Natural gas	10.8	14.3	19.0	22.7
	Nuclear	2.0	8.3	12.1	12.5
	Hydraulic, etc.	1.5	1.9	2.2	4.8
U.S.	Coal	18.5	23.0	23.6	23.8
	Oil	47.1	42.0	38.6	39.5
	Natural gas	27.9	23.8	23.7	22.8
	Nuclear	2.5	5.8	8.6	9.2
	Hydraulic, etc.	4.0	5.5	5.4	4.8
Japan	Coal	17.4	18.5	16.9	20.5
	Oil	75.1	59.6	53.8	47.4
	Natural gas	2.8	8.5	11.1	13.9
	Nuclear	2.5	10.1	14.8	14.8
	Hydraulic, etc.	2.2	3.3	3.4	3.4
OECD average	Coal	22.7	24.8	21.6	20.8
	Oil	51.2	43.4	41.0	39.6
	Natural gas	18.8	18.6	20.3	22.2
	Nuclear	2.3	7.3	10.8	11.1
	Hydraulic, etc.	4.9	6.0	6.3	6.4

Following are the seven countries' HIs for degrees of diversification of energy sources based on the above primary energy supply breakdown.

Country	1970s				1980s			
	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	4,609	133	0.0075	7.1	2,756	96	0.0105	10.0
Germany	3,726	107	0.0093	8.7	3,121	108	0.0092	8.8
U.K.	3,658	105	0.0095	8.9	3,118	108	0.0093	8.8
U.S.	3,257	94	0.0107	10.0	2,897	100	0.01	9.5
China	3,805	109	0.0091	8.6	4,053	141	0.0071	6.8
Japan	5,860	169	0.0059	5.6	3,703	128	0.0078	7.4
South Korea	5,406	155	0.0064	6.0	4,171	145	0.0069	6.6
OECD average	3,477				2,885			
Country	1990s				2000s			
	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	2,924	107	0.0093	9.0	3,048	115	0.0087	8.2
Germany	2,643	97	0.0103	10.0	2,495	94	0.0107	10.0
U.K.	3,007	110	0.0091	8.8	3,048	114	0.0087	8.2
U.S.	2,736	100	0.01	9.7	2,743	103	0.0097	9.1
China	4,373	160	0.0062	6.0	4,447	167	0.006	5.6
Japan	3,256	119	0.0084	8.1	2,886	108	0.0092	8.6
South Korea	4,343	159	0.0063	6.1	3,514	132	0.0076	7.1
OECD average	2,727				2,662			



The right figure compares HIs for degrees of diversification of energy sources in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. It indicates that those other than China and France made progress in the diversification of primary energy supply between the 1980s and 2000s. For all seven research target countries, the diversification of primary energy supply made progress as indicated by the graph area size for the 2000s that is smaller than for the 1980s.

Although no large gap is seen between the seven research target countries, HIs deteriorated in France and China while improving in the remaining countries through the 2000s. The deterioration might have been attributable to nuclear energy's rising share of primary energy supply in France and a further rise in the originally high share for coal in China.

(b) Electricity generation

Following is a source-by-source breakdown of electricity generation (%) for each country as a precondition for the assessment :

Country	Power source	1970s	1980s	1990s	2000s
France	Coal	25.2	14.7	6.6	5.0
	Oil	30.1	5.0	1.8	1.2
	Natural gas	4.8	1.2	0.9	3.4
	Nuclear	10.0	58.6	76.3	78.4
	Hydraulic, etc.	29.9	20.4	14.4	12.0
U.K.	Coal	62.6	66.5	47.6	34.7
	Oil	21.9	12.6	5.7	1.4
	Natural gas	2.1	1.0	18.7	38.8
	Nuclear	12.1	18.4	25.8	21.0
	Hydraulic, etc.	1.4	1.5	2.1	4.1
China	Coal	59.0	63.3	75.2	79.1
	Oil	19.8	15.0	5.4	2.4
	Natural gas	0.0	0.4	0.4	0.5
	Nuclear	-	-	0.9	1.9
	Hydraulic, etc.	21.1	21.3	18.0	16.2
South Korea	Coal	5.2	18.7	27.3	39.2
	Oil	84.1	37.0	18.2	8.3
	Natural gas	0.0	4.7	11.7	14.9
	Nuclear	2.9	34.0	40.7	36.4
	Hydraulic, etc.	7.8	5.5	2.2	1.2

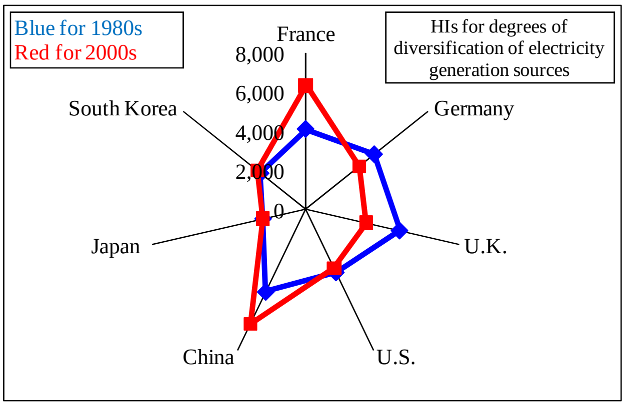
Country	Power source	1970s	1980s	1990s	2000s
Germany	Coal	66.4	62.6	55.9	51.0
	Oil	8.9	2.9	1.7	1.2
	Natural gas	13.4	7.9	8.0	10.5
	Nuclear	6.5	21.9	29.2	27.2
	Hydraulic, etc.	4.9	4.7	5.1	10.1
U.S.	Coal	45.4	55.2	52.8	50.7
	Oil	15.8	6.3	3.4	2.8
	Natural gas	17.0	12.2	13.7	18.1
	Nuclear	8.2	15.1	19.4	19.6
	Hydraulic, etc.	13.5	11.2	10.8	8.8
Japan	Coal	9.0	13.5	17.2	26.1
	Oil	63.1	33.6	21.7	12.2
	Natural gas	5.6	17.3	21.2	24.2
	Nuclear	6.1	21.2	29.0	27.3
	Hydraulic, etc.	16.2	14.4	10.8	10.2
OECD average	Coal	23.0	25.0	21.3	20.6
	Oil	50.7	42.9	41.7	40.2
	Natural gas	19.0	18.7	20.1	22.0
	Nuclear	2.4	7.3	10.7	11.0
	Hydraulic, etc.	4.9	6.1	6.2	6.2

Following are the seven countries' HIs for degrees of diversification of energy sources based on the above electricity generation breakdown.

Country	1970s				1980s			
	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	2,534	99	0.0101	10	4,081	154	0.0065	5.4
Germany	4,727	185	0.0054	5.4	4,484	170	0.0059	5
U.K.	4,551	179	0.0056	5.6	4,923	186	0.0054	4.5
U.S.	2,847	112	0.009	8.9	3,578	135	0.0074	6.2
China	4,318	169	0.0059	5.9	4,686	177	0.0056	4.7
Japan	4,394	172	0.0058	5.8	2,224	84	0.0119	10
South Korea	7,166	281	0.0036	3.5	2,931	111	0.009	7.6
OECD average	2,548				2,645			

Country	1990s				2000s			
	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score	HI	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	6,060	240	0.0042	3.5	6,304	228	0.0044	3.5
Germany	4,058	161	0.0062	5.3	3,488	126	0.0079	6.4
U.K.	3,316	131	0.0076	6.5	3,160	114	0.0088	7.1
U.S.	3,438	136	0.0073	6.2	3,333	120	0.0083	6.7
China	6,006	238	0.0042	3.6	6,519	235	0.0042	3.4
Japan	2,144	85	0.0118	10	2,228	80	0.0124	10
South Korea	2,870	114	0.0088	7.5	3,152	114	0.0088	7.1
OECD average	2,524				2,769			

The right figure compares HIs for degrees of diversification of electricity generation sources in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. It indicates that the diversification made progress in Germany and the United Kingdom between the 1980s and 2000s. But France and China went in the direction of oligopoly. Japan and South Korea had already diversified electricity generation sources in the 1980s.



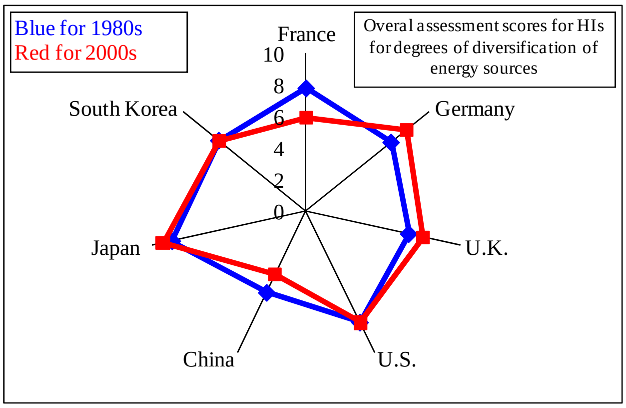
In contrast to degrees of diversification of primary energy supply, those of diversification of electricity generation indicate large gaps between the seven countries. The assessment score was high for Japan that featured a balanced diversification and lower for France with a very high share for nuclear energy and China with a very high share for coal.

(c) Overall assessment of HIs for degrees of diversification of energy sources

Following are the results of the overall assessment of HIs for degrees of diversification of energy sources combining the above (a) and (b) :

Country	1970s			1980s			1990s			2000s		
	Primary energy	Power generation	Average	Primary energy	Power generation	Average	Primary energy	Power generation	Average	Primary energy	Power generation	Average
France	7.1	10.0	8.5	10.0	5.4	7.7	9.0	3.5	6.3	8.2	3.5	5.9
Germany	8.7	5.4	7.1	8.8	5.0	6.9	10.0	5.3	7.6	10.0	6.4	8.2
U.K.	8.9	5.6	7.2	8.8	4.5	6.7	8.8	6.5	7.6	8.2	7.1	7.6
U.S.	10.0	8.9	9.5	9.5	6.2	7.9	9.7	6.2	7.9	9.1	6.7	7.9
China	8.6	5.9	7.2	6.8	4.7	5.8	6.0	3.6	4.8	5.6	3.4	4.5
Japan	5.6	5.8	5.7	7.4	10.0	8.7	8.1	10.0	9.1	8.6	10.0	9.3
South Korea	6.0	3.5	4.8	6.6	7.6	7.1	6.1	7.5	6.8	7.1	7.1	7.1

The right figure compares overall assessment scores for degrees of diversification of energy sources in the 1980s and 2000s.



Since assessment scores for the diversification of primary energy supply indicated no large gaps between the countries, the gaps seen in overall assessment scores are attributable to large gaps in scores for the diversification of electricity generation sources.

The assessment focused on whether primary energy supply or electricity generation sources are diversified, irrespective of what sources are desirable or not. Since the assessment scores are affected by country-by-country holdings and availability of fossil fuel resources, these assessment scores should be separated from the selection of energy sources. France with little fossil fuel resources has depended heavily on nuclear energy. Japan with little fossil fuel resources has chosen to diversify energy sources. China with abundant coal resources has depended heavily on coal.

Countries have thus made different choices. Although we have computed assessment scores for these countries' energy diversification, these scores cannot be used for assessing policies behind the different degrees of diversification. We must take note of this point in using this assessment model.

2-4 Transportation Risk Management : Degree of Dependence on Choke Points for Crude Oil Transportation

2-4-1 Definition of Choke Points and Their Significance for Energy Security

Choke points are narrow straits used globally as parts of maritime transportation routes. If choke points are blockaded, stable energy supply in energy resources importing countries may be affected gravely and immediately. In this sense, choke points are a very important factor for energy security. Although there are maritime transportation routes where natural gas and coal carriers pass frequently, we have selected the degree of dependence on choke points for transportation of crude oil alone because oil accounts for major shares of primary energy supply in all research target countries and because maritime transportation does not necessarily have large weights for natural gas and coal due to their fuel characteristics.

2-4-2 Choke Points Selected for Assessment

For our assessment model, we selected the following four choke points that have seen massive oil transportation and actual interruptions to tanker passages :

- Hormuz Strait: The strait is located at the exit of the Persian Gulf known as a big oil producing area. Mines were laid during the Iran-Iraq War in the 1980s. At the end of 2006, oil transportation through the strait totaled 16.5-17.0 million barrels per day.
- Malacca Strait: Massive Middle Eastern and African crude oil bound for East Asia passes the strait. Pirate attacks, oil spills caused by ship collisions and low visibility caused by dense fog have been seen at the strait. At the end of 2006, oil transportation through the strait totaled 15 million bpd.
- Bab-el-Mandeb Strait: The strait is located between Yemen and Somalia. Pirate attacks have occurred at the strait over recent years. At the end of 2006, oil transportation through the strait totaled 3.3 million bpd.
- Suez Canal: Middle Eastern oil bound for Europe passes the canal. After the six-day war in 1967, the canal was closed for eight years. At the end of 2006, oil transportation through the canal totaled 4.5 million bpd.

2-4-3 Concept of Crude Oil Passing Choke Points

Although multiple routes are conceivable for the transportation of crude oil, we have set the following preconditions for our estimation :

- All Middle Eastern crude oil bound for Europe is deemed to have passed the Suez Canal.
- All Saudi Arabian crude oil bound for Europe is deemed to have been shipped from Yanbu on the Red Sea side and transported to Europe without passing the Hormuz or Bab-el-Mandeb Strait.
- Middle Eastern crude oil bound for the United States is deemed to have been transported without passing the Malacca Strait, although such crude oil can be expected to have passed the strait.
- Ports for shipping Indonesian crude oil exist in the Malacca Strait. For our estimation, 50% of Indonesia-produced crude oil is deemed to have been exported to East Asia via the Malacca Strait.
- The above paces of crude oil transportation through the choke points are deemed to have

remained unchanged over the research target period.

Based on the above preconditions, choke points for the research target countries and their crude oil import source countries are selected as follows :

Country	Crude oil	Choke points for crude oil transportation
France Germany U.K.	Iran, Iraq, Kuwait, Qatar, UAE	(1) Hormuz, (2) Bab-el-Mandeb, (3) Suez
	Oman	(1) Bab-el-Mandeb, (2)Suez
	Saudi Arabia	(1) Suez
	Indonesia	(1) Bab-el-Mandeb, (2) Suez
U.S.	Iran, Iraq, Kuwait, Qatar, Saudi Arabia, UAE	(1) Hormuz
	Indonesia	(1) Malacca
China Japan South Korea	Iran, Iraq, Kuwait, Qatar, Saudi Arabia, UAE	(1) Hormuz, (2) Malacca
	Oman, Western Africa, Europe, South America (Atlantic side)	(1) Malacca
	Northern Africa	(1) Suez, (2) Bab-el-Mandeb, (3) Malacca
	50% of Indonesia-produced crude	(1) Malacca

2-4-4 Adopted Statistics/Materials and Research Target Periods

・IEA "Oil Information" for 1978-2008. For South Korea, the research period is between 1994 and 2008.

・Data for China are from China's import statistics between 1990 and 2008.

2-4-5 Details of Computation Procedure

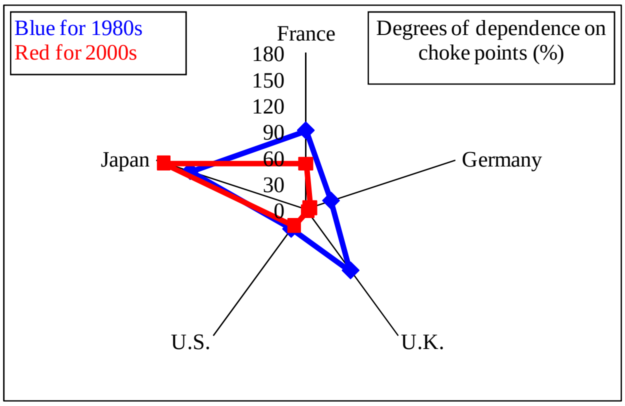
The percentage share for crude oil imported via choke points for each research target country was computed as an indicator of the degree of dependence on choke points for crude oil transportation. Oil producing countries specified in the above IEA statistics were adopted for our estimation. The research target countries are deemed to have imported no crude oil from "others" in the statistics. However, the former USSR is deemed to be one country. Crude oil may pass multiple choke points depending on the combination of specific research target countries and oil producing nations (for example, Japan's crude oil imports from Northern Africa including Libya pass the Suez Canal, the Bab-el-Mandeb Strait and the Malacca Strait as shown in the above table). In this case, crude oil import volume is counted for each passage. Therefore, the degree of dependence on choke points for crude oil transportation may exceed 100% for some countries.

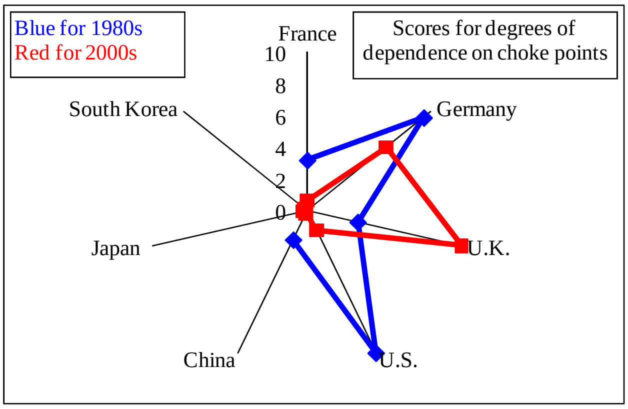
2-4-6 Computation Results

Computation results are as follows :

Country	1970s				1980s			
	Choke point share	Ratio to OECD average	Inverse of ratio to OECD average	Score	Choke point share	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	155.1	146	0.0069	2.6	89.7	123	0.0081	3.2
Germany	80.4	75	0.0133	5.1	30.3	42	0.024	9.4
U.K.	193.6	182	0.0055	2.1	87.1	120	0.0084	3.3
U.S.	41.1	39	0.0259	10.0	28.6	39	0.0255	10.0
China	-	-	-	-	-	-	-	-
Japan	162.4	152	0.0066	2.5	138.9	191	0.0052	2.1
South Korea	-	-	-	-	-	-	-	-
OECD average	106.6				72.8			

Country	1990s				2000s			
	Choke point share	Ratio to OECD average	Inverse of ratio to OECD average	Score	Choke point share	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	72.4	101	0.0099	2.0	51.8	80	0.0124	0.6
Germany	14.6	20	0.0492	10.0	5.0	8	0.1277	6.4
U.K.	33.5	47	0.0214	4.4	3.2	5	0.2000	10.0
U.S.	25.1	35	0.0285	5.8	23.4	36	0.0276	1.4
China	77.5	108	0.0092	1.9	104.6	162	0.0062	0.3
Japan	150.0	209	0.0048	1.0	171.4	266	0.0038	0.2
South Korea	149.8	209	0.0048	1.0	156.4	243	0.0041	0.2
OECD average	71.6				64.4			





The figures compare percentage degrees of dependence on choke points for crude oil transportation for France, Germany, the United Kingdom, the United States and Japan in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. They indicate that the degrees declined for four research target countries other than Japan. The narrower graph area size for the 2000s indicates that the degree of dependence on choke points for the five research target countries as a whole decreased.

European countries with North Sea crude oil, as well as the United States that imports crude oil from Venezuela and other South American countries, have been able to reduce their degrees of dependence on the Middle East and on choke points. In contrast, it has been difficult for East Asian countries to reduce their dependence on choke points even by reducing their dependence on Middle Eastern crude oil because their crude oil imports from Africa and South America pass the Malacca Strait. The availability of crude oil that does not pass the Malacca Strait is limited for these countries. Naturally, assessment scores were lower for East Asian countries including Japan and South Korea.

The dependence on choke points has some correlationship with the dependence on Middle Eastern crude oil. For reference, degrees of dependence on choke points (choke point shares), degrees of dependence on Middle Eastern crude oil and crude oil self-sufficiency rates for the seven research target countries are compared as follows :

Country	Category	1970s	1980s	1990s	2000s
France	Choke point share	155.1	89.7	72.4	51.8
	Degree of dependence on Middle Eastern crude oil	76.9	47.6	44.3	27.6
	Crude oil self-sufficiency rate	1.7	3.6	3.5	1.7
Germany	Choke point share	80.4	30.3	14.6	5.0
	Degree of dependence on Middle Eastern crude oil	36.6	20.2	14.8	8.6
	Crude oil self-sufficiency rate	4.9	5.6	3.6	3.8
U.K.	Choke point share	193.6	87.1	33.5	3.2
	Degree of dependence on Middle Eastern crude oil	83.2	44.2	20.3	3.9
	Crude oil self-sufficiency rate	20.4	135.9	122.7	115.1
U.S.	Choke point share	41.1	28.6	25.1	23.4
	Degree of dependence on Middle Eastern crude oil	35.3	22.6	24.4	23.2
	Crude oil self-sufficiency rate	67.3	66.4	49.1	37.8
China	Choke point share	-	-	77.5	104.6
	Degree of dependence on Middle Eastern crude oil	-	-	47.8	47.6
	Crude oil self-sufficiency rate	-	-	100.5	64.4
Japan	Choke point share	162.4	138.9	150.0	171.4
	Degree of dependence on Middle Eastern crude oil	77.6	70.3	79.1	88.0
	Crude oil self-sufficiency rate	0.3	0.3	0.4	0.3
South Korea	Choke point share	-	-	149.8	156.4
	Degree of dependence on Middle Eastern crude oil	-	-	74.7	79.6
	Crude oil self-sufficiency rate	-	-	0.1	0.5

2-5 Domestic Risk Management : Electricity Supply Reliability

We paid attention to the electricity supply reliability, one of the major energy supply pillars, as a domestic risk management indicator and adopted the reserve electricity supply rate as a specific index. But we must note that the reserve supply rate is an annual average and different from a reserve supply rate at an electricity demand peak.

2-5-1 Adopted Statistics/Materials and Research Target Periods

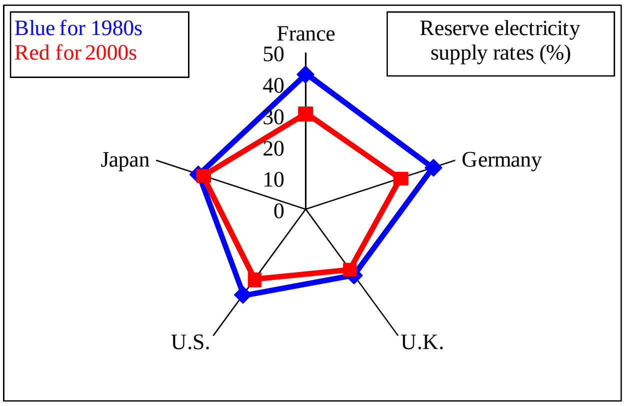
・Japan Electric Power Information Center’s “Overseas Electric Power Industry Statistics,” etc. for 1970-2006. But the research period for China is limited to two years -- 2005 and 2006 -- due to the availability of data. For South Korea, the research period is between 1990 and 2006.

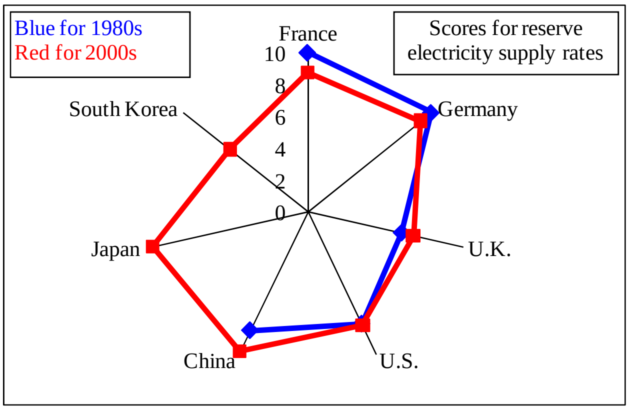
2-5-2 Details of Computation Procedure

The reserve electricity supply rate (%) is defined as (1 – Electricity demand peak / Total electricity generation capacity) * 100. For each decade and country, we computed an average total electricity generation capacity and an average electricity demand peak, and the ratio of a reserve electricity supply rate to the OECD average for each country and decade. The total electricity generation capacity includes private generation capacity.

2-5-3 Computation Results

Country	1970s			1980s			1990s			2000s		
	Reserve supply rate	Ratio to OECD average	Score	Reserve supply rate	Ratio to OECD average	Score	Reserve supply rate	Ratio to OECD average	Score	Reserve supply rate	Ratio to OECD average	Score
France	31.8	100	8.1	43	122	10	40.9	140	8.8	30.3	104	8.7
Germany	39.3	124	10	42.7	121	9.9	46.6	160	10	31.8	108	9.1
U.K.	33.3	105	8.5	26.2	74	6.1	23	79	4.9	23.7	81	6.8
U.S.	29.6	93	7.6	33.8	96	7.9	25.8	88	5.5	27.8	95	8
China	-	-	-	-	-	-	-	-	-	34.9	119	10
Japan	32.4	102	8.2	35.8	102	8.3	28.5	98	6.1	34.2	117	9.8
South Korea	-	-	-	-	-	-	22.9	79	4.9	21.9	75	6.3
OECD average	31.7			35.2			29.1			29.3		





The above left figure compares reserve electricity supply rates for France, Germany, the United Kingdom, the United States and Japan in the 1980s after the second oil crisis and in the 2000s when energy prices spiked and indicate that the graph area size for the 2000s is narrower. This means that the reserve electricity supply rate declined for the five research target countries as a whole.

France and Germany received high scores between the 1970s and 1990s. In the 2000s, China, Japan and Germany received high scores. But scores for many research target countries were close. No extremely low score was seen. From the 1980s to 1990s, reserve electricity supply rates declined for all other than Germany. Although the decline might be linked to electric utility industry reforms in Europe and the United States, the fact that the rate soared in Germany that should have been very susceptible to the effects of such reforms indicates that we should not easily link the reserve supply rate fall to the reform.

2-6 Demand Conservation : Energy Consumption per GDP

In this section, we paid attention to the demand conservation as another major item of energy security in addition to the energy supply side and selected energy consumption per GDP (energy intensity) as a specific demand conservation indicator.

2-6-1 Adopted Statistics/Materials and Research Target Periods

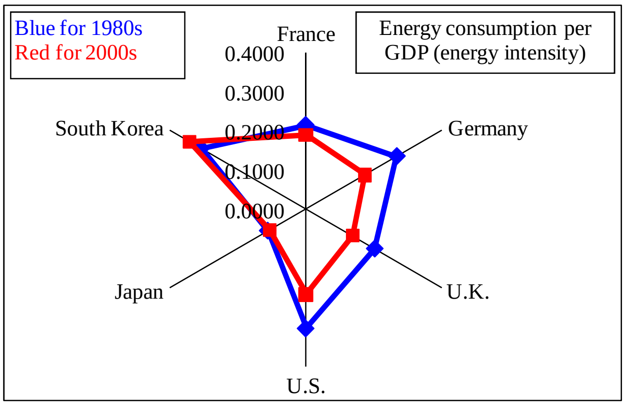
・IEA “Energy Balances of OECD, Non-OECD Countries” 1971-2007

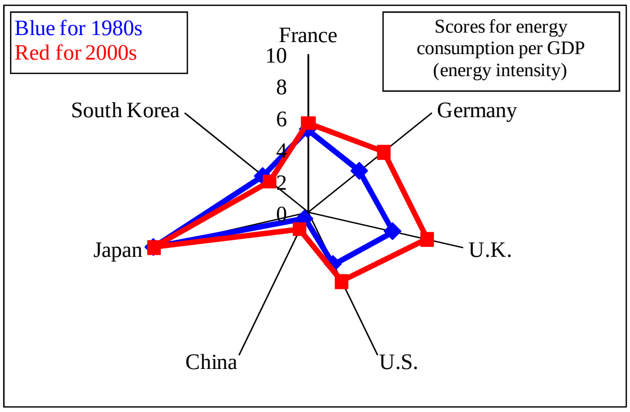
2-6-2 Details of Computation Procedure

Energy intensity is defined as primary energy supply / GDP. We computed the ratios of the seven research target countries' energy intensities to the OECD average as assessment values by dividing these intensities by the average. As a lower assessment value indicates a better condition, we adopted inverses of assessment values as assessment scores.

2-6-3 Computation Results

Country	1970				1980			
	Energy intensity	Ratio to OECD average	Inverse of ratio to OECD average	Score	Energy intensity	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	0.2355	79	0.0126	5.8	0.2130	86	0.0116	5.2
Germany	0.3098	104	0.0096	4.4	0.2675	108	0.0092	4.2
U.K.	0.2541	86	0.0117	5.4	0.2026	82	0.0122	5.5
U.S.	0.3906	132	0.0076	3.5	0.3042	123	0.0081	3.7
China	3.6764	1,240	0.0008	0.4	2.3484	951	0.0011	0.5
Japan	0.1371	46	0.0216	10.0	0.1113	45	0.0222	10.0
South Korea	0.2873	97	0.0103	4.8	0.3064	124	0.0081	3.6
OECD average	0.2966				0.2469			
Country	1990				2000			
	Energy intensity	Ratio to OECD average	Inverse of ratio to OECD average	Score	Energy intensity	Ratio to OECD average	Inverse of ratio to OECD average	Score
France	0.2065	95	0.0105	5.3	0.1879	97	0.0103	5.6
Germany	0.2004	92	0.0108	5.4	0.1739	90	0.0112	6.1
U.K.	0.1747	80	0.0124	6.2	0.1370	71	0.0142	7.7
U.S.	0.2575	119	0.0084	4.2	0.2179	112	0.0089	4.8
China	1.3067	601	0.0017	0.8	0.8649	446	0.0022	1.2
Japan	0.1085	50	0.0200	10.0	0.1056	54	0.0184	10.0
South Korea	0.3563	164	0.0061	3.0	0.3408	176	0.0057	3.1
OECD average	0.2172				0.1941			





The above left figure compares energy intensities in six research target countries other than China in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. Energy intensities declined in five countries excluding South Korea. The smaller graph area size in the 2000s indicates an energy intensity decline for the six countries as a whole, or a progress in energy conservation.

Japan logged an energy intensity score that was dominantly high for each decade. South Korea's energy intensity is high, though overshadowed by China's even higher intensity, indicating that South Korea will have to further improve energy efficiency. Among other countries excluding Japan, the United Kingdom and Germany posted remarkable improvements in energy intensity. The two countries have improved energy efficiency under specific policy goals for industrial and commercial sectors, indicating that Japan may not necessarily be guaranteed to retain a dominantly high assessment score in the future.

2-7 Supply Interruption Risk Management : Number of Days of On-land Oil Reserves

In this section, we paid attention to oil reserves for assessing the degree of energy supply interruption risk management and selected the number of days of on-land oil reserves as a specific indicator.

2-7-1 Adopted Statistics/Materials and Research Target Periods

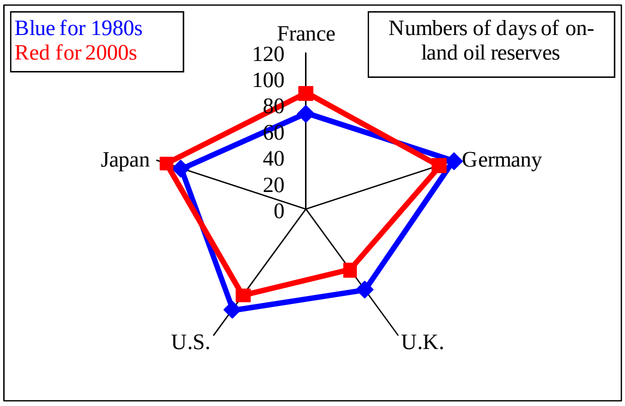
・IEA "Oil Market Report" from May-end 1983 to January 2009. No data exist for China that has not joined the IEA. Data for South Korea are for the period between 1997-end and 2008-end.

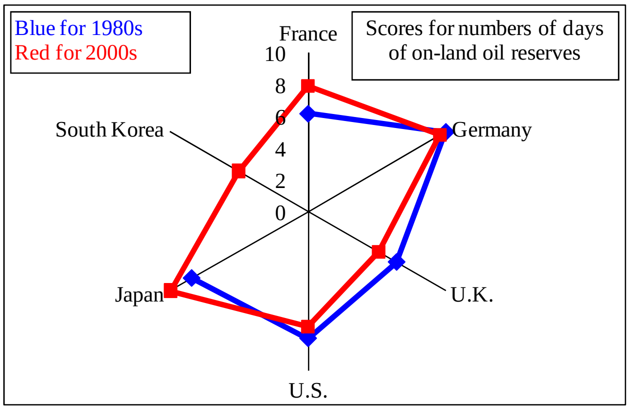
2-7-2 Details of Computation Procedure

We extracted the number of days of on-land oil reserves for each country and each decade from the above report and computed the ratios of the numbers for the six research target countries to the OECD average by dividing the numbers by the average. As the number of days of on-land oil reserves at the end of each year is selected for the assessment, we must take note of the fact that oil reserves here do not include offshore reserves.

2-7-3 Computation Results

Country	1980s			1990s			2000s		
	Number of days of reserves	Ratio to OECD average	Score	Number of days of reserves	Ratio to OECD average	Score	Number of days of reserves	Ratio to OECD average	Score
France	72.9	77	6.1	76.0	87	7.0	88.3	108	7.9
Germany	118.6	125	10.0	108.0	123	10.0	107.2	131	9.6
U.K.	76.1	80	6.4	62.3	71	5.8	57.7	71	5.1
U.S.	95.1	100	8.0	89.5	102	8.3	81.3	100	7.3
China	-	-	-	-	-	-	-	-	-
Japan	100.1	106	8.4	103.8	119	9.6	112.1	137	10.0
South Korea	-	-	-	33.0	38	3.1	56.3	69	5.0
OECD average	94.9			87.5			81.7		





The above left figure compares the numbers of days of reserves for France, Germany, the United Kingdom, the United States and Japan in the 1980s after the second oil crisis and in the 2000s when energy prices spiked. Oil reserves increased in France and Japan from the 1980s to the 2000s and decreased in Germany, the United Kingdom and the United States.

Assessment scores are indicated in the above right figure. Germany and Japan post slightly higher scores. But no large gaps exist between the scores excluding those for South Korea and that for the United Kingdom in the 2000s. This may be because the IEA has recommended the IEA member countries to keep emergency oil reserves at an equivalent to 90 or more days of net oil imports. Scores are higher for countries that have secured the recommended number of days of reserves and are lower for those that have been increasing reserves toward the target. But the research target countries might have had some perception gaps regarding the necessity of oil reserves. For example, the United Kingdom, as an oil-producing country, is specially allowed to keep the reserves at a level that is 25% less than the IEA target. In operating this assessment model, we may have to take into account possible offshore oil reserves and pipeline infiltration.

2-8 Overview

In this section, we analyze the meanings of the seven key indicators' assessment results for energy security.

2-8-1 Primary Energy Self-sufficiency Rate

The primary energy self-sufficiency rate depends heavily on the presence of domestic energy resources. Resource-rich countries can raise their respective rates with policies to promote the development of resources. Resource-poor countries have little room to dramatically raise their rates with policies as far as their energy supply is structurally dominated by fossil fuels. They must expand nuclear and renewable energy uses to raise their rates. In fact, France has raised its primary energy self-sufficiency rate to a high level by improving its energy supply structure.

2-8-2 Diversification of Energy Import Source Countries

Each research target country tends to depend on energy supply from foreign countries that are rich with resources and geographically close. There are limits on the diversification of energy import source countries as the geographical distribution of resources is uneven. Since any increase in energy supply from high-risk countries does not contribute to improving energy security, each country must take country risks into account in selecting energy import source countries. But we must take note of the fact that some real conditions fail to be reflected in our assessment results. For example, the United States' perception of risks regarding Venezuela with a high country risk may deviate from the country risk assessment value.

2-8-3 Diversification of Energy Sources

Since the oil crises, reduction of the dependence on oil has become a major policy target in many countries. As a matter of course, however, ways to cut dependence on oil have differed from country to country depending on the presence or absence of domestic resources and the availability of resources. For example, France has enhanced its nuclear power generation, while the United Kingdom and Germany have expanded natural gas use.

2-8-4 Transportation Risk Management : Degree of Dependence on Choke Points for Crude Oil Transportation

It is difficult for any policy to address the choke points that depend on geographical relations between energy resource importing and exporting countries. Each country may have to diversify its energy import source countries and energy sources to help reduce its dependence on choke points for crude oil transportation. We here took up the dependence on choke points as an indicator to depict energy security features of major countries. Low scores for Japan and South Korea and a high score for the United Kingdom simply reflect their respective energy security features. Choke points exist on routes of transportation of energy sources other than crude oil, including pipelines for the transportation of Russian gas to Europe. An analysis of transportation risk management for other energy sources is left as a challenge for the future.

2-8-5 Domestic Risk Management : Electricity Supply Reliability

Electricity supply reliability depends heavily on domestic electric utility industry systems. The promotion of deregulation in the industry may cause competition progress, cost-cutting pressures, investment cuts and a decline in surplus capacity. The promotion of renewable energies may lead to a drop in demand for grid electricity, needs for backup electricity sources and an increase in surplus capacity. In this sense, we may have to analyze the relationship between energy security and changes in domestic electric utility industry systems. Our assessment model failed to produce sufficient data leading to any specific conclusion on the relationship. Therefore, the relationship between energy security and electric utility industry systems is left as a challenge for the future.

Supply risk management (including supply multiplexing and securement of alternatives) is required for petroleum products and gas as well as electricity.

2-8-6 Demand Conservation : Energy Consumption per GDP (Energy Intensity)

The importance of demand conservation for energy security depends heavily on energy demand and energy self-sufficiency rates, as symbolized by lower assessment scores for China and the United States with higher energy self-sufficiency rates and by a higher score for Japan with a lower rate. At a time when all countries are stepping up energy conservation efforts, however, how long Japan could maintain its superiority is uncertain.

2-8-7 Supply Interruption Risk Management : Number of Days of On-land Oil Reserves

Oil reserve policy postures depend on the dependence on oil imports. A lower score for the

United Kingdom indicates that the country has increased its oil production through its North Sea oilfield development and reduced its dependence on oil through natural gas development efforts to obtain a 25% cut in the IEA-imposed oil reserve target equivalent to 90 days' net imports. It may be desirable to analyze supply interruption risk management for other energy sources than oil, including European efforts to manage natural gas supply interruption risks.

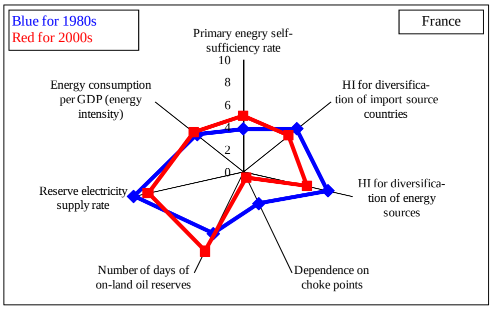
3. Characteristics of National Energy Security Policies

After comparing key assessment items of the research target countries in the previous chapter, we give a brief analysis of assessment items and supplementary indicators for each research target country in this chapter.

3-1 France – Expansion of Nuclear Energy Use –

Assessment results for each decade and indicator for France are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	2.5	3.8	4.6	4.9
2. HI for diversification of energy import source countries	5.3	6.1	6.9	5.1
3. HI for diversification of energy sources	8.5	7.7	6.3	5.9
4. Dependence on choke points	2.6	3.2	2.0	0.6
5. Reserve electricity supply rate	8.1	10.0	8.8	8.7
6. Energy consumption per GDP (energy intensity)	5.8	5.2	5.3	5.6
7. Number of days of on-land oil reserves	-	6.1	7.0	7.9
[Simple average of seven indicators]	5.5	6.0	5.8	5.5



First, we would like to comment on how France has secured energy resources.

France has positively and from an early start promoted its nuclear energy development as it has been poor with fossil energy resources other than coal. As a result, it has successfully raised its primary energy self-sufficiency rate covering nuclear energy while making up for a decline in its coal self-sufficiency rate. France's positive nuclear energy development policy has surely made effective contributions to raising its energy self-sufficiency rate.

While promoting nuclear energy development, France has striven to reduce its dependence on oil and diversify oil and gas import source countries. As a result, it has made relative progress in diversifying import source countries. But its score for the diversification of energy sources is lower due to nuclear energy's dominant share of primary energy supply. Given that the efforts to develop and diffuse nuclear energy have led to a strong nuclear industry representing the country and to its greater presence in the global competition for resources, however, the lower score does not necessarily mean any poor performance.

France, as well as other countries, has reduced its dependence on choke points for crude oil transportation by striving to diversify crude oil import source countries. But the United Kingdom's sharp cut in dependence has worked to relatively reduce the international assessment score for France.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

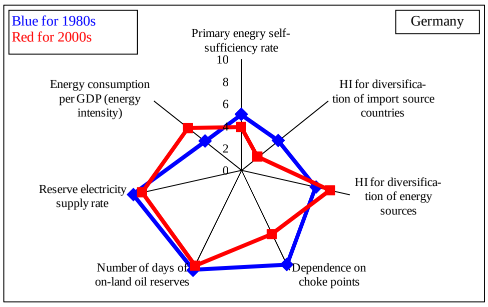
France has stably secured on-land oil reserves including both private and public sector inventories, as indicated by the relatively higher assessment score.

France had maintained the reserve electricity supply rate at a higher level through the expansion of nuclear power generation. But the rate has declined to 30% due to a downward revision of a nuclear power generation plan since the 1980s and the electric utility industry deregulation under the 1996 EU electricity directive. Among the research target countries, however, France still features a relatively high reserve electricity rate. As France has adopted energy demand conservation as one of energy policy goals since the Socialist Party created its energy policy in the 1980s, it posts the fourth highest energy efficiency score after Japan, Germany and the United Kingdom. France may have room to further improve its energy efficiency as it plans to cut final energy consumption by 2% per year until 2015 and by 2.5% until 2030. It is thus expected to make progress in energy conservation.

3-2 Germany – Dependence on Russia for Oil and Gas Supply –

Assessment results for each decade and indicator for Germany are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	5.1	5.0	3.9	3.9
2. HI for diversification of energy import source countries	5.1	4.2	3.7	1.9
3. HI for diversification of energy sources	7.1	6.9	7.6	8.2
4. Dependence on choke points	5.1	9.4	10.0	6.4
5. Reserve electricity supply rate	10.0	9.9	10.0	9.1
6. Energy consumption per GDP (energy intensity)	4.4	4.2	5.4	6.1
7. Number of days of on-land oil reserves	-	10.0	10.0	9.6
［Simple average of seven indicators］	6.1	7.1	7.2	6.4



First, we would like to comment on how Germany has secured energy resources.

Germany has aspired to expand the introduction of renewable energies as it intends to refrain from depending heavily on nuclear energy despite a decline in production of coal, the only energy source for which Germany had a high self-sufficiency rate. While the introduction of renewable energies has accelerated under the 2000 renewable energy law, natural gas imports have increased. Therefore, the overall energy self-sufficiency rate is still low. The relevant assessment score is not so high. Germany has increased its dependence on Russia for oil and natural gas supply while reducing its dependence on Middle Eastern crude oil substantially. Therefore, its assessment score regarding the diversification of energy import source countries has declined. Meanwhile, a decline in coal's share of primary energy supply has been combined with an increase in shares for natural gas, nuclear and renewable energies to make progress in the diversification of energy sources.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

Germany has substantially reduced its dependence on choke points for crude oil transportation in line with a drop in its dependence on Middle Eastern crude. But the United Kingdom's sharp cut in dependence has worked to relatively reduce the international assessment score for Germany. Natural gas pipeline route countries have become a great matter of concern to Germany, although the matter has failed to be reflected in our assessment model. It is now striving to develop bypass pipeline routes.

Although Germany had kept its reserve electric supply rate at very high levels until the 1990s, the rate for the 2000s has fallen to 32% due to electric utilities' reduction of reserve power generation capacity as part of their business efficiency improvement efforts since the late 1990s.

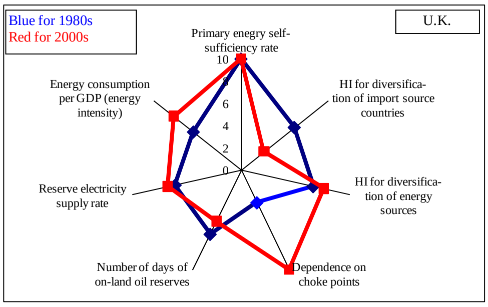
We will have to closely watch how Germany's reserve electricity supply rate would be influenced by the EU-wide revision of grid reliability standards after grid reliability shortages caused the Western European blackout in November 2006.

Since the 1990s after the German unification, Germany has striven to structurally improve the former East Germany's energy industry and demand to improve its energy efficiency. Its relative assessment score regarding energy efficiency has leveled off due to more remarkable efficiency improvements in other countries. For the future, Germany has put forward its goal of doubling energy productivity by 2020 from the 1990 level under the EU energy efficiency and service directive. Germany has promoted private-sector oil reserves as well as stockpiling through the German National Petroleum Stockpiling Agency**,** known as EBV, securing on-land oil reserves equivalent to more than 100 days' net imports since the 1980s. The excellent performance is reflected in the high assessment score.

3-3 U.K. – North Sea Gas Field Development –

Assessment results for each decade and indicator for the United Kingdom are as follows :

Indicator / Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	6.1	10.0	10.0	10.0
2. HI for diversification of energy import source countries	4.3	6.2	4.1	2.6
3. HI for diversification of energy sources	7.2	6.7	7.6	7.6
4. Dependence on choke points	2.1	3.3	4.4	10.0
5. Reserve electricity supply rate	8.5	6.1	4.9	6.8
6. Energy consumption per GDP (energy intensity)	5.4	5.5	6.2	7.7
7. Number of days of on-land oil reserves	-	6.4	5.8	5.1
[Simple average of seven indicators]	5.6	6.3	6.1	7.1



First, we would like to comment on how the United Kingdom has secured energy resources.

The United Kingdom had traditionally maintained its energy self-sufficiency rate at around 100% thanks to its domestic coal resources. Even since its coal self-sufficiency rate declined substantially on inflow of cheaper coals imports, the United Kingdom has kept its energy self-sufficiency rate at high levels by taking advantage of North Sea oil and gas development. Its energy self-sufficiency score is the highest among the research target countries. But oil and gas production has been declining. Without progress in the development of renewable and nuclear energies, its energy self-sufficiency rate could decline substantially. The diversification of energy import source countries has made little progress as Norway has maintained a dominant share of the United Kingdom's crude oil and natural gas imports. Although the country had promoted the diversification of energy sources through the expansion of nuclear and natural gas use until the 1980s, its excessive dependence on natural gas has recently become a major problem. Regarding the dependence on choke points for crude oil transportation, the United Kingdom has been the only dominant winner among the research target countries over recent years thanks to its heavy dependence on domestic North Sea and Norwegian crude oil.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

The United Kingdom features the lowest reserve electricity supply rate among the Western research target countries. This may be because the electric utility industry deregulation and electricity wholesale transactions since the 1980s have led the industry to eliminate high-cost electricity sources and reduce investment in electricity source development. As the United Kingdom substantially increased its electric grid capacity as a key element of the electricity supply reliability in 1986, it is inappropriate to assess the country's electricity supply reliability by the reserve electricity supply rate alone.

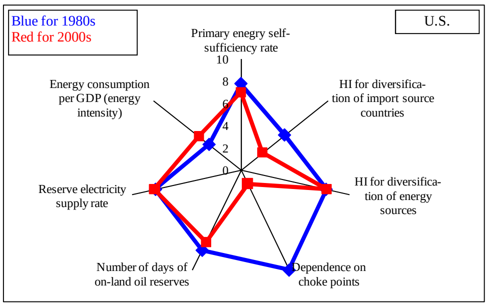
As for energy efficiency, the United Kingdom posts the second best score after Japan among the research target countries. In response to the 2002 EU building-energy-efficiency directive, the United Kingdom has improved its energy consumption efficiency. Particularly, it improved the household sector's energy efficiency, outdoing Japan. In its 2007 energy efficiency action plan, the United Kingdom established sector-by-sector energy conservation measures, indicating that further energy efficiency improvement can be expected.

The assessment score for crude oil reserves for the United Kingdom is low. This is because the oil producing country is required to stockpile less crude oil than oil importing countries. The United Kingdom, though with private sector oil reserves, has thus had relatively less reserves than other countries. In this sense, its low score is reasonable.

3-4 U.S. – Abundant Domestic Resources –

Assessment results for each decade and indicator for the United States are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	8.2	7.7	7.1	7.0
2. HI for diversification of energy import source countries	4.9	5.0	3.5	2.5
3. HI for diversification of energy sources	9.5	7.9	7.9	7.9
4. Dependence on choke points	10.0	10.0	5.8	1.4
5. Reserve electricity supply rate	7.6	7.9	5.5	8.0
6. Energy consumption per GDP (energy intensity)	3.5	3.7	4.2	4.8
7. Number of days of on-land oil reserves	-	8.0	8.3	7.3
［Simple average of seven indicators］	7.3	7.2	6.1	5.5



First, we would like to comment on how the United States has secured energy resources.

The United States, while having abundant energy resources, is the world's largest energy consumer. Although its crude oil self-sufficiency rate has declined on a production fall, it has expanded coal and natural gas production to meet demand. It has thus kept the energy self-sufficiency rate at relatively high levels, boasting of the third highest score after the United Kingdom and China among the research target countries. But the United States heavily depends on Canada, Mexico, Venezuela and the Middle East for oil supply, on Canada for natural gas supply and on Colombia for coal supply, failing to diversify energy import source countries. Even since oil crises, it has made no policy efforts to diversify import source countries. Canadian, Mexican and Venezuelan crude oil accounts for a large share of U.S. oil imports, contributing to the country's high assessment score regarding the dependence on choke points for crude oil transportation. Its assessment score for the diversification of energy sources is relatively high as it has traditionally developed and used domestic coal and natural gas.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

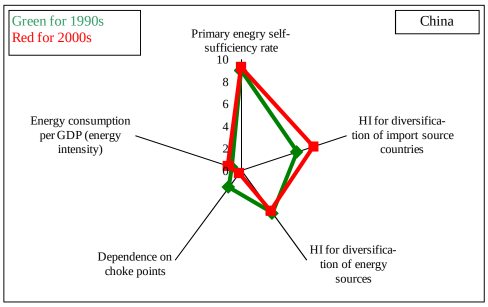
As the electric utility industry deregulation has led to the stagnation of equipment investment since the second half of the 1990s, the U.S. reserve electricity supply rate has been lower since the 1990s among Western countries that have implemented the electric utility industry deregulation.

The energy intensity score for the United States had been lower than for other Western countries before energy conservation policies under the 1992 Energy Policy Act reduced the U.S. energy intensity by 12.8% from 2000 to 2006 to indicate a sign of improvement. The United States has had strategic petroleum reserves without private sector reserves as seen in Japan and featured flexible measures to increase and release reserves.

3-5 China – Diversification and Consumption Conservation Left as Future Challenges –

Assessment results for each decade and indicator for China are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	10.0	9.3	9.0	9.2
2. HI for diversification of energy import source countries	-	-	5.3	6.8
3. HI for diversification of energy sources	7.2	5.8	4.8	4.5
4. Dependence on choke points	-	-	1.9	0.3
5. Reserve electricity supply rate	-	-	-	10.0
6. Energy consumption per GDP (energy intensity)	0.4	0.5	0.8	1.2
7. Number of days of on-land oil reserves	-	-	-	-
[Simple average of seven indicators]	5.9	5.2	4.4	5.4



First, we would like to comment on how China has secured energy resources.

China has domestic coal and oil resources. Until the 1980s when energy consumption was still limited, China had maintained full energy self-sufficiency. As energy demand has expanded rapidly on fast economic growth, China has increased its dependence on oil imports. It became a net oil importer in the 1990s and started LNG import in 2006. Nuclear power generation was introduced in China only in the 1990s, falling short of contributing to boosting the energy self-sufficiency rate. China has attempted to diversify oil import source countries by widening the range of its oil import source countries to cover Russia, Vietnam, Venezuela and African countries such as Angola. But the limited range of natural gas import source countries and coal's large share of energy supply indicate that the diversification of energy sources and import source countries is left as a future challenge. China posts a slightly higher assessment score for the dependence on choke points for crude oil transportation than Japan and South Korea as oil imports still slip below total consumption. If oil imports increase further, however, China may have to consider reducing its dependence on Middle Eastern crude oil. As China's inland region borders with many countries including Central Asian nations, Russia, India and Southeast Asian nations, the country has an option to import oil and gas via pipelines. But a full geopolitical analysis may be required on such option.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

As electricity source development has been accelerated since around 2003, China's reserve electricity supply rate for power generation capacity averaged about 35% for 2005 and 2006, the highest among the research target countries for the 2000s for which Chinese data are available. But the development of electricity transmission cables and other infrastructure facilities and fuel transportation systems has failed to catch up with rapid economic growth, causing frequent blackouts even in the mid-2000s. If electric grid development is put into the assessment model, the assessment results may be different.

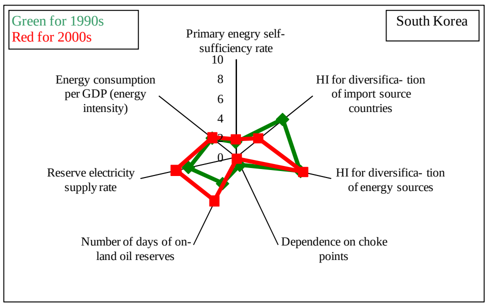
China logs the lowest score for energy consumption efficiency among the research target countries. The Chinese government, which had given top priority to economic growth for a long time, has started full-fledged efforts to improve energy efficiency. The 11th five-year development plan called for reducing energy intensity by 20% during the 2006-2010 period. The 2008 revised energy conservation law emphasizes the importance of energy conservation as a solution to energy supply shortages. As a result, China achieved an energy intensity cut of about 14% by the first half of 2009. It can be expected to make fast progress in energy conservation.

We refrained from subjecting China's oil reserves to our assessment in the absence of appropriate statistics or materials. But China has promoted the construction of national oil reserve bases since the early 2000s. Its oil reserves in 2009 are estimated to have covered 59 days' net imports.

3-6 South Korea – Domestic Risk Management Improved, Resources Securement Seen as a Future Challenge –

Assessment results for each decade and indicator for South Korea are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	1.0	1.5	1.7	1.8
2. HI for diversification of energy import source countries	8.1	5.7	5.5	2.7
3. HI for diversification of energy sources	5.7	8.7	9.1	9.3
4. Dependence on choke points	2.5	2.1	1.0	0.2
5. Reserve electricity supply rate	8.2	8.3	6.1	9.8
6. Energy consumption per GDP (energy intensity)	10.0	10.0	10.0	10.0
7. Number of days of on-land oil reserves	-	8.4	9.6	10.0
[Simple average of seven indicators]	5.9	6.4	6.1	6.3



First, we would like to comment on how South Korea has secured energy resources.

In a manner to follow Japan's course of action, South Korea has shifted its key energy source from coal to oil and to natural gas, resulting in a substantial fall in its fossil energy self-sufficiency rate. In the past, South Korea featured a high coal self-sufficiency rate. But the rate suffered a substantial decline that has been offset by the introduction of nuclear energy. South Korea's present primary energy self-sufficiency rate is as low as Japan's, belonging to a lower rate group among industrial countries. While diversifying natural gas import source countries to cover the Middle East, Indonesia and Australia, South Korea still depends heavily on Middle Eastern crude oil. Therefore, its assessment score for the diversification of energy import source countries is as low as Japan's. For the same reason, South Korea's score for the dependence on choke points for crude oil transportation is also low. South Korea has made some progress in the diversification of energy sources through its positive introduction and diffusion of nuclear energy and natural gas. But its score for the diversification of energy sources is not so good among the research target countries. In order to make further progress in the diversification of energy sources, South Korea may have to switch from oil to renewable energies.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

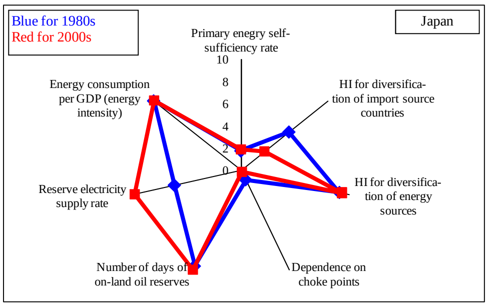
South Korea features a high level of electricity supply risk management. While its reserve electricity supply rate has remained around 20%, the average annual power outage duration has been limited to 18.80 minutes per household and the average power outage frequency to 0.45 per year. South Korea's international assessment score for electricity supply risk management is high, indicating that it has built a stable electricity supply network. South Korea has started efforts to improve energy efficiency relatively earlier than other Asian countries. But such efforts have fallen short of gaining any high score in international assessment. Under the 2008-2030 basic national energy plan, South Korea has established the fourth energy use rationalization plan calling for energy intensity to be cut by 11.3% by 2012. It is seeking to reduce energy intensity by 46% by 2030.

South Korea joined the IEA only in 2002 and has just begun to stockpile oil reserves. With both government and private sector oil reserves, South Korea has recently achieved the IEA-imposed oil reserve target equivalent to 90 days' net imports. Average oil reserves for the 2000s are limited to about 56 days' net imports, forcing its score for oil reserves to be lower among the research target countries.

3-7 Japan – Excellent Performance in Domestic Risk Management –

Assessment results for each decade and indicator for Japan are as follows :

Indicator \ Score	1970s	1980s	1990s	2000s
1. Primary energy self-sufficiency rate	2.8	2.4	1.5	1.8
2. HI for diversification of energy import source countries	2.8	7.2	6.1	3.0
3. HI for diversification of energy sources	4.8	7.1	6.8	7.1
4. Dependence on choke points	-	-	1.0	0.2
5. Reserve electricity supply rate	-	-	4.9	6.3
6. Energy consumption per GDP (energy intensity)	4.8	3.6	3.0	3.1
7. Number of days of on-land oil reserves	-	-	3.1	5.0
[Simple average of seven indicators]	3.8	5.1	3.8	3.8



First, we would like to comment on how Japan has secured energy resources.

Japan's energy self-sufficiency rate has been persistently low. Its relevant international assessment score has been low even since its fuel switch from coal to oil and to nuclear energy and natural gas because these energy sources other than nuclear are not produced domestically. Japan's international assessment score for the diversification of energy import source countries has been low due to its heavy dependence on Middle Eastern crude oil and Australian coal. Its score for the dependence on choke points for crude oil transportation is also low due to the heavy dependence on Middle Eastern crude oil. While Japan has relatively diversified natural gas import source countries, its overall diversification of energy import source countries has stagnated. Japan posts the highest assessment score for the diversification of energy sources among the research target countries as it has expanded the use of natural gas and nuclear energy to replace oil in a well-balanced manner.

Next, we would like to comment on energy supply interruption countermeasures, risk management and demand conservation.

Japan's domestic electricity infrastructure has been well developed. Since the creation of the Central Electric Power Council in 1958, Japanese power utilities have cooperatively operated their electricity transmission networks. Japan's electric grid reliability has been persistently high. In 2005, the Electric Power System Council of Japan was inaugurated to maintain and improve the electricity supply reliability under the electric utility industry deregulation. As a certain level of power generation capacity has been maintained even since the deregulation, general power utilities' reserve supply rate has remained around 35% in the past excluding the 1990s.

Japan has taken the initiative in the world in improving energy efficiency by introducing positive improvement policies early. Through enhanced energy conservation efforts under the 1979 Act on the Rational Use of Energy, known as the energy conservation law, Japan in the 1980s achieved an energy intensity level that is not so different from the present level. The energy intensity regulation scope has been expanded to cover transportation and commercial sectors, electrical appliances and housing. The 2006 new national energy strategy calls for reducing energy intensity by 30% by 2030. Oil reserves have been widely recognized as an important factor for energy security in Japan. The nation's on-land oil reserves have been equivalent to more than 100 days' net imports since the 1980s. Its international assessment score for oil reserves in the 2000s is the highest among the research target countries.

Japan's weak and strong points found through its comparison with the other research target countries are cited in the following table :

Weak points	Strong points
・Japan has no domestic fossil energy resources. **・Large geological/geographical handicaps It is difficult for Japan to substantially raise the energy self-sufficiency rate, diversify energy import source countries and reduce its dependence on choke points for crude oil transportation.** **・Relative decline in capabilities to obtain resources (Decline in competitiveness)**	**・Japan has strong motives to enhance energy security.** **・Japan has made great achievements in domestic measures (including energy conservation and the maintenance of a high reserve electricity supply rate and massive oil reserves).** **・Energy conservation and other low-carbon technologies have developed into the source for international competitiveness.**

Japan has no domestic major energy resources, is geographically far from oil/gas producing countries and depends on many choke points for transportation of crude oil from oil producing countries. These weak points are preconditions given to Japan. The only solution for Japan is to take measures while recognizing the preconditions. The preconditions have led to Japan's strong point – the existence of strong motives to enhance energy security. These motives have served as the driver of risk management measures including energy conservation and the maintenance of a high reserve electricity supply rate and massive oil reserves. Energy conservation and other low-carbon technologies and institutions for their diffusion have developed into the source for the Japanese energy industry's international competitiveness.

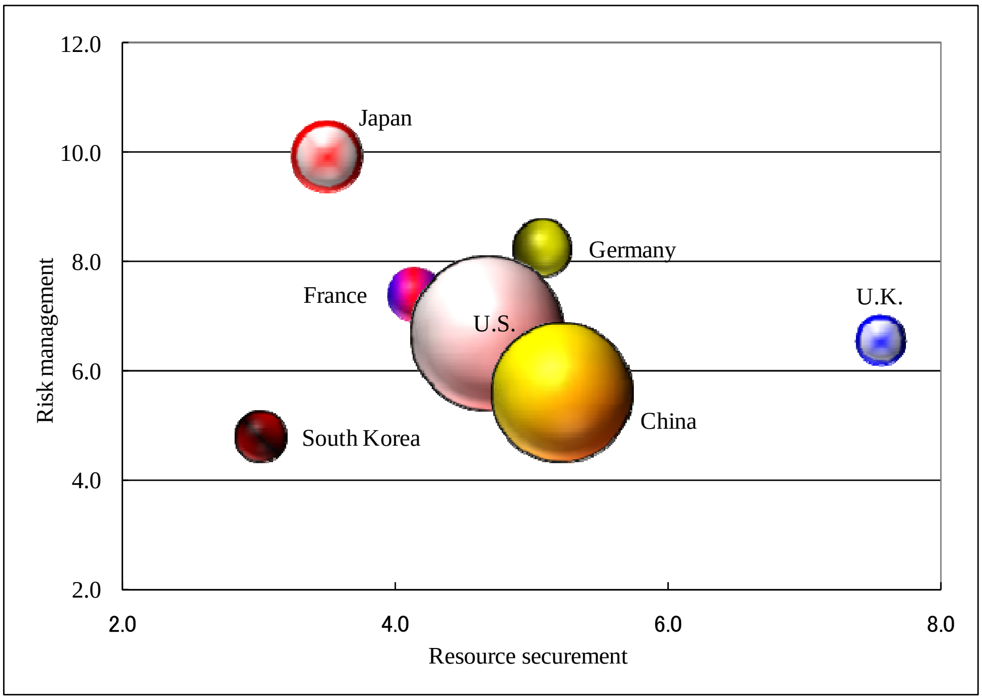
Meanwhile, concerns have emerged about a relative decline in Japan's presence in international competition for oil, gas, uranium and other resources. But this weak point is different from the abovementioned precondition of poor domestic resources. Japan must overcome this weak point with conviction to secure stable energy supply. If Japan can increase its presence in international competition for resources by taking advantage of excellent energy conservation technologies that have achieved one of the world's lowest energy intensity levels and of power generation technologies including nuclear and highly efficient coal thermal plant technologies that have enabled Japan to have a well-balanced energy portfolio, the nation's energy security may be improved dramatically.

4. Overview and Implications

Our analysis has so far looked into characteristics and effects of each research target country's energy security policy in each decade based on energy security component indicators. We have built on the analysis to classify the research target countries into two groups – resources securement-oriented and risk management-oriented nations – based on their energy security policy characteristics in order to further specify their national features. Specifically, a simple average of scores for the first to fourth key indicators (the primary energy self-sufficiency rate, the degree of diversification of energy import source countries, the degree of diversification of energy sources and the dependence on choke points for crude oil transportation) was computed for each country to indicate the degree of resources securement, or the degree of expansion of measures to secure necessary sufficient energy supply stably and cheaply. A simple average of the fifth to seventh key indicators (the electricity supply reliability, the energy consumption per GDP and the number of days of oil reserves) was computed for each country to represent the degree of risk management, or the degree of expansion of energy supply interruption countermeasures and risk management measures.

The computation results are given in Fig. 4-1. Circles represent these countries' economic (GDP) sizes. According to the results, the United Kingdom and China are resource securement-oriented countries that give greater priority to stable energy supply. Japan, Germany and France are risk management-oriented countries that give greater priority to energy supply interruption countermeasures and demand conservation than to stable energy supply. Given that the United Kingdom and China had been energy producers (exporters), that Japan and France have not

Fig. 4-1 Degrees of Resource Securement and Risk Management by Country



been energy producers but importers, and that such preconditions have supported their respective economic, social and technological development, the computation results can be interpreted as reasonable. Such simple indicators can reflect these countries' policy characteristics.

The averages here are of these indicators for the 2000s alone to show the present characteristics of the research target countries.

Our analysis has indicated that Japan has persistently seen its energy self-sufficiency rate at lower levels than the other research target countries (the United States, the United Kingdom, France, Germany, China and South Korea) since the 1970s and offset the weak point with consumption conservation (reduction of energy intensity) and the diversification of overseas resources securement risks (the diversification of energy sources). Like Japan, South Korea is an East Asian maritime country poor with domestic energy resources. But Japan has persistently gone ahead of South Korea in cutting energy intensity and diversifying energy sources. Japan's energy security policy has supported the world's second largest GDP size even with the lowest energy self-sufficiency rate among the research target countries, and can be assessed as successful so far.

In the future, however, we expect to see rapid population growth and economic growth in China and India, the relevant intensification of competition for resources, new diplomatic strategies of resource producing countries, global warming prevention measures' constraints on resources and other energy resource-related developments which had not been seen in the 20th century. We also believe that we may have to pay attention to the actual and projected development of energy conservation, renewable energy, nuclear and other low-carbon technologies, and industrial policies and structures of countries with these low-carbon technologies as even more important elements of energy security.

In this chapter, we put forward policy proposals to maintain or improve energy security components as defined in this report.

4-1 Securement of Domestic/Quasidomestic Energy

Under the assessment method adopted for this research, countries like Japan poor with domestic oil and natural gas resources may have difficulties gaining high assessment scores for the securement of domestic/quasidomestic energy[2]. Even if so, it is important to proceed with such measures as the positive introduction of nuclear power generation and the promotion of renewable energy introduction. Based on the realities regarding the securement of domestic fuels, Japan should maintain its policy priority to the further stable securement of overseas resources, the diversification of energy sources and the steady development and diffusion of renewable energies.

4-2 Securement of Overseas Energy Resources and Management of Transportation Risks

Assessment results in this research indicate that Japan has diversified energy sources relatively better while posting high degrees of oligopoly among resource import source countries and of dependence on choke points for crude oil transportation. But such phenomenon is seen in many industrial countries, indicating that Japan's energy source diversification efforts are not necessarily excellent. As far as all research target countries depend on oil for most of primary energy supply

[2] Under a method that was not adopted for our research model, stakes in oil, gas, coal, uranium and other overseas resources are counted as domestic resources to boost the energy self-sufficiency rate. Some people have called for positive efforts to buy stakes in overseas resources.

and are expected to continuously depend on choke points for transportation of oil, they cannot be expected to achieve any fundamental improvement in the securement of overseas energy resources and the management of transportation risks. If so, Japan should accept the realities and take sustainable and effective measures to prevent the oligopoly among oil import source countries from deteriorating further. At the same time, Japan should strive to diversify overall energy import source countries and explore new resource producing countries. In this sense, Japan should enhance relations with resource producing countries. Given that it is unrealistic to select promising oil producing countries with low risks alone, Japan should take measures to make relations with high-risk countries sustainable as much as possible while continuing efforts to diversify energy resources.

4-3 Domestic Risk Management

Among the research target countries, Japan posted average levels of assessment scores for oil reserves and the reserve electricity supply rate to which we have paid attention. Improvements in these scores may mean increases in oil reserve and power generation capacity surpluses. As far as oil companies and electric utilities are in the private sector in Japan, they may limit such increases in consideration of their business efficiency. Rather, Japan should appreciate the effects on energy security of the past efforts to maintain surplus oil reserves and power generation capacity and should maintain some policy measures for private oil firms and electric utilities.

4-4 Demand Conservation in Developing Countries

Japan’s excellent energy intensity performance has been appreciable. But Germany and the United Kingdom have rapidly caught up with Japan in cutting energy intensity over recent years. It is uncertain whether Japan will remain the most advanced nation in energy conservation in the world.

Rather, we must pay attention to the fact that the promotion of energy conservation at a very low cost can be expected in China that features several times higher energy intensity than Japan. Japan’s early transfer of energy conservation technologies to China to hold down Asian energy demand growth accompanying economic development will be an important challenge for Japan’s energy security. In this respect, Japan should consider the technology transfer’s harmonization with global warming prevention measures and the selection and dissemination of various low-carbon technologies.

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