Chapter 2

Developing an Energy Security Index

June 2012

This chapter should be cited as
Quantitative Assessment of Energy Security Working Group (2011), 'Developing an Energy Security Index' in Koyama, K. (ed.), *Study on the Development of an Energy Security Index and an Assessment of Energy Security for East Asian Countries*, ERIA Research Project Report 2011-13, Jakarta: ERIA, pp.7-47.

CHAPTER 2

Developing an Energy Security Index

1. Definition of Energy Security

The definition of energy security changes depending on what the subject of energy security is ("what" is being protected), the threat to energy security ("against what" is it being protected), the measures to promote energy security ("who" "is doing what" to protect "with whom") and how these points are recognized. There is no universal definition that transcends time periods.

For this study, energy security has been defined as, "the securing of the amount of energy required for people's lives, economic, social, and defense activities, among other purposes, at affordable prices."

Figure 2-1 indicates the major components of energy security throughout the energy supply chain.

The principle is the use of risk management, focused on improving the energy security situation. Risk management includes the dispersion of risks, such as through the diversification of energy sources, the absorption of risks, for example by creating a reserve margin of power generation capacities, and preparations against unavoidable supply disruptions such as by building up strategic reserves. The improvement of energy security also includes the development of domestic energy sources and the enhancement of resource acquisition in foreign countries.

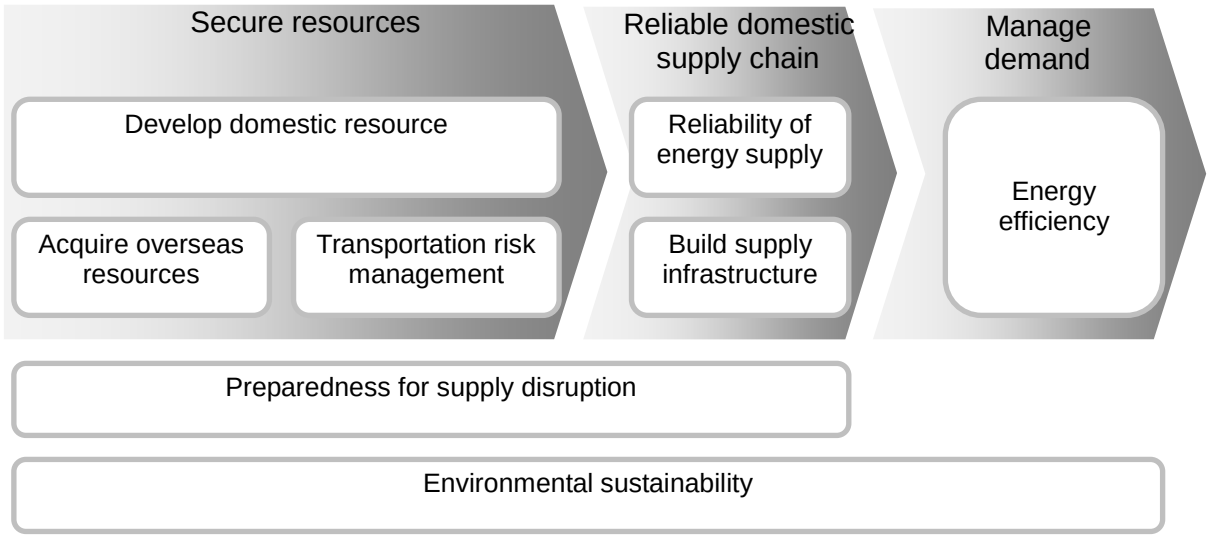
The energy supply issue consists of three stages – "secure resources" "secure a reliable domestic supply chain" and "manage demand." A generally conceivable resource-securing method is to develop or acquire resources at home or abroad and transport them to the domestic market. Therefore, the "development of domestic resources," "acquisition of overseas resources" and "transportation risk management" are deemed major items constituting the first stage of the supply chain. The "reliability

of the energy supply" and "construction of supply infrastructure" are required to "secure a reliable domestic supply chain" and are deemed major items for this stage. "Energy efficiency" is cited as a major item indicating that something is being done to "manage demand." On top of these factors, "preparedness for supply disruptions" has also to be seen as a major component of energy security.

Environmental sustainability has been added to the factors comprising the energy security issue, in light of heightened awareness of global environmental concerns. Most greenhouse gas emissions are produced by energy sources, and so it goes without saying that an important factor to ponder when thinking about energy issues is consideration for the environment, including climate change issues.

If any of these factors is dropped, it may be structurally difficult for the supply chain to maintain a stable state of energy security.

Figure 2-1: Components of energy security



2. Developing an Energy Security Index

The following proposal has been made for the creation of an Index that can quantitatively express the condition of each factor underlying overall energy security (in other words, an "Energy Security Index: ESI").

Transportation risk management has not been evaluated here, because it is difficult

to create an appropriate index, given, for example, the wide difference of evaluation factors between sea transport using ships and land transport via pipeline, railway or road.

Table 2-1: List of ESI components

Components	Quantitative Assessment	ESIs
Development of domestic resources	1. Self-sufficiency	1-1. TPES self-sufficiency ratio (including nuclear) 1-2. Reserve/production ratio 1-3. Reserve/consumption ratio
Acquisition of overseas resources	2. Diversification of import source countries 3. Diversification of energy sources 4. Dependence on Middle East	2. Diversity of import source countries (oil, gas and coal) 3. Diversity of energy sources of TPES / electricity 4. Middle East dependence for oil and gas
Transportation risk management	-	-
Securing a reliable domestic supply chain	5-1. Reliability of energy supply 5-2. Build supply infrastructure	5-1-1. Reserve margin of generation capacity 5-1-2. Power outage frequency / duration 5-2. Commercial energy access ratio
Management of demand	6. Energy efficiency	6-1. TPES/GDP ratio 6-2. TFEC/GDP ratio
Preparedness for supply disruptions	7. Strategic reserves	7. Days of on-land oil stocks
Environmental sustainability	8. CO_2 intensity	8-1. CO_2 emissions/TPES ratio 8-2. CO_2 emissions/Fossil fuel ratio 8-3. CO_2 emissions/GDP ratio 8-4. CO_2 emissions/Capita

Each ESI definition and calculation method is as follows.

1-1. TPES self sufficiency ratio (including nuclear)

This is an important measurement of the strength of a country's strength in energy security in terms of how dependant the country in for its energy resources on internal sources, regardless of whether the energy type is fossil fuel or not.

Total Primary Energy Supply (TPES) is made up of indigenous production + imports - exports - international marine bunkers +/- stock changes.

Indigenous Production is the production of primary energy, i.e. hard coal, lignite, peat, crude oil, natural gas liquids (NGLs), natural gas, nuclear, hydro, geothermal, solar

and heat the ambient environment extracted using heat pumps.

Production is calculated after the removal of impurities (e.g. sulfur from natural gas). In addition, with nuclear power stations, once the uranium has been charged, it is possible to run power stations continuously for a long period of time. Since there is no need to frequently import fuel, nuclear power can be seen as a semi-domestic energy resource.

TPES self-sufficiency ratio = (Indigenous Production) / (TPES) * 100

1-2. Reserve/Production ratio

Usually, the R/P ratio (Reserve/production ratio) is utilized as an indicator to show the remaining amount of unexploited resources a country currently posseses. The R/P ratio has been adopted as a measurement of the amount of resources held by a country.

R/P ratio = (Reserve) / (Production)

1-3. Reserve/Consumption ratio

In the context of energy security, the R/C ratio (Reserve/consumption ratio) is proposed as an additional indicator. The reason that consumption has been adopted here is, for example, to cater for the case that a portion of production is exported. From the perspective of securing a country's energy security, the halting of exports and reallocation of the energy source for the country's own use might be considered. In other words, dividing reserves by consumption, as with the R/C ratio, gives an indication of how much energy a country can use in the extreme.

R/C ratio = (Reserve) / (Consumption)

2. Diversity of import source countries

The diversity of import source countries has been adopted as a measurement of the supply security of fossil fuels. If import source countries are diversified, even if the supply from a certain country is halted, it is thought to be highly likely that the difference will be made up by other import source countries.

Here the Hirschmann-Herfindahl index has been adopted as a good measure of the scale of diversity. (see below)

HHI: Hirschmann-Herfindahl Index

HHI is defined as the sum of the squares of the individual market shares of every firm in the market. An HHI of 1 would mean there is just one firm in the market, a monopoly structure. The HHI 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 HHI 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."

3. Diversity of energy sources of TPES / electricity

Energy sources possess different characteristics in terms of available amounts, their ease of trading, price, and their associated environmental burdens. As no single energy resource exists that excels in all factors, each characteristic should be used tactfully. It is important to develop an energy mix with a good balance among sources. In other words, by diversifying energy sources, the merits of each energy source can be drawn out while at the same time reducing the demerits and risks of each source. Diversification of energy sources is considered both in the composition of TPES and in the power source structure.

HHI has been adopted as a measure of diversity.

4. Middle East dependence of oil and gas supply

The importation of energy from regions with high geopolitical risks can be said to pose high risks in terms of energy security. This is because of the existence of the possibility that supply will be cut off due to political pressure or environmental changes.

Geopolitical risks are seen in many regions across. In the case of oil and gas supply, however, the instability of the Middle East, which holds a large number of energy sources, is of particular importance. Thus this study explicitly considers the impact potential of Middle East dependence for oil and gas supply.

Middle East dependency = (Imports from Middle East) / (Total Imports) * 100

5. Reliable domestic supply chain

Necessary infrastructure must be developed in order to supply energy in a stable manner such that it meets domestic demand. This refers to things like fossil fuel supply chain items (e.g. tanker trucks and gasoline stands), as well as gas pipelines and power distribution networks.

Here the number of gasoline stands per capita may be used as a measurement for the coverage of the fossil fuel supply chain. However, due to differences between countries, there is no cohesive standard in the statistics on this factor. The same is true for gas pipeline networks. In consideration of the relative difficulty of collecting such data, oil and gas data has not analyzed in this study.

5-1. Reserve margin of generation capacity

There is a need to secure power generation capabilities sufficient to meet demand in order to ensure a stable supply of electric power. More concretely, a country must sustain its power generation capabilities for peak demand, including reserve capabilities in case something extraordinary happens.

Reserve margin of generation capacity
= (Total Generation Capacity) / (Peak Demand) *100

There is a need to draw attention to two points related to the evaluation of this measurement. The first is the necessity to minimize surplus capacity from an economic perspective, and thus the situation of competition in the electric power market will have an effect on this measurement. The other point has to do with low operation rates of renewable power sources, which increases the need for backup power supply sources (in other words, power supply sources with low operation rates) to cope with unstable output in the event that the power supplied from renewable energy increases in the future. Should this happen, it is expected that the reserve margin will rise far above current levels.

5-2. Power outage frequency/duration

The extent of power outages (their frequency and duration) can be said to be a measurement directly showing the level of stability of the power supply.

This study has adopted the duration of power outages per customer (minutes/year) and the frequency of such outages per customer (times/year).

Power outage duration

= (Accumulated duration of power outage) / (Total number for customers).

Power outage frequency

= (Outage frequency per year) / (Total number of customers).

5-3. . Commercial energy access ratio

The commercial energy access ratio was chosen as a measurement of the extent to which there is a system in place to supply energy domestically, apart from the electric power supply sources. The commercial energy access ratio also shows the development stage of an economy. Based on the premise that all citizens want a supply of commercial energy, the maintenance of a situation in which energy can be supplied can be said to be one of the factors that comprises energy security. Here, because the category of commercial energy is not defined on the Internal Energy Agency (IEA) statistics, etc., the following method is used for its calculation.

Commercial energy access ratio

= (TPES – Non-commercial energy) / (TPES) * 100

where;

Non-commercial energy

= (Primary supply of solid biofuels) – (Input energy for transformation purpose)

6. Energy efficiency

Demand management is one important factor in energy security. Briefly, it shows the level of efficiency of energy consumption. Two metrics are used for the measurement of the efficiency of energy consumption.

In evaluating these measurements, there is a need to pay attention to the point that the relationship between energy consumption and GDP will change based on a country's economic structure. For example, the balance of a country's energy consumption to its GDP differs between countries which focus their economy on energy intensive industries such as steel production, and countries with a focus on the financial sector.

6-1. . TPES/GDP ratio

One ratio to be considered is the TPES/GDP ratio, which uses the total primary energy supply (TPES) to show the comprehensive utilization rate for energy, including in conversion sectors such as power generation and oil production.

TPES/GDP ratio = (TPES) / (GDP)

6-2. TFEC/GDP ratio

Another metric of interest is the TFEC/GDP ratio, which uses the total final energy consumption (TFEC) to measure the energy-use efficiency at the end-user level.

TFEC/GDP ratio = (TFEC) / (GDP)

7. Days of on-land oil stocks

The existence of stocks would constitute a major response should there be a temporary halting in the supply of fossil fuels. IEA countries are supposed to maintain emergency stocks equivalent to 90 days worth of net fossil fuel imports. Days of onshore oil reserves was chosen here in consideration of the probable ease of obtaining data.

The number of days is obtained from the "Oil market report" of the IEA, and the calculation method is defined by the IEA.

reference: IEA definition)

Days of onland oil stock = (Total stock) / (Forward demand)

where;

Total stock = industry stock + government controlled stock

Forward demand = forward quarter average daily demand calculated by the IEA

8. CO_2 intensity

Issues of energy and global environmental sustainability are inextricably linked. As one important factor comprising energy security, it is thought that CO_2 intensity is an appropriate measurement in evaluating environmental sustainability, and thus four factors measuring different aspects of CO_2 intensity have been chosen.

The CO_2 emissions/TPES ratio reflects the extent to which low carbon energies are used and the consumption efficiency for energy. The CO_2 emissions/fossil fuel ratio reflects the energy mix among coal, petroleum and natural gas as well as their energy use efficiency. The CO_2 emissions/GDP ratio measures CO_2 in terms of its relationship to economic growth. The level of CO_2 emissions per capita measures the amount of fossil fuel used per person and more closely reflects the extent of economic development and its relationship to CO_2.

CO_2 emissions/TPES ratio = (CO_2 Emissions) / (TPES)
CO_2 emission/fossil fuel ratio = (CO_2 Emissions) / (Primary supply of fossil fuel)
CO_2 emissions/GDP = (CO_2 Emissions) / (GDP)
CO_2 emissions per capita = (CO_2 Emissions) / (Population)

3. Data

The results for calculations of the ESI, in principle, use common statistical data gathered from public sources in each country, with the aim of eliminating discrepancies due to statistical methods. From this perspective, the IEA statistics and the *BP Statistical Review of World Energy* were primarily used. IEA statistics include 'Coal Information,' 'Oil Information,' 'Natural Gas Information,' and 'CO2 Emissions from Fuel Combustion.'

Because data is not available for two of the above statistics for Lao PDR, Energy Balance data from the *WG on Analysis on Energy Saving Potential in East Asia* by ERIA, and the World Bank data were used.

Working group members verified and amended the data collected by the IEEJ,

which served as secretariat, and at the same time, requests were made to provide additional data to fill holes in the framework where possible, and such data were developed for the purpose of calculations. In the case of differences between IEA, BP and national statistics, national statistics were prioritized.

Statistics used to calculate ESI are as follows.

Table 2-2: ESI and Statistics

ESI	Statistics
1-1.TPES self sufficiency ratio (including nuclear)	Energy Balance of OECD, Non-OECD Countries (IEA) Cambodia: National statistics Lao PDR: WG on Analysis on Energy Saving Potential in East Asia (ERIA)
1-3. Reserve/Production ratio	Reserves: BP Statistical Review of World Energy, National statistics Production: BP Statistical Review of World Energy, National statistics
1-2. Reserve/Consumption ratio	Reserve: BP Statistical Review of World Energy National statistics Consumption: Energy Balance of OECD, Non-OECD Countries (IEA)
2. Diversity of import source countries	Coal Information, Oil Information and Natural Gas Information (IEA) National statistics
3. Diversity of energy sources in TPES / electricity	Energy Balance of OECD, Non-OECD Countries (IEA) Cambodia: National statistics Lao PDR: WG on Analysis on Energy Saving Potential in East Asia (ERIA)
4. Middle East dependence of oil and gas	Oil Information and Natural Gas Information (IEA) National statistics
5-1-1. Reserve margin of generation capacity	Statistics of the "Japan Electric Power Information Center" National statistics
5-1-2. Power outage frequency / duration	Statistics of the "Japan Electric Power Information Center" National statistics
5-2. Commercial energy access ratio	Energy Balance of OECD, Non-OECD Countries (IEA) Lao PDR: WG on Analysis on Energy Saving Potential in East Asia (ERIA)
6-1. TPES/GDP ratio	Energy Balance of OECD, Non-OECD Countries (IEA) Cambodia: TPES: National statistics Lao PDR: TPES: WG on Analysis on Energy Saving Potential in East Asia (ERIA) GDP: World Bank
6-2. TFEC/GDP ratio	Energy Balance of OECD, Non-OECD Countries (IEA) Cambodia: TFEC: National statistics Lao PDR: TFEC: WG on Analysis on Energy Saving Potential in East Asia (ERIA)

ESI	Statistics
	GDP: World Bank
7. Days of on-land oil stocks	Monthly Oil Market Report (IEA) National statistics
8-1. CO2 emissions/TPES ratio	CO2 Emissions from Fuel Combustion (IEA) Energy Balance of OECD, Non-OECD Countries (IEA) Cambodia: TPES: National statistics Lao PDR: CO2: World Bank TPES: WG on Analysis on Energy Saving Potential in East Asia (ERIA)
8-2. CO2 emissions/GDP ratio	CO2 Emissions from Fuel Combustion (IEA) Energy Balance of OECD, Non-OECD Countries (IEA) Lao PDR: World Bank
8-3. CO2 emissions per capita	CO2 Emissions from Fuel Combustion (IEA) Energy Balance of OECD, Non-OECD Countries (IEA) Lao PDR: World Bank

4. Calculating the ESI

It is possible to calculate annual ESI values. However, the purpose of this study was not to analyze changes in indices due to short-term factors such as economic fluctuations. Its purpose was to analyze changes in energy security from a longer-term perspective. Blocks of ten years were used and average values were gathered within the entire period observed. However, in the 2000s, there was striking economic growth in East Asian countries in particular, and this had a major effect on the energy environment. For this reason, this period was split into five-year periods.

Period Abbreviations

1970s	: 1970 - 1979
1980s	: 1980 - 1989
1990s	: 1990 - 1999
2000s-1	: 2000 - 2005
2000s-2	: 2006 – 2009

In addition, within this study a comparative analysis on calculated ESI with three standards was carried out. However, the comparison with the ERIA average was made only when data could be obtained from more than half of the ERIA Member Countries, in other words, eight countries or more.

Among these data, there is a need for caution when doing analysis using the OECD average by time period and the ERIA average by time period. This is because the efficiency of energy consumption in the OECD improves over time; or put another way, the principle for the comparative analysis changes, and for this reason, in doing a comparison with OECD data by time period, it is difficult to see the extent to which the efficiency of energy consumption is improving in East Asian countries.

- OECD average by time period
- OECD average for all time periods
- ERIA average by time period

e.g.)
Comparison against OECD average
= (Index A for country X) / (OECD average of Index A)

Here, depending on what ESI values are being measured, the larger values may indicate a "better situation" or the smaller values may indicate a "better situation." For this reason, in comparing between the OECD and ERIA averages, a conversion is made so that the larger values would indicate the "better situation." Concretely, inverse values are used for the measurements listed below.

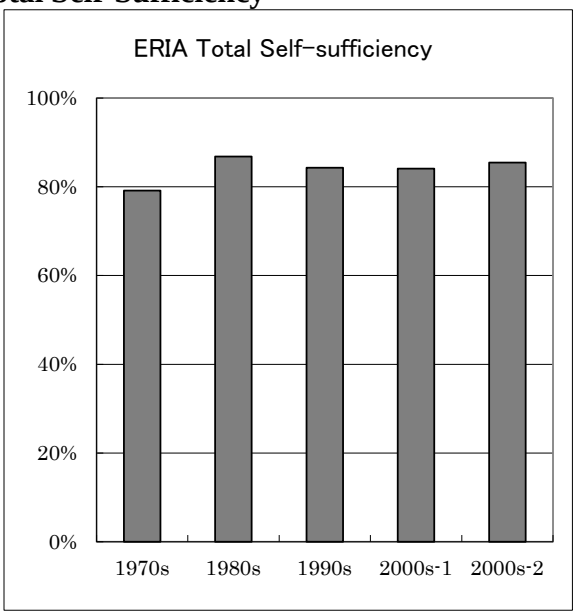
- Diversity of import source countries
- Diversity of energy sources of TPES / electricity
- Middle East dependency of oil and gas
- TPES/GDP ratio
- TFEC/GDP ratio
- CO_2 emissions/TPES ratio
- CO_2 emissions/ GDP ratio
- CO_2 emissions per capita

ESI calculation results are shown from the next section onwards. Figures show the results of ERIA average ESI calculations, while charts show comparisons among ESI calculation results for each country. Where data is not available from more than eight countries, the ERIA average is not shown in figures. Shaded areas in charts show calculations done based on received national statistics (including zero data).

4.1. Self Sufficiency

Although TPES self-sufficiency within the ERIA average has shifted a small amount, the value has basically stayed around 80%.

Figure 2-2: ERIA Total Self-Sufficiency



Looking at the data by country, there are some countries which show a trend of falling self-sufficiency through the period. The representative countries among these are China and India, which have seen energy consumption increase along with economic growth. The trend here is thought to indicate that the speed at which their domestic energy production is expanding has not kept up with consumption.

On the other hand, there are also examples of countries with increasing self-sufficiency. Among these are countries such as Australia and Myanmar, which have self-sufficiency rates above 100%. These countries are rich in fossil fuel sources, and are also thought to be advancing well toward resource development. Conversely, countries like South Korea and the Philippines with self-sufficiency ratios below 100% do not have enough fossil fuel sources to cover demand, but are thought to be heightening their self-sufficiency ratios through the use of nuclear energy, biomass and other renewable energies.

As a reference, please see the Annex for the TPES Self-sufficiency excluding nuclear energy, as well self-sufficiency rates for coal, crude oil and natural gas.

Table 2-3: Results of TPES Self-sufficiency (including Nuclear)

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	120.0%	161.9%	196.4%	232.4%	234.7%
Brunei	2186.2%	1088.5%	796.4%	837.0%	623.9%
Cambodia	-	-	82.9%	80.3%	74.8%
China	101.9%	104.9%	101.2%	97.3%	93.1%
India	91.5%	94.0%	86.9%	79.9%	75.8%
Indonesia	234.0%	194.2%	163.7%	151.2%	169.9%
Japan	10.5%	16.6%	19.4%	19.0%	18.7%
South Korea	29.0%	27.1%	16.8%	18.6%	19.7%
Lao PDR	-	-	91.7%	99.0%	92.4%
Malaysia	120.9%	205.6%	183.0%	155.5%	132.9%
Myanmar	97.8%	101.0%	98.1%	134.7%	149.3%
New Zealand	56.0%	78.7%	88.0%	81.0%	83.7%
Philippines	47.5%	62.3%	50.1%	51.2%	57.9%
Singapore	0.0%	0.0%	0.0%	0.2%	0.2%
Thailand	54.9%	62.1%	58.7%	56.8%	59.2%
Vietnam	90.6%	93.7%	116.0%	129.9%	127.0%
OECD avg.	67.0%	76.7%	75.1%	71.6%	70.7%
ERIA avg.	79.2%	86.8%	84.3%	84.1%	85.5%

Below are comparisons with the OECD average and the ERIA average. Large values show a better situation.

Table 2-4: Comparison (TPES Self-sufficiency, including nuclear)

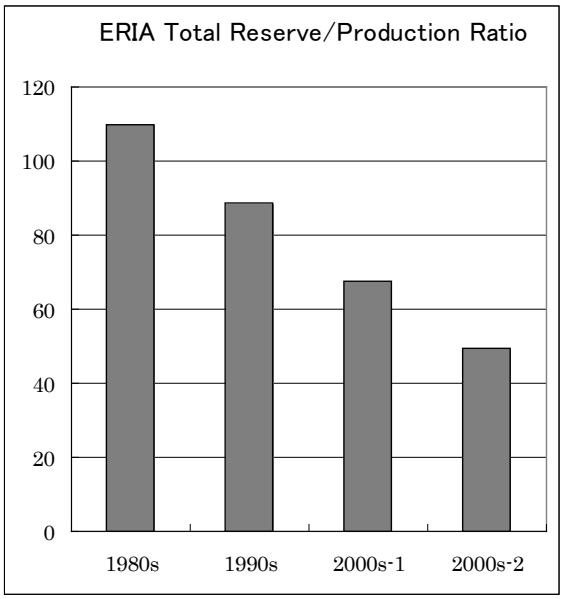
Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	1.8	2.1	2.7	3.2	3.3	1.6	2.2	2.7	3.2	3.2	1.5	1.9	2.3	2.8	2.7
Brunei	32.6	14.2	10.9	11.7	8.8	30.0	15.0	10.9	11.5	8.6	27.6	12.5	9.4	10.0	7.3
Cambodia	-	-	1.1	1.1	1.1	-	-	1.1	1.1	1.0	-	-	1.0	1.0	0.9
China	1.5	1.4	1.4	1.4	1.3	1.4	1.2	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.1
India	1.4	1.2	1.2	1.1	1.1	1.3	1.3	1.2	1.1	1.0	1.2	1.1	1.0	1.0	0.9
Indonesia	3.5	2.5	2.2	2.1	2.4	3.2	2.7	2.2	2.1	2.3	3.0	2.2	1.9	1.8	2.0
Japan	0.2	0.2	0.3	0.3	0.3	0.1	0.2	0.3	0.3	0.3	0.1	0.2	0.2	0.2	0.2
Korea	0.4	0.4	0.2	0.3	0.3	0.4	0.4	0.2	0.3	0.3	0.4	0.3	0.2	0.2	0.2
Lao PDR	-	-	1.3	1.4	1.3	-	-	1.3	1.4	1.3	-	-	1.1	1.2	1.1
Malaysia	1.8	2.7	2.5	2.2	1.9	1.7	2.8	2.5	2.1	1.8	1.5	2.4	2.2	1.8	1.6
Myanmar	1.5	1.3	1.3	1.9	2.1	1.3	1.4	1.3	1.9	2.1	1.2	1.2	1.2	1.6	1.7
New Zealand	0.8	1.0	1.2	1.1	1.2	0.8	1.1	1.2	1.1	1.2	0.7	0.9	1.0	1.0	1.0
Philippines	0.7	0.8	0.7	0.7	0.8	0.7	0.9	0.7	0.7	0.8	0.6.	0.7	0.6	0.6	0.7
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
Vietnam	1.4	1.2	1.6	1.8	1.8	1.2	1.3	1.6	1.8	1.7	1.1	1.1	1.4	1.5	1.5

4.2. Reserve/Production ratio (R/P ratio)

When doing the calculations, R/P ratios were first calculated for coal, crude oil and natural gas, and then the R/P ratio for fossil fuels as a whole was calculated using a weighted average for the primary energy supply, which comprised of coal, crude oil and natural gas.

The ERIA Total R/P ratio was over 100 years for the 1980s, but fell to about 90 years in the 1990s, about 70 years in 2000s-1 and to about 50 years in 2000s-2. The reason for this is the increased speed of energy production increases more than the amount of fossil fuel reserves available due to new development.

Figure 2-3: ERIA Total R/P ratio



Looking at the data by country, there are many countries showing a a decreasing R/P ratio. This, like the trend of the ERIA average, is because the speed of energy production increases is outpacing increases in energy reserves.

Countries showing results differing from this trend are Japan, South Korea and New Zealand. Although these countries have few fossil fuel resources they are shown to have a small amount of coal reserves in BP statistics. Because the amount of energy produced from coal is falling year by year in these countries, the result is that their R/P ratios increase.

Table 2-5: Results of R/P ratio

Country	1980s	1990s	2000s-1	2000s-2
Australia	182.6	176.9	135.1	115.4
Brunei	29.8	34.2	25.7	24.5
Cambodia	-	-	-	-
China	131.9	80.6	53.3	35.3
India	87.0	158.3	133.9	84.5
Indonesia	92.4	37.5	40.3	49.1
Japan	18.2	33.0	100.5	75.9
South Korea	2.3	5.1	5.9	12.4
Lao PDR	-	-	-	-
Malaysia	330.6	38.7	29.5	24.8
Myanmar	108.6	134.8	45.8	31.6
New Zealand	11.7	6.8	17.2	24.9
Philippines	-	-	-	-
Singapore	-	-	-	-
Thailand	51.9	9.4	17.4	16.6
Vietnam	-	36.0	29.0	25.8
OECD avg.	-	66.2	60.1	52.2
ERIA avg.	109.6	88.6	67.5	49.4

The following chart shows a comparison with the OECD and ERIA averages. Larger values show a better situation.

Table 2-6: Comparison (Reserve/ Production ratio)

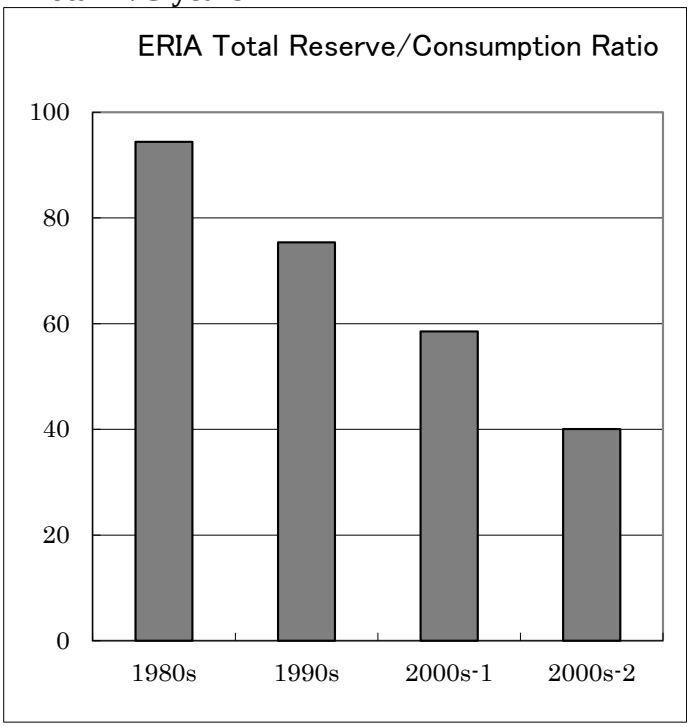
Country	vs. OECD				vs. OECD (whole periods)				vs. ERIA			
	1980s	1990s	2000s 1	2000s 2	1980s	1990s	2000s 1	2000s 2	1980s	1990s	2000s 1	2000s 2
Australia	-	2.7	2.2	2.2	-	2.8	2.2	1.9	1.7	2.0	2.0	2.3
Brunei	-	0.5	0.4	0.5	-	0.5	0.4	0.4	0.3	0.4	0.4	0.5
Cambodia	-	-	-	-	-	-	-	-	-	-	-	-
China	-	1.2	0.9	0.7	-	1.3	0.9	0.6	1.2	0.9	0.8	0.7
India	-	2.4	2.2	1.6	-	2.5	2.2	1.4	0.8	1.8	2.0	1.7
Indonesia	-	0.6	0.7	0.9	-	0.6	0.6	0.8	0.8	0.4	0.6	1.0
Japan	-	0.5	1.7	1.5	-	0.5	1.6	1.2	0.0	0.1	0.1	0.3
Korea	-	0.1	0.1	0.2	-	0.1	0.1	0.2	0.0	0.1	0.1	0.3
Lao PDR	-	0.2	-	-	-	-	-	-	-	-	-	-
Malaysia	-	0.3	0.5	0.5	-	0.6	0.5	0.4	3.0	0.4	0.4	0.5
Myanmar	-	0.4	0.8	0.6	-	2.2	0.7	0.5	1.0	1.5	0.7	0.6
New Zealand	-	0.5	0.3	0.5	-	0.1	0.3	0.4	0.1	0.1	0.3	0.5
Philippines	-	0.6	-	-	-	-	-	-	-	-	-	-
Singapore	-	0.7	-	-	-	-	-	-	-	-	-	-
Thailand	-	0.8	0.3	0.3	-	0.2	0.3	0.3	0.5	0.1	0.3	0.3
Vietnam	-	0.9	0.5	0.5	-	0.6	0.5	0.4	-	0.4	0.4	0.5

4.3. Reserve/Consumption ratio (R/C ratio)

When doing these calculations, R/C ratios were first calculated for coal, crude oil and natural gas, and then the R/C ratio for fossil fuels as a whole was calculated using a weighted average for the primary energy supply, which comprises coal, crude oil and natural gas.

There is a trend toward a decreasing R/C ratio within the ERIA average. The reason for this is the the speed of energy consumption increases is outpacing increases in fossil fuel reserves available due to new development.

Figure 2-4: ERIA Total R/C years



Looking at the data by country, there are many countries showing a trend toward a decreasing R/C ratio. This, like the trend of the ERIA average, is because the speed of energy consumption increases is outpacing increases in energy reserves.

Countries showing results differing from this trend are Indonesia and New Zealand from 2000s-1 onward. Both countries saw the addition of new fossil fuel reserves outpace the expansion of their demand for the period.

Looking at the situation in 2000s-2, Australia, Brunei, Indonesia had ratios of over 100 years, signaling that they possess rich resources in comparison to domestic energy

demand. On the other hand, although China and India possess rich resources as well, especially coal, their large energy consumption means that their R/C ratio is shrinking.

Coal, crude oil and natural gas R/C ratios are shown in the Annex.

Table 2-7: Results of R/C ratio

Country	1980s	1990s	2000s-1	2000s-2
Australia	450.2	466.3	375.0	333.4
Brunei	1,256.2	273.0	202.3	142.1
Cambodia				
China	128.3	75.5	53.0	31.5
India	81.9	148.1	114.9	69.6
Indonesia	209.3	90.2	97.0	130.5
Japan	1.5	1.0	0.7	0.4
South Korea	1.0	0.6	0.2	0.3
Lao PDR				
Malaysia	164.7	108.5	63.2	51.5
Myanmar	130.2	155.4	187.8	112.5
New Zealand	12.6	8.7	24.0	29.7
Philippines				
Singapore				
Thailand	12.6	7.1	12.9	10.3
Vietnam		304.1	75.4	72.3
OECD avg.	-	55.8	47.9	41.3
ERIA avg.	94.4	75.4	58.5	40.1

The following chart shows a comparison with the OECD and ERIA averages. Larger values show a better situation.

Table 2-8: Comparison (Reserve/Consumption ratio)

Country	vs. OECD				vs. OECD (whole periods)				vs. ERIA			
	1980s	1990s	2000s 1	2000s 2	1980s	1990s	2000s 1	2000s 2	1980s	1990s	2000s 1	2000s 2
Australia	-	8.4	7.8	8.1	-	9.1	7.3	6.5	4.8	6.2	6.4	8.3
Brunei	-	4.9	4.2	3.4	-	5.3	4.0	2.8	13.3	3.6	3.5	3.5
Cambodia	-	-	-	-	-	-	-	-	-	-	-	-
China	-	1.4	1.1	0.8	-	1.5	1.0	0.3	1.4	1.0	0.9	0.8
India	-	2.7	2.4	1.7	-	2.9	2.2	1.4	0.9	2.0	2.0	1.7
Indonesia	-	1.6	2.0	3.2	-	1.8	1.9	2.6	2.2	1.2	1.7	3.3
Japan	-	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Korea	-	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lao PDR	-	-	-	-	-	-	-	-	-	-	-	-
Malaysia	-	1.9	1.3	1.2	-	2.1	1.2	1.0	1.7	1.4	1.1	1.3
Myanmar	-	2.8	3.9	2.7	-	3.0	3.7	2.2	1.4	2.1	3.2	2.8
New Zealand	-	0.2	0.5	0.7	-	0.2	0.5	0.6	0.1	0.1	0.4	0.7
Philippines	-	-	-	-	-	-	-	-	-	-	-	-
Singapore	-	-	-	-	-	-	-	-	-	-	-	-
Thailand	-	0.1	0.3	0.2	-	0.1	0.3	0.2	0.1	0.1	0.2	0.3
Vietnam	-	5.5	1.6	1.7	-	5.9	1.5	1.4	-	4.0	1.3	1.8

4.4. Diversity of Import Source Countries

As there are countries among the ERIA member countries that are not importing coal, crude oil or natural gas, the subjects of comparison for the measurement of the diversity of import source countries is limited. The following are HHI calculation results showing the extent of the diversification of import source countries.

Diversity increased for coal in the importing countries of China, India, and South Korea, while concentration increased in Japan. For crude oil, while Australia, China, New Zealand and Thailand progressed in terms of import diversity, Japan and South Korea saw a trend toward concentration. While few countries are importing natural gas, all such countries moved toward the diversification of import sources.

Table 2-9: Result of HHI (Diversity of import source countries)

Country	Coal Imports					Crude oil Imports					Natural gas Imports				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia						2.549	2.443	1.420	1.309	1.440					
Brunei															
Cambodia															
China			4.737	2.329	2.378			1.428	1.034	1.095					5.740
India	5.630	9.104	5.991	3.798	3.294									10.000	5.831
Indonesia															
Japan	3.082	2.950	3.303	3.799	4.200	1.713	1.399	1.517	1.697	1.859	3.566	3.448	2.519	1.839	1.458
Korea	3.379	2.889	2.461	2.956	2.636			1.477	1.425	1.553		10.000	5.768	2.267	1.955
Lao PDR															
Malaysia															
Myanmar															
New Zealand				7.409	8.102		3.135	2.096	1.411	1.300					
Philippines															
Singapore															
Thailand					5.854		2.230	1.713	1.562	1.787			10.000	10.000	10.000
Vietnam															
OECD Total	1.484	1.780	1.543	1.468	1.516	983	691	696	698	704	2.459	1.660	1.531	1.135	964

The following shows a comparison with the OECD average by time period. With HHI, the better situation is shown by lower values, but as inverse numbers have been used for HHI for the purpose of this comparison, the large values here show the better situation.

Table 2-10: Comparison (Diversity of import source countries)

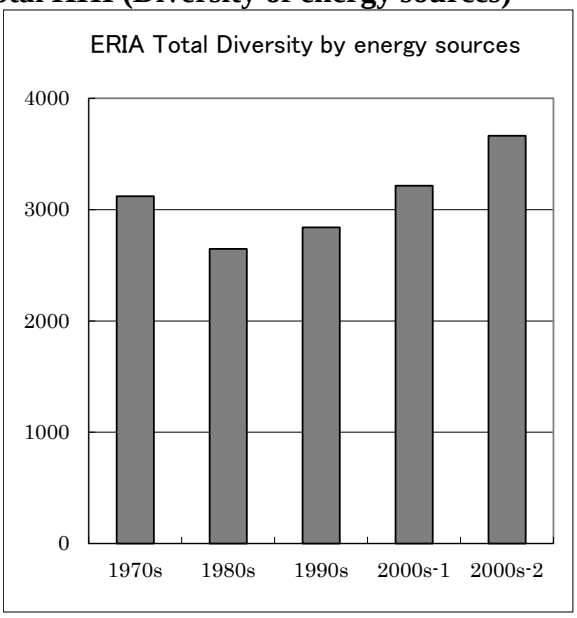
Country	Coal Imports					Crude oil Imports					Natural gas Imports				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia						0.4	0.3	0.5	0.5	0.5					
Brunei															
Cambodia															
China			0.3	0.6	0.6			0.5	0.7	0.6					0.2
India	0.3	0.2	0.3	0.4	0.5									0.1	0.2
Indonesia															
Japan	0.5	0.6	0.5	0.4	0.4	0.6	0.5	0.5	0.4	0.4	0.7	0.5	0.6	0.6	0.7
Korea	0.4	0.6	0.6	0.5	0.6			0.5	0.5	0.5		0.2	0.3	0.5	0.5
Lao PDR															
Malaysia															
Myanmar															
New Zealand				0.2	0.2		0.2	0.3	0.5	0.5					
Philippines															
Singapore															
Thailand					0.3		0.3	0.4	0.4	0.4			0.2	0.1	0.1
Vietnam															

4.5. Diversity of Energy Sources of TPES / Electricity

First the extent of diversity among energy sources in TPES and electricity were calculated, and concretely, in HHI. Next, a simple average of the two HHI values was taken, and this was used to calculate total values for the diversity of energy sources of TPES and electricity. HHI calculation results for TPES and electricity individually are shown in the Annex.

For ERIA as a whole, although diversification increased from the 1970s and 1980s, since then concentration has been progressing. One reason for this may be an increase in the consumption of coal by power stations, which resulted in a worsening in the extent of diversification of electricity supply sources.

Figure 2-5: ERIA Total HHI (Diversity of energy sources)



Excluding China and Thailand, diversification increased throughout the period of evaluation. The reason for increased concentration in China and Thailand is thought to be a surge of coal and natural gas in the power station sector. Limiting the analysis to only electricity, and excluding China and Thailand, the concentration of energy usage increased in many countries, including India, Indonesia, Japan, South Korea, Malaysia and Myanmar.

Table 2-11: Result of HHI (Diversity of energy sources)

((TPES + Generation)/ 2)

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	4,572	4,571	5,048	4,917	4,829
Brunei	9,647	8,987	8,653	7,911	8,155
Cambodia	-	-	10,000	9,637	9,589
China	4,066	4,369	5,185	5,331	5,718
India	4,286	4,217	4,175	4,079	3,984
Indonesia	5,310	3,725	2,923	2,802	2,858
Japan	5,127	2,960	2,693	2,567	2,508
South Korea	6,286	3,551	3,606	3,377	3,245
Lao PDR	-	-	8,419	8,032	7,467
Malaysia	6,293	4,432	4,020	4,708	4,198
Myanmar	5,801	5,217	5,520	5,136	4,999
New Zealand	4,350	4,082	3,756	3,203	2,882
Philippines	6,127	3,348	3,202	2,338	2,230

Country	1970s	1980s	1990s	2000s-1	2000s-2
Singapore	9,996	9,997	8,123	6,797	7,319
Thailand	5,011	3,261	3,207	4,286	4,168
Vietnam	7,148	5,440	5,869	4,188	3,580
OECD avg.	3,018	2,770	2,633	2,592	2,521
ERIA avg.	3,120	2,648	2,840	3,215	3,662

The following is a comparison with OECD and ERIA averages. With HHI, the better situation is shown by lower values, but as inverse numbers have been used for HHI for the purpose of this comparison, the large values here show the better situation. HHI calculation results for TPES and electricity individually are shown in the Annex.

Table 2-12: Comparison (Diversity of energy sources)
((TPES + Generation)/ 2)

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.7	0.6	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.7	0.6	0.6	0.7	0.8
Brunei	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Cambodia	-	-	0.3	0.3	0.3	-	-	0.3	0.3	0.3	-	-	0.3	0.3	0.4
China	0.7	0.6	0.5	0.5	0.4	0.6	0.6	0.5	0.5	0.5	0.8	0.6	0.5	0.6	0.6
India	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.7	0.8	0.9
Indonesia	0.6	0.7	0.9	0.9	0.9	0.5	0.7	0.9	0.9	0.9	0.6	0.7	1.0	1.1	1.3
Japan	0.6	0.9	1.0	1.0	1.0	0.5	0.9	1.0	1.0	1.1	0.6	0.9	1.1	1.3	1.5
Korea	0.5	0.8	0.7	0.8	0.8	0.4	0.7	0.7	0.8	0.8	0.5	0.7	0.8	1.0	1.1
Lao PDR	-	-	0.3	0.3	0.3	-	-	0.3	0.3	0.4	-	-	0.3	0.4	0.5
Malaysia	0.5	0.6	0.7	0.6	0.6	0.4	0.6	0.7	0.6	0.6	0.5	0.6	0.7	0.7	0.9
Myanmar	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7
New Zealand	0.7	0.7	0.7	0.8	0.9	0.6	0.6	0.7	0.8	0.9	0.7	0.6	0.8	1.0	1.3
Philippines	0.5	0.8	0.8	1.1	1.1	0.4	0.8	0.8	1.1	1.2	0.5	0.8	0.9	1.4	1.6
Singapore	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.5	0.5
Thailand	0.6	0.8	0.8	0.6	0.6	0.5	0.8	0.8	0.6	0.6	0.6	0.8	0.9	0.8	0.9
Vietnam	0.4	0.5	0.4	0.6	0.7	0.4	0.5	0.4	0.6	0.7	0.4	0.5	0.5	0.8	1.0

4.6. Middle East Dependence of Oil and Gas

The number of ERIA member countries that did evaluations of oil and gas was limited.

The following shows calculation results. Japan, South Korea, and Thailand show trends toward increased dependency on the Middle East. The reason seems to be that while imports from Southeast Asia appear to be leveling out, imports from the Middle East, rich as it is in natural resources, have been increasing. On the other hand, the dependency of Australia on the Middle East for its oil decreased significantly, while China and New Zealand maintained nearly steady values.

Table 2-13: Middle East Dependence rate

Country	Crude oil					Natural gas				
	1970s	1980s	1990s	2000s-1	2000s-2	1970s	1980s	1990s	2000s-1	2000s-2
Australia	85.4%	68.4%	35.5%	20.0%	15.4%	-	-	-	-	-
Brunei	-	-	-	-	-	-	-	-	-	-
Cambodia	-	-	-	-	-	-	-	-	-	-
China	-	-	47.8%	48.3%	47.1%	-	-	-	-	4.2%
India	-	-	-	-	-	-	-	-	100.0 %	79.9%
Indonesia	-	-	-	-	-	-	-	-	-	-
Japan	77.6%	70.3%	79.1%	88.1%	88.1%	5.7%	8.7%	10.4%	22.0%	24.7%
South Korea	-	-	74.7%	77.8%	83.3%	-	0.0%	0.9%	49.0%	47.7%
Lao PDR	-	-	-	-	-	-	-	-	-	-
Malaysia	-	-	-	-	-	-	-	-	-	-
Myanmar	-	-	-	-	-	-	-	-	-	-
New Zealand	-	64.1%	70.8%	59.8%	64.1%	-	-	-	-	-
Philippines	-	-	-	-	-	-	-	-	-	-
Singapore	-	-	-	-	-	-	-	-	-	-
Thailand	-	58.0%	71.0%	77.7%	80.3%	-	-	0.0%	0.0%	0.0%
Vietnam	-	-	-	-	-	-	-	-	-	-
OECD avg.	55.1%	38.2%	39.0%	36.5%	33.2%	0.4%	1.4%	2.0%	6.2%	7.8%

The following is a comparison with the OECD average by time period. With dependency on the Middle East, the better situation is shown by lower values, but as inverse numbers have been used, the large values here show the better situation.

Table 2-14: Comparison (Middle East Dependence)

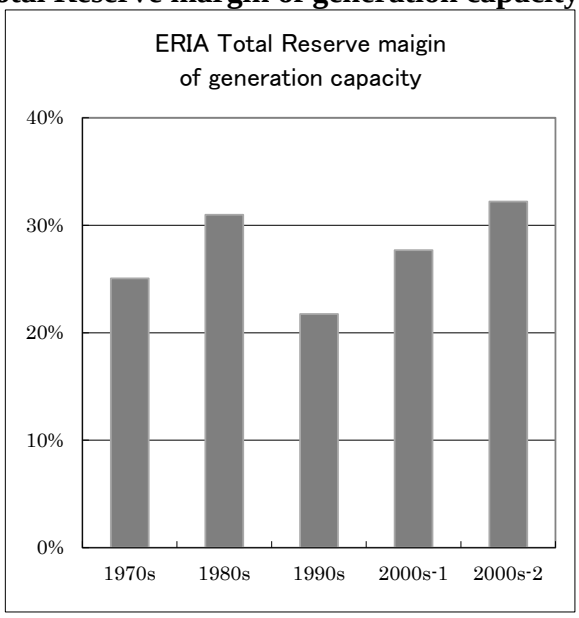
Country	Crude oil					Natural gas				
	1970s	1980s	1990s	2000s-1	2000s-2	1970s	1980s	1990s	2000s-1	2000s-2
Australia	0.6	0.6	1.1	1.8	2.1	-	-	-	-	-
Brunei	-	-	-	-	-	-	-	-	-	-
Cambodia	-	-	-	-	-	-	-	-	-	-
China	-	-	0.8	0.8	0.7	-	-	-	-	1.9
India	-	-	-	-	-	-	-	-	0.1	0.1
Indonesia	-	-	-	-	-	-	-	-	-	-
Japan	0.7	0.5	0.5	0.4	0.4	0.1	0.2	0.2	0.3	0.3
South Korea	-	-	0.5	0.5	0.4	-	-	2.3	0.1	0.2
Lao PDR	-	-	-	-	-	-	-	-	-	-

Country	Crude oil					Natural gas				
	1970s	1980s	1990s	2000s-1	2000s-2	1970s	1980s	1990s	2000s-1	2000s-2
Malaysia	-	-	-	-	-	-	-	-	-	-
Myanmar	-	-	-	-	-	-	-	-	-	-
New Zealand	-	0.6	0.6	0.6	0.5	-	-	-	-	-
Philippines	-	-	-	-	-	-	-	-	-	-
Singapore	-	-	-	-	-	-	-	-	-	-
Thailand	-	0.7	0.5	0.5	0.4	-	-	-	-	-
Vietnam	-	-	-	-	-	-	-	-	-	-

4.7. Reserve Margin of Generation Capacity

The Reserve margin of generation capacity for ERIA as a whole was above 30% in the 1980s, and then shrank to close to 20% in the 1990s. After that, it rose again to over 30% in 2000s-2.

Figure 2-6: ERIA Total Reserve margin of generation capacity



Looking at the data per country, there are variations in the trends of reserve margins. It is thought that there are a variety of reasons for such differences, including progress in policies, and investments, in power sources development, the situation of competition in the power generation field, and so on.

Table 2-15: Reserve margin of generation capacity

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	32.6%	36.5%	29.0%	27.5%	25.7%
Brunei	-	-	-	-	-
Cambodia	-	-	-	-	-
China	-	-	-	34.9%	37.0%
India	-	-	35.8%	35.5%	36.2%
Indonesia	-	-	33.6%	19.0%	10.1%
Japan	23.7%	29.2%	20.0%	24.1%	26.4%
South Korea	31.9%	37.9%	14.9%	14.5%	10.3%
Lao PDR	-	-	-	-	-
Malaysia	-	-	0.9%	26.4%	32.1%
Myanmar	-	-	-	-	-
New Zealand	-	-	31.5%	31.9%	31.3%
Philippines	-	-	41.8%	44.7%	43.4%
Singapore	-	-	-	-	-
Thailand	-	-	20.5%	24.9%	21.9%
Vietnam	-	24.3%	34.7%	18.2%	15.1%
OECD avg.	31.7%	35.3%	29.0%	29.1%	31.7%
ERIA avg.	25.1%	31.0%	21.8%	27.7%	32.2%

The following chart shows a comparison with the OECD and ERIA averages. Larger values show a better situation.

Table 2-16: Comparison (Reserve margin of generation capacity)

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	1.0	1.0	1.0	0.9	0.8	1.0	1.2	0.9	0.9	0.8	1.3	1.2	1.3	1.0	0.8
Brunei															
Cambodia															
China				1.2	1.2				1.1	1.2				1.3	1.1
India			1.2	1.2	1.1			1.1	1.1	1.2			1.6	1.3	1.1
Indonesia			1.2	0.7	0.3			1.1	0.6	0.3			1.5	0.7	0.3
Japan	0.7	0.8	0.7	0.8	0.8	0.8	0.9	0.6	0.8	0.8	0.9	0.9	0.9	0.9	0.8
Korea	1.0	1.1	0.5	0.5	0.3	1.0	1.2	0.5	0.5	0.3	1.3	1.2	0.7	0.5	0.3
Lao PDR															
Malaysia			0.0	0.9	1.0			0.0	0.8	1.0			0.0	1.0	1.0
Myanmar															
New Zealand			1.1	1.1	1.0			1.0	1.0	1.0			1.4	1.2	1.0
Philippines			1.4	1.5	1.4			1.3	1.4	1.4			1.9	1.6	1.3
Singapore															
Thailand			0.7	0.9	0.7			0.7	0.8	0.7			0.9	0.9	0.7
Vietnam		0.7	1.2	0.6	0.5		0.8	1.1	0.6	0.5		0.8	1.6	0.7	0.5

4.8. Power Outage Frequency/Duration

Data on power outage frequency and power outage duration could only be obtained from a limited number of countries. The following shows the situations for these countries.

Table 2-17: Power outage frequency

Unit: times/ year

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	-	-	--	2.24	2.10
Brunei	-	-	-	-	-
Cambodia	-	-	-	-	-
China	-	-	-	-	-
India	-	-	-	-	-
Indonesia	-	-	-	13.88	11.15
Japan	1.60	0.85	0.25	0.20	0.31
South Korea	-	4.25	1.26	0.53	-
Lao PDR	-	-	-	-	-
Malaysia	-	-	-	1.43	0.85
Myanmar	-	-	-	-	-
New Zealand	-	-	2.01	1.66	2.44
Philippines	-	-	-	-	-
Singapore	-	-	-	-	-
Thailand	-	-	-	-	-
Vietnam	-	-	-	-	-

Table 2-18: Power outage duration

Unit: minutes/ year

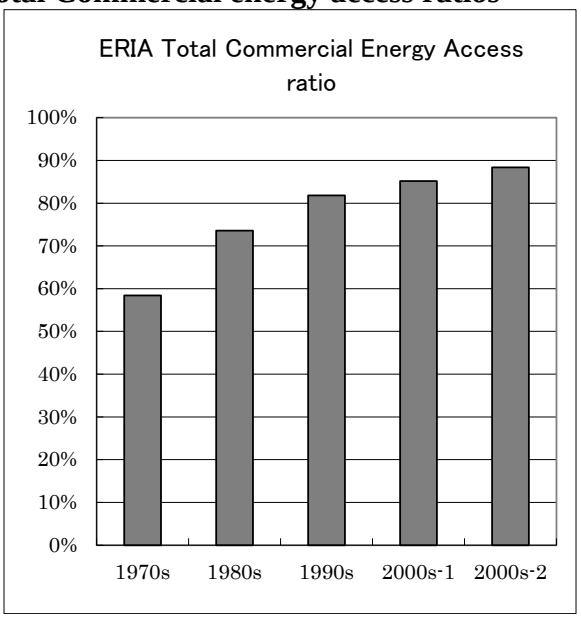
Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	-	-	-	212.1	246.4
Brunei	-	-	-	-	-
Cambodia	-	-	-	-	-
China	-	-	-	-	-
India	-	-	-	-	-
Indonesia	-	-	-	13.6	21.0
Japan	226.8	121.5	40.4	28.7	115.6
South Korea	-	494.4	122.2	19.5	18.0
Lao PDR	-	-	-	-	-
Malaysia	-	-	552.7	191.5	72.8
Myanmar	-	-	-	-	-

Country	1970s	1980s	1990s	2000s-1	2000s-2
New Zealand	-	-	5.0	4.7	21.8
Philippines	-	-	-	-	-
Singapore	-	-	-	-	-
Thailand	-	-	-	-	-
Vietnam	-	-	-	-	-

4.9. Commercial Energy Access Ratio

Access to commercial energy has improved for ERIA as a whole over all time periods.

Figure 2-7: ERIA Total Commercial energy access ratios



The trend here is similar no matter the country observed. Access to commercial energy improved in all countries.

Table 2-19: Commercial energy access ratios

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	-	98.5%	96.2%	96.3%	96.9%
Brunei	98.1%	99.6%	100.0%	100.0%	100.0%
Cambodia	-	-	21.9%	28.2%	33.7%
China	65.7%	72.6%	79.6%	85.0%	90.5%
India	40.8%	50.6%	62.9%	69.0%	73.7%
Indonesia	38.4%	54.1%	65.3%	71.0%	73.6%
Japan	-	99.5%	99.5%	99.5%	99.5%

Country	1970s	1980s	1990s	2000s-1	2000s-2
South Korea	-	-	99.8%	99.9%	99.9%
Lao PDR	-	-	25.7%	31.2%	38.3%
Malaysia	-	94.6%	96.8%	97.6%	98.0%
Myanmar	28.9%	29.5%	26.1%	31.3%	36.4%
New Zealand	97.1%	95.8%	94.9%	93.9%	94.3%
Philippines	65.0%	68.7%	77.9%	85.5%	87.4%
Singapore	99.8%	100.0%	100.0%	100.0%	100.0%
Thailand	76.9%	81.3%	89.2%	91.4%	91.3%
Vietnam	27.3%	26.7%	33.2%	49.7%	59.5%
OECD avg.	99.2%	98.8%	97.9%	97.8%	97.7%
ERIA avg.	58.4%	73.6%	81.8%	85.2%	88.4%

The following chart shows a comparison with the OECD and ERIA averages. Larger values show a better situation.

Table 2-20: Comparison (Commercial energy access ratio)

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	-	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0	-	1.4	1.2	1.2	1.1
Brunei	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	1.4	1.2	1.2	1.2
Cambodia	-	-	0.2	0.3	0.3	-	-	0.2	0.3	0.3	-	-	0.3	0.3	0.4
China	0.7	0.7	0.8	0.9	0.9	0.7	0.7	0.8	0.9	0.9	1.1	1.0	1.0	1.0	1.0
India	0.4	0.5	0.6	0.7	0.8	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.8	0.9	0.9
Indonesia	0.4	0.5	0.7	0.7	0.8	0.4	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.9
Japan	-	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0	-	1.4	1.2	1.2	1.2
Korea	-	-	1.0	1.0	1.0	-	-	1.0	1.0	1.0	-	-	1.2	1.2	1.2
Lao PDR	-	-	0.3	0.3	0.4	-	-	0.3	0.3	0.4	-	-	0.3	0.4	0.4
Malaysia	-	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0	-	1.3	1.2	1.2	1.1
Myanmar	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.5	0.4	0.3	0.4	0.4
New Zealand	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	1.3	1.2	1.1	1.1
Philippines	0.7	0.7	0.8	0.9	0.9	0.7	0.7	0.8	0.9	0.9	1.1	0.9	1.0	1.0	1.0
Singapore	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	1.4	1.2	1.2	1.2
Thailand	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.9	1.3	1.1	1.1	1.1	1.1
Vietnam	0.3	0.3	0.3	0.5	0.6	0.3	0.3	0.3	0.5	0.6	0.5	0.4	0.4	0.6	0.7

In Working Group meetings, the adoption of the electrification rate was proposed instead of commercial energy access. However, it is not easy to obtain data for electrification rates in line with a cohesive definition. The IEA provided electrification rate data to the World Energy Outlook (WEO) in 2000, 2005 and 2009, and this data is shown below as a reference. The ERIA Total Electrification rate is calculated using a weighted average for population, assuming the figures for OECD countries without the IEA data for the WEO to be 100%.

Table 2-21: Electrification rate

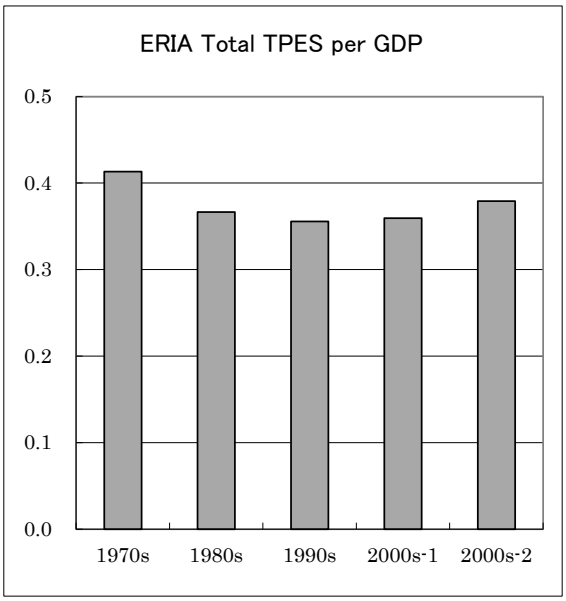
Country	2000 (WEO 2002)		2005 (WEO 2006)		2009 (WEO 2011)	
	Electrification rate (%)	Population without electricity (million)	Electrification rate (%)	Population without electricity (million)	Electrification rate (%)	Population without electricity (million)
Australia	-	-	-	-	-	-
Brunei	99.2%	0.0	99.2%	0.0	99.7%	0.0
Cambodia	15.8%	10.3	20.1%	10.9	24.0%	11.3
China	98.6%	17.6	99.4%	8.5	99.4%	8.0
India	43.0%	579.1	55.5%	487.2	75.0%	288.8
Indonesia	53.4%	98.0	54.0%	101.2	64.5%	81.6
Japan	-	-	-	-	-	-
South Korea	-	-	-	-	-	-
Lao PDR	-	-	-	-	55.0%	2.6
Malaysia	96.9%	0.7	97.8%	0.6	99.4%	0.2
Myanmar	5.0%	45.3	11.3%	45.1	13.0%	43.5
New Zealand	-	-	-	-	-	-
Philippines	87.4%	9.5	80.5%	16.2	89.7%	9.5
Singapore	100.0%	-	100.0%	-	100.0%	-
Thailand	82.1%	10.9	99.0%	0.6	99.3%	0.5
Vietnam	75.8%	19.0	84.2%	13.2	97.6%	2.1
ERIA avg.	73.5%	790.4	78.2%	683.5	86.3%	448.1

Note: WEO provided only Non-OECD Electrification rate.

4.10. TPES/GDP Ratio

The TPES/GDP ratio fell from the 1970s to the 1990s, showing, in other words, that energy efficiency was improving. However, from then through to 2000s-2, TPES/GDP ratio has increased, indicating a worsening of energy efficiency. Up until the 1990s the GDP growth rate was higher than the growth in the energy consumption rate, but since then there has been a reversal in. Reasons for the reversal are the increasing energy demand in China and the lower GDP growth in Japan. In terms of energy demand, China is dominant in the East Asia region and their share is about half. On the other hand, in terms of GDP, Japan is dominant and their share is also about half of the total. With these factors in mind the increase in East Asian energy demand, mainly led by China is higher than that of GDP growth which is dominated by Japan. Thus the ratio of TPES to GDP worsened throughout the 2000s time-period.

Figure 2-8: ERIA Total TPES/GDP ratio



The following shows the TPES/GDP ratio for ERIA member countries. Most countries show a trend of improvements in energy efficiency over the evaluation period. Brunei and Malaysia, however, showed a worsening in energy efficiency. New Zealand's energy efficiency worsened until the 1990s, and improved after that.

Table 2-22: TPES/GDP ratio

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	0.321	0.299	0.280	0.250	0.243
Brunei	0.165	0.313	0.402	0.382	0.483
Cambodia	-	-	1.158	0.879	0.665
China	3.676	2.348	1.307	0.877	0.800
India	1.322	1.248	1.102	0.913	0.776
Indonesia	1.053	0.878	0.871	0.912	0.803
Japan	0.146	0.114	0.109	0.108	0.099
South Korea	0.331	0.317	0.348	0.333	0.304
Lao PDR	-	-	1.096	0.897	0.844
Malaysia	0.417	0.463	0.492	0.514	0.511
Myanmar	2.797	2.270	1.958	1.114	0.827
New Zealand	0.269	0.287	0.328	0.286	0.255
Philippines	0.509	0.498	0.535	0.470	0.363
Singapore	0.266	0.222	0.275	0.192	0.124

Country	1970s	1980s	1990s	2000s-1	2000s-2
Thailand	0.658	0.517	0.542	0.612	0.593
Vietnam	2.178	1.911	1.369	1.168	1.074
OECD avg.	0.299	0.247	0.217	0.196	0.180
ERIA avg.	0.413	0.366	0.356	0.359	0.379

The following is a comparison with OECD and ERIA averages. With the TPES/GDP ratio, the better situation is shown by lower values, but as inverse numbers have been used for the TPES/GDP ratio for the purpose of this comparison, the large values here show the better situation.

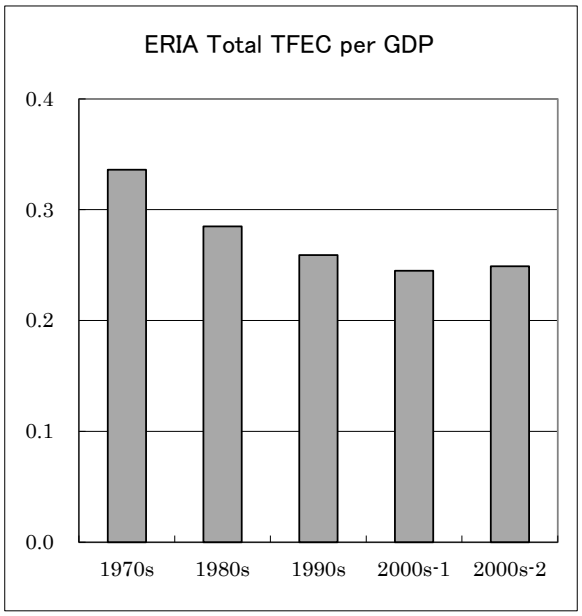
Table 2-23: Comparison (TPES/GDP ratio)

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.9	0.8	0.8	0.8	0.7	0.7	0.8	0.8	0.9	0.9	1.3	1.2	1.3	1.4	1.5
Brunei	1.8	0.8	0.5	0.5	0.4	1.4	0.7	0.6	0.6	0.5	2.5	1.2	0.9	0.9	0.8
Cambodia	-	-	0.2	0.2	0.3	-	-	0.2	0.3	0.3	-	-	0.3	0.4	0.6
China	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.1	0.2	0.3	0.4	0.5
India	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.5
Indonesia	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.4	0.4	0.4	0.5
Japan	2.1	2.2	2.0	1.8	1.8	1.5	2.0	2.1	2.1	2.3	2.8	3.2	3.2	3.3	3.8
Korea	0.9	0.8	0.6	0.6	0.6	0.7	0.7	0.6	0.7	0.7	1.2	1.1	1.0	1.1	1.2
Lao PDR	-	-	0.2	0.2	0.2	-	-	0.2	0.3	0.3	-	-	0.3	0.4	0.4
Malaysia	0.7	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	1.0	0.8	0.7	0.7	0.7
Myanmar	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.3	0.1	0.2	0.2	0.3	0.5
New Zealand	1.1	0.9	0.7	0.7	0.7	0.8	0.8	0.7	0.8	0.9	1.5	1.3	1.1	1.2	1.5
Philippines	0.6	0.5	0.4	0.4	0.5	0.4	0.5	0.4	0.5	0.6	0.8	0.7	0.7	0.8	1.0
Singapore	1.1	1.1	0.8	1.0	1.4	0.8	1.0	0.8	1.2	1.8	1.5	1.6	1.3	1.8	3.0
Thailand	0.5	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.6	0.7	0.6	0.6	0.6
Vietnam	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3

4.11. TFEC/GDP Ratio

TEC/GDP ratio shrank across all time periods, indicating progress in the improvement of energy efficiency at the end-user level.

Figure 2-9: ERIA Total TFEC/GDP Ratio



The following shows TFEC/GDP ratio for ERIA member countries. Most countries exhibited trends toward improved energy efficiency over the evaluation period.

Table 2-24: TFEC/GDP Ratio

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	0.218	0.197	0.182	0.159	0.109
Brunei	0.026	0.056	0.092	0.095	0.168
Cambodia	-	-	1.027	0.757	0.412
China	3.125	1.933	0.985	0.587	0.371
India	1.186	1.047	0.823	0.622	0.373
Indonesia	0.932	0.753	0.644	0.683	0.431
Japan	0.105	0.076	0.073	0.072	0.050
South Korea	0.258	0.223	0.246	0.224	0.148
Lao PDR	-	-	0.996	0.816	0.544
Malaysia	0.283	0.278	0.297	0.319	0.234
Myanmar	2.504	1.967	1.729	0.993	0.565
New Zealand	0.198	0.211	0.249	0.218	0.139
Philippines	0.411	0.340	0.358	0.284	0.158
Singapore	0.105	0.107	0.095	0.097	0.072
Thailand	0.841	0.608	0.630	0.603	0.385
Vietnam	2.067	1.760	1.270	1.039	0.677
OECD avg.	0.222	0.176	0.149	0.135	0.094
ERIA avg.	0.336	0.285	0.259	0.245	0.249

The following chart shows a comparison with the OECD and ERIA averages. with the TFEC/GDP ratio, the better situation is shown by lower values, but as inverse numbers have been used for the TFEC/GDP ratio for the purpose of this comparison, the large values here show the better situation.

Table 2-25: Comparison (TFEC/GDP ratio)

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	1.4	1.3	1.2	1.2	1.6	0.7	0.8	0.8	1.0	1.4	1.9	1.8	1.9	2.2	3.4
Brunei	11.4	4.5	2.4	2.1	1.1	5.9	2.8	1.7	1.6	0.9	15.6	6.6	3.8	3.7	2.2
Cambodia	-	-	0.2	0.3	0.4	-	-	0.1	0.2	0.4	-	-	0.3	0.5	0.9
China	0.1	0.1	0.2	0.3	0.5	0.0	0.1	0.2	0.3	0.4	0.1	0.2	0.4	0.6	1.0
India	0.3	0.2	0.3	0.3	0.5	0.1	0.1	0.2	0.2	0.4	0.3	0.3	0.4	0.6	1.0
Indonesia	0.3	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.5	0.5	0.9
Japan	2.9	3.3	3.0	2.7	3.6	1.5	2.0	2.1	2.1	3.1	3.9	4.8	4.8	4.9	7.5
Korea	1.2	1.1	0.9	0.9	1.2	0.6	0.7	0.6	0.7	1.0	1.6	1.6	1.4	1.6	2.5
Lao PDR	-	-	0.2	0.2	0.3	-	-	0.2	0.2	0.3	-	-	0.4	0.4	0.7
Malaysia	1.1	0.9	0.7	0.6	0.8	0.5	0.6	0.5	0.5	0.7	1.4	1.3	1.2	1.1	1.6
Myanmar	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	0.4	0.7
New Zealand	1.5	1.2	0.9	0.9	1.3	0.8	0.7	0.6	0.7	1.1	2.1	1.7	1.4	1.6	2.7
Philippines	0.7	0.7	0.6	0.7	1.1	0.4	0.5	0.4	0.5	1.0	1.0	1.1	1.0	1.2	2.4
Singapore	2.9	2.3	2.3	2.0	2.5	1.5	1.4	1.6	1.6	2.1	3.9	3.4	3.7	3.6	5.1
Thailand	0.4	0.4	0.3	0.3	0.5	0.2	0.3	0.2	0.3	0.4	0.5	0.6	0.6	0.6	1.0
Vietnam	0.1	0.1	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.6

4.12. Days of On-land Oil Stocks

IEA member countries are supposed to sustain emergency oil stocks equivalent to over 90 days of their net oil imports. Data on emergency stocks is available for OECD countries, but not for non-OECD countries other than Myanmar.

The following shows a comparison of days of on-land oil stocks against the OECD average. Only Japan exceeded the OECD average.

Note: This analysis is based on the data obtained from the "Monthly oil market report" of the IEA. The definition of "Days" in the "Monthly oil market report" is different from that calculated by using net imports of oil.

(See page 14)—shall adjust

Table 2-26: Days of on-land oil stocks

Country	1980s		1990s		2000s-1		2000s-2	
	Days	vs. OECD	Days	vs. OECD	Days	vs. OECD	Days	vs. OECD
Australia	64	0.7	48	0.5	40	0.5	40	0.5
Brunei								
Cambodia								
China								
India								
Indonesia								
Japan	101	1.1	103	1.2	105	1.3	122	1.4
South Korea			34	0.4	53	0.7	66	0.7
Lao PDR						0.0		
Malaysia								
Myanmar							71	0.8
New Zealand	74	0.8	69	0.8	59	0.8	50	0.6
Philippines								
Singapore								
Thailand								
Vietnam								
OECD avg.	95		88		79		89	

4.13. CO_2 Emission

The CO_2 emissions/ TPES, CO_2 emissions/fossil fuel, CO_2 emissions/GDP ratios, and CO_2 emissions per capita were adopted as measurements by which to evaluate CO_2 emissions.

ERIA's total CO_2 emissions/TPES ratio increased with time. The reason for this is thought to be an expansion in the use of commercial energy.

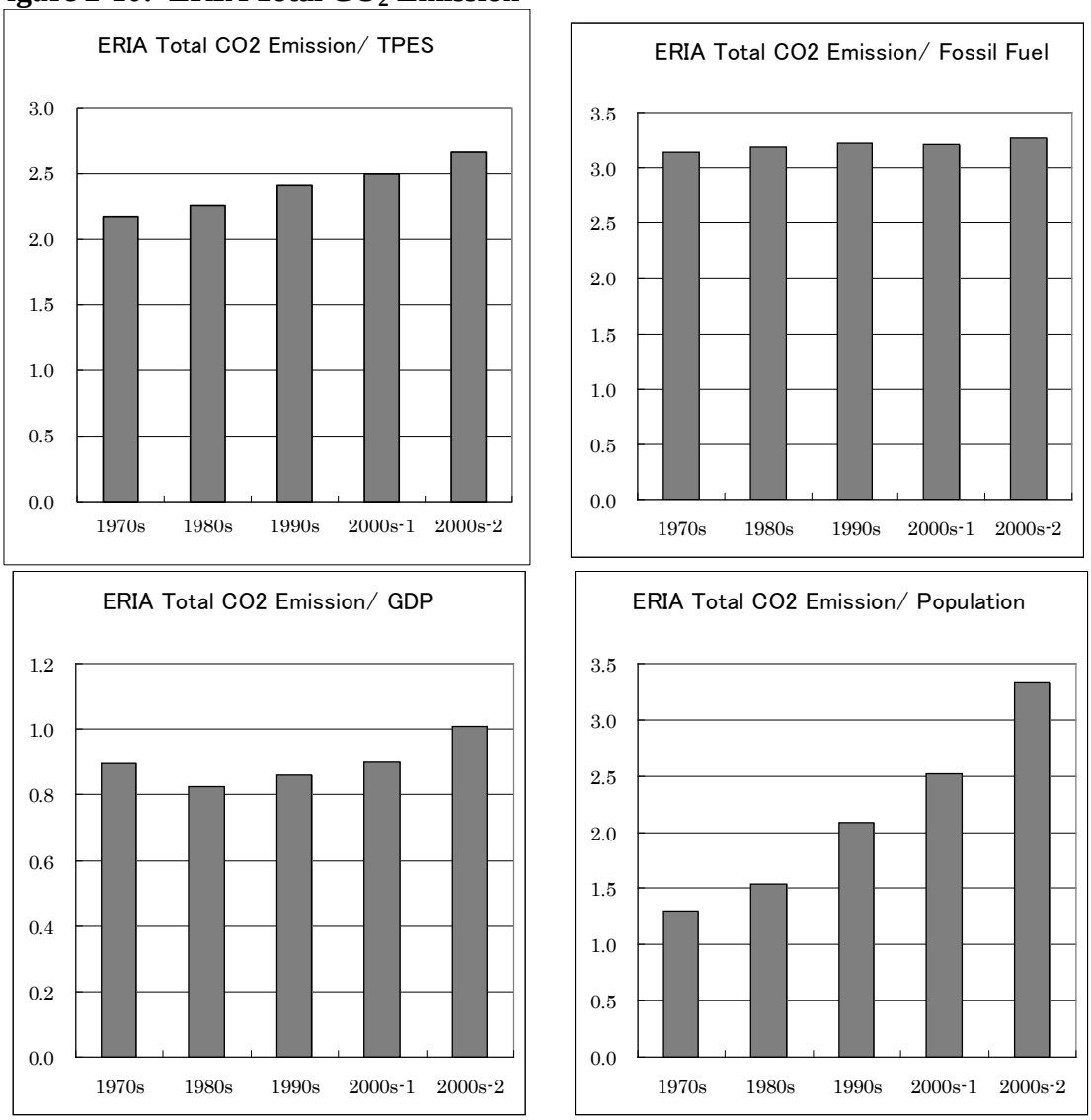
ERIA's total CO_2 emissions/fossil fuel ratio hardly changed at all, signifying that there was no major change in the composition of fossil fuel usage or energy use efficiency.

ERIA's total CO_2 emissions/GDP ratio shrank from the 1970s to the 1980s, but has basically been on an increasing trend after that. The reason for this is thought to be the dulling of economic growth which was led by a stagnant Japanese economy and, conversely, the increased speed at which energy demand expanded, dominated by China.

ERIA's total CO_2 emissions per capita increased greatly over the years. One reason

for the increase is thought to be the shift toward commercial energy from firewood and other energies calculated to have zero CO_2 emissions, along with economic growth.

Figure 2-10: ERIA Total CO_2 Emission



The following are the calculation results for CO_2 emissions per country, and their comparison with the OECD and ERIA averages. With CO_2 emissions, the better situation is shown by lower values, but as inverse numbers have been used for CO_2 emissions for the purpose of this comparison, the large values here show the better situation.

Comparing differences in CO_2 emissions per primary energy supply source in the 1970s and 2000s-2, only Japan, South Korea and New Zealand decreased CO_2

emissions. Other countries increased emissions over the period. It is thought that one reason for this is the improvement of energy use efficiency due to the increased use of nuclear energy and other non-CO_2 emitting energy sources over the period, as well as the increased use of low-carbon natural gas among fossil fuels and improved energy use efficiency.

Table 2-27: CO_2 Emissions/TPES ratio

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	2.90	2.98	3.04	3.23	3.09
Brunei	1.92	1.93	1.96	2.01	1.55
Cambodia	-	-	0.53	0.76	0.91
China	2.19	2.49	2.80	2.87	3.05
India	1.34	1.67	2.02	2.14	2.29
Indonesia	0.93	1.27	1.51	1.77	1.87
Japan	2.76	2.45	2.33	2.33	2.34
South Korea	3.07	2.76	2.41	2.24	2.22
Lao PDR	-	-	0.34	0.71	0.67
Malaysia	2.11	2.03	2.27	2.40	2.47
Myanmar	0.50	0.49	0.52	0.68	0.76
New Zealand	1.99	1.78	1.71	1.89	1.92
Philippines	1.56	1.29	1.65	1.79	1.77
Singapore	2.29	2.43	2.04	2.19	2.58
Thailand	1.37	1.63	2.17	2.23	2.24
Vietnam	0.81	0.81	0.92	1.43	1.70
OECD Total	2.71	2.55	2.42	2.38	2.34
ERIA Total	2.17	2.25	2.41	2.50	2.66

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.9	0.9	0.8	0.7	0.8	0.9	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.8	0.9
Brunei	1.4	1.3	1.2	1.2	1.5	1.3	1.3	1.3	1.2	1.6	1.1	1.2	1.2	1.2	1.7
Cambodia	-	-	4.6	3.2	2.6	-	-	4.7	3.3	2.7	-	-	4.5	3.3	2.9
China	1.2	1.0	0.9	0.8	0.8	1.1	1.0	0.9	0.9	0.8	1.0	0.9	0.9	0.9	0.9
India	2.0	1.5	1.2	1.1	1.0	1.9	1.5	1.2	1.2	1.1	1.6	1.4	1.2	1.2	1.2
Indonesia	2.9	2.0	1.6	1.3	1.3	2.7	2.0	1.6	1.4	1.3	2.3	1.8	1.6	1.4	1.4
Japan	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.1	1.1	3.1	0.8	0.9	1.0	1.1	1.1
Korea	0.9	0.9	1.0	1.1	1.1	0.8	0.9	1.0	1.1	1.1	0.7	0.8	1.0	1.1	1.2
Lao PDR	-	-	7.1	3.3	3.5	-	-	7.3	3.5	3.7	-	-	7.1	3.5	4.0
Malaysia	1.3	1.3	1.1	1.0	0.9	1.2	1.2	1.1	1.0	1.0	1.0	1.1	1.1	1.0	1.1
Myanmar	5.4	5.2	4.7	3.5	3.1	4.9	5.0	4.8	3.7	3.3	4.3	4.6	4.7	3.7	3.5
New Zealand	1.4	1.4	1.4	1.3	1.2	1.3	1.4	1.5	1.3	1.3	1.1	1.3	1.4	1.3	1.4
Philippines	1.7	2.0	1.5	1.3	1.3	1.6	1.9	1.5	1.4	1.4	1.4	1.8	1.5	1.4	1.5
Singapore	1.2	1.0	1.2	1.1	0.9	1.1	1.0	1.2	1.1	1.0	0.9	0.9	1.2	1.1	1.0
Thailand	2.0	1.6	1.1	1.1	1.0	1.8	1.5	1.1	1.1	1.1	1.6	1.4	1.1	1.1	1.2
Vietnam	3.3	3.1	2.6	1.7	1.4	3.1	3.1	2.7	1.7	1.5	2.7	2.8	2.6	1.7	1.6

The CO_2 emissions/fossil fuel ratio decreased in every country.in the 1970s and 2000s-2,

Table 2-28: CO_2 Emissions/Fossil fuel primary supply

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	3.15	3.20	3.24	3.43	3.28
Brunei	1.96	1.94	1.96	2.01	2.27
Cambodia	-	-	2.95	2.98	2.95
China	3.38	3.48	3.61	3.50	3.52
India	3.43	3.38	3.30	3.22	3.23
Indonesia	2.64	2.68	2.49	2.89	2.86
Japan	2.90	2.82	2.84	2.85	2.85
South Korea	3.10	3.07	2.80	2.74	2.74
Lao PDR	-	-	2.32	3.81	2.09
Malaysia	2.62	2.35	2.47	2.55	2.60
Myanmar	2.93	2.73	2.61	2.54	2.48
New Zealand	2.88	2.61	2.60	2.77	2.88
Philippines	2.93	3.15	3.03	3.11	3.12
Singapore	2.29	2.43	2.02	2.12	2.59
Thailand	2.82	2.98	2.94	2.79	2.79
Vietnam	3.48	3.62	3.40	3.25	3.20
OECD Total	2.93	2.94	2.91	2.88	2.86
ERIA Total	3.14	3.19	3.22	3.20	3.27

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.8	0.9	1.0	1.0	1.0	0.9	1.0
Brunei	1.5	1.5	1.5	1.4	1.3	1.5	1.5	1.5	1.4	1.3	1.6	1.6	1.6	1.6	1.4
Cambodia	-	-	1.0	1.0	1.0	-	-	1.0	1.0	1.0	-	-	1.1	1.1	1.1
China	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9
India	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0
Indonesia	1.1	1.1	1.2	1.0	1.0	1.1	1.1	1.2	1.0	1.0	1.2	1.2	1.3	1.1	1.1
Japan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
Korea	0.9	1.0	1.0	1.1	1.0	0.9	0.9	1.0	1.1	1.1	1.0	1.0	1.1	1.2	1.2
Lao PDR	-	-	1.3	0.8	1.4	-	-	1.3	0.8	1.4	-	-	1.4	0.8	1.6
Malaysia	1.1	1.3	1.2	1.1	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.4	1.3	1.3	1.3
Myanmar	1.0	1.1	1.1	1.1	1.2	1.0	1.1	1.1	1.1	1.2	1.1	1.2	1.2	1.3	1.3
New Zealand	1.0	1.1	1.1	1.0	1.0	1.0	1.1	1.1	1.1	1.0	1.1	1.2	1.2	1.2	1.1
Philippines	1.0	0.9	1.0	0.9	0.9	1.0	0.9	1.0	0.9	0.9	1.1	1.0	1.1	1.0	1.0
Singapore	1.3	1.2	1.4	1.4	1.1	1.3	1.2	1.4	1.4	1.1	1.4	1.3	1.6	1.5	1.3
Thailand	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2
Vietnam	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0

The ratio of CO_2 Emissions to GDP decreased in Australia, China, Japan, South Korea, Myanmar, and the Philippines in the 1970s and 2000s-2, and increased or remained at a nearly steady level over the years in other ERIA member countries.

Table 2-29 CO_2 Emissions /GDP ratio

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	0.93	0.89	0.85	0.81	0.75
Brunei	0.32	0.60	0.79	0.77	1.10
Cambodia	-	-	0.61	0.66	0.60
China	8.07	5.84	3.66	2.52	2.44
India	1.77	2.08	2.23	1.96	1.78
Indonesia	0.98	1.11	1.32	1.61	1.50
Japan	0.40	0.28	0.25	0.25	0.23
South Korea	1.02	0.88	0.84	0.75	0.68
Lao PDR	-	-	0.37	0.64	0.56
Malaysia	0.88	0.94	1.12	1.23	1.26
Myanmar	1.41	1.12	1.01	0.76	0.63
New Zealand	0.54	0.51	0.56	0.54	0.49
Philippines	0.80	0.64	0.88	0.84	0.64
Singapore	0.61	0.54	0.56	0.42	0.32
Thailand	0.90	0.84	1.18	1.36	1.33
Vietnam	1.78	1.55	1.26	1.67	1.83
OECD Total	0.81	0.63	0.52	0.47	0.42
ERIA Total	0.90	0.83	0.86	0.90	1.01

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	1.0	0.9	1.0	1.1	1.3
Brunei	2.6	1.0	0.7	0.6	0.4	1.8	0.9	0.7	0.7	0.5	2.8	1.4	1.1	1.2	0.9
Cambodia	-	-	0.9	0.7	0.7	-	-	0.9	0.8	0.9	-	-	1.4	1.4	1.7
China	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.4	0.4
India	0.5	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.5	0.4	0.4	0.5	0.6
Indonesia	0.8	0.6	0.4	0.3	0.3	0.6	0.5	0.4	0.3	0.4	0.9	0.7	0.7	0.6	0.7
Japan	2.0	2.3	2.1	1.9	1.8	1.4	2.0	2.2	2.2	2.4	2.2	3.0	3.4	3.6	4.4
Korea	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.2	1.5
Lao PDR	-	-	1.4	0.7	0.8	-	-	1.5	0.9	1.0	-	-	2.3	1.4	1.8
Malaysia	0.9	0.7	0.5	0.4	0.3	0.6.	0.6	0.5	0.5	0.4	1.0	0.9	0.8	0.7	0.8
Myanmar	0.6	0.6	0.5	0.6	0.7	0.4	0.5	0.6	0.7	0.9	0.6	0.7	0.8	1.2	1.6
New Zealand	1.5	1.2	0.9	0.9	0.9	1.0	1.1	1.0	1.0	1.1	1.7	1.6	1.5	1.7	2.1
Philippines	1.0	1.0	0.6	0.6	0.7	0.7	0.9	0.6	0.7	0.9	1.1	1.3	1.0	1.1	1.6
Singapore	1.3	1.2	0.9	1.1	1.3	0.9	1.0	1.0	1.3	1.7	1.5	1.5	1.5	2.1	3.1
Thailand	0.9	0.7	0.4	0.3	0.3	0.6	0.7	0.5	0.4	0.4	1.0	1.0	0.7	0.7	0.8
Vietnam	0.5	0.4	0.4	0.3	0.2	0.3	0.4	0.4	0.3	0.3	0.5	0.5	0.7	0.5	0.6

All ERIA member countries saw increases in CO_2 emissions per capita in the 1970s and 2000s-2,. Driving this trend were increases in energy consumption per person, along with economic growth and rising living standards.

Table 2-30: CO_2 Emissions per capita

Country	1970s	1980s	1990s	2000s-1	2000s-2
Australia	12.55	13.98	15.87	18.19	18.30
Brunei	8.07	13.33	14.67	13.99	19.49
Cambodia	-	-	0.15	0.23	0.30
China	1.17	1.64	2.32	2.97	4.72
India	0.39	0.55	0.82	1.00	1.24
Indonesia	0.30	0.53	1.01	1.40	1.59
Japan	7.84	7.37	8.94	9.42	9.19
South Korea	2.30	3.80	7.32	9.41	10.22
Lao PDR	-	-	0.10	0.23	0.26
Malaysia	1.32	2.04	3.82	5.23	6.30
Myanmar	0.14	0.14	0.14	0.19	0.24
New Zealand	5.64	5.80	6.92	7.97	7.70
Philippines	0.69	0.58	0.80	0.87	0.77
Singapore	4.04	5.99	10.36	10.19	9.61
Thailand	0.57	0.81	2.12	2.94	3.43
Vietnam	0.30	0.30	0.38	0.78	1.15
OECD Total	10.98	10.37	10.57	10.93	10.51
ERIA Total	1.30	1.54	2.09	2.52	3.33

Country	vs. OECD					vs. OECD (whole periods)					vs. ERIA				
	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2	1970s	1980s	1990s	2000s 1	2000s 2
Australia	0.9	0.7	0.7	0.6	0.6	0.8	0.8	0.7	0.6	0.6	0.1	0.1	0.1	0.1	0.2
Brunei	1.4	0.8	0.7	0.8	0.5	1.3	0.8	0.7	0.8	0.5	0.2	0.1	0.1	0.2	0.2
Cambodia	-	-	69.2	47.2	35.0	-	-	69.8	46.1	35.5	-	-	13.7	10.9	11.1
China	9.3	6.3	4.6	3.7	2.2	9.1	6.5	4.6	3.6	2.3	1.1	0.9	0.9	0.8	0.7
India	28.4	18.8	12.8	11.0	8.5	27.6	19.3	12.9	10.7	8.6	3.4	2.8	2.5	2.5	2.7
Indonesia	36.2	19.4	10.4	7.8	6.6	35.1	20.0	10.5	7.6	6.7	4.3	2.9	2.1	1.8	2.1
Japan	1.4	1.4	1.2	1.2	1.1	1.4	1.4	1.2	1.1	1.2	0.2	0.2	0.2	0.3	0.4
Korea	4.8	2.7	1.4	1.2	1.0	4.6	2.8	1.5	1.1	1.0	0.6	0.4	0.3	0.3	0.3
Lao PDR	-	-	106.0	46.8	40.8	-	-	106.8	45.6	41.3	-	-	21.0	10.8	12.9
Malaysia	8.3	5.1	2.8	2.1	1.7	8.1	5.2	2.8	2.0	1.7	1.0	0.8	0.5	0.5	0.5
Myanmar	77.0	75.5	78.0	56.4	44.4	74.8	77.5	78.6	55.0	45.0	9.1	11.2	15.4	13.0	14.1
New Zealand	1.9	1.8	1.5	1.4	1.4	1.9	1.8	1.5	1.3	1.4	0.2	0.3	0.3	0.3	0.4
Philippines	16.0	17.9	13.3	12.6	13.6	15.6	18.4	13.4	12.3	13.8	1.9	2.7	2.6	2.9	4.3
Singapore	2.7	1.7	1.0	1.1	1.1	2.6	1.8	1.0	1.0	1.1	0.3	0.3	0.2	0.2	0.3
Thailand	19.2	12.8	5.0	3.7	3.1	18.6	13.1	5.0	3.6	3.1	2.3	1.9	1.0	0.9	1.0
Vietnam	36.0	34.4	27.8	14.1	9.1	35.0	35.4	28.1	13.7	9.3	4.3	5.1	5.5	3.2	2.9

5. Conclusion

East Asia is composed of countries with very different levels of economic development and fossil fuel reserves. For the indices where data can be obtained from eight or more countries, the average, minimum and maximum values for ERIA are shown in the chart below. Great differences can be seen in these values, demonstrating the diverse situation of energy security in East Asia countries.

Table 2-31: ERIA Average, Max and Min of ESIs

ESI		1970s	1980s	1990s	2000s-1	2000s-2
TPES self-sufficiency (including Nuclear)	ERIA avg.	79%	87%	84%	84%	85%
	Max	2186%	1089%	796%	837%	624%
	Min	0%	0%	0%	0%	0%
Reserve/ Production ratio	ERIA avg.	-	110	89	68	49
	Max	-	331	177	135	115
	Min	-	0	0	0	0
Reserve/ Consumption ratio	ERIA avg.	-	94	75	59	40
	Max	-	1,256	466	375	333
	Min	-	0	0	0	0
HHI (Diversity of energy sources)	ERIA avg.	3,120	2,648	2,840	3,215	3,662
	Max	9,996	9,997	10,000	9,637	9,589
	Min	4,066	2,960	2,693	2,338	2,230
Reserve margin of generation capacity	ERIA avg.	25%	31%	22%	28%	32%
	Max	33%	38%	42%	45%	43%
	Min	24%	24%	1%	15%	10%
Commercial energy access ratio	ERIA avg.	58%	74%	82%	85%	88%
	Max	100%	100%	100%	100%	100%
	Min	27%	27%	22%	28%	34%
TPES/ GDP ratio	ERIA avg.	0.41	0.37	0.36	0.36	0.38
	Max	3.68	2.35	1.96	1.17	1.07
	Min	0.15	0.11	0.11	0.11	0.10
TFEC/ GDP ratio	ERIA avg.	0.336	0.285	0.259	0.245	0.249
	Max	3.125	1.967	1.729	1.039	0.565
	Min	0.026	0.056	0.073	0.072	0.050
CO_2 emissions / TPES ratio	ERIA avg.	2.17	2.25	2.41	2.50	2.66
	Max	3.07	2.98	3.04	3.23	3.13
	Min	0.50	0.49	0.50	0.68	0.77
CO_2 smissions / fossil fuel ratio	ERIA avg.	3.14	3.19	3.22	3.20	3.27
	Max	3.48	3.62	3.61	3.81	3.52
	Min	1.96	1.94	1.96	2.01	2.09

ESI		1970s	1980s	1990s	2000s-1	2000s-2
CO_2 smissions / GDP ratio	ERIA avg.	0.90	0.83	0.86	0.90	1.00
	Max	8.07	5.84	3.66	2.52	2.49
	Min	0.32	0.28	0.25	0.25	0.23
CO_2 smissions / capita	ERIA avg.	1.30	1.54	2.09	2.52	3.27
	Max	12.55	13.98	15.87	18.19	19.20
	Min	0.14	0.14	0.14	0.19	0.25

The following is a summary of the special characteristics of the major ESIs.

- ERIA Total TPES self-sufficiency (including nuclear) has been over 80% since the 1980s. This is natural for countries with high fossil fuel self-sufficiency ratios, and there are also countries with low fossil fuel resources that are complementing their self-sufficiency ratios with nuclear energy and other energy sources.
- There is a trend among fossil fuel rich countries toward shrinking R/P and R/C ratios. The background to this is the increase in the speed of domestic energy consumption compared with the speed of development of new energy resources.
- ERIA Total Diversity by energy sources showed a concentrating trend toward coal. The background to this is the fact that East Asian countries are rich in coal and there is an increasing use of coal, mainly in the power generation sector.
- The ERIA Total Reserve margin of generation capacity demonstrated an increasing trend, but there were also countries where this value fell greatly.
- The Commercial Energy access ratio, and the electrification rate, which is shown as a reference, rose in all countries.
- ERIA Total TPES/GDP ratio and TFEC/GDP ratio values fell, indicating an improvement in energy efficiency.
- Many countries demonstrated worsening measurements related to CO_2 Emissions. The background to this is the increasing consumption of fossil fuels along with economic growth and improving standards of living.