STUDY ON THE DEVELOPMENT OF AN ENERGY SECURITY INDEX AND AN ASSESSMENT OF ENERGY SECURITY POLICY FOR EAST ASIAN COUNTRIES

STUDY ON THE DEVELOPMENT OF AN ENERGY SECURITY INDEX AND AN ASSESSMENT OF ENERGY SECURITY POLICY FOR EAST ASIAN COUNTRIES

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DISCLAIMER

This report was prepared by the Working Group for the "Study on the Development of an Energy Security Index and an Assessment of Energy Security for East Asian Countries" under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the working group, who represent the participating East Asia Summit (EAS) region countries, discussed and agreed to utilise certain data and methodologies to develop the energy security index. These data and methodologies may differ from those normally used in each country. Therefore, the calculated result presented here should not be viewed as official national analyses of the participating countries.

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Foreword

Energy security forms the basis of energy policy in every country. It goes without saying that countries must secure sufficient supply of energy at an affordable price to sustain the lives of the people and their economic activities. Energy security is a top priority of the policy agenda particularly in East Asia where countries are now confronted with increasing energy demand resulting from improved living standards and economic growth, and the continuing historically high energy prices, such as that of crude oil. With the majority of emissions coming from energy, including air pollutants and greenhouse gases, it is also clear that harmony with the environment has become an integral element of energy policy.

Against this backdrop, ERIA established a working group to carry out a study aimed to quantitatively assess and analyse the energy security situation in East Asian countries and to provide policy recommendations to improve their specific situations.

It is my hope that the outcomes of this study will serve as a point of reference for policymakers in East Asian countries and contribute to the improvement of energy security in the region as a whole.

Ichiro Kutani
Leader of the Working Group
June 2014

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Ichiro Kutani
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List of Abbreviations and Acronyms

APS	alternative policy scenario
ASEAN	Association of Southeast Asian Nations
BAU	business-as-usual
BP	BP Statistical Review of World Energy
CO_2	carbon dioxide
EAS	East Asia Summit
ECTF	Energy Cooperation Task Force
ERIA	Economic Research Institute for ASEAN and East Asia
ESI	energy security index
ESP	energy saving potential
E&P	exploration and production
GDP	gross domestic product
GHG	greenhouse gas
HHI	Hirschmann-Herfindahl Index
IEA	International Energy Agency
IEEJ	The Institute for Energy Economics, Japan
IMF	International Monetary Fund
LNG	liquefied natural gas
ME	Middle East
N.A.	not available
OECD	Organisation for Economic Co-operation and Development
R/C ratio	reserve/consumption ratio
R/P ratio	reserve/production ratio
SOE	state-owned enterprises
SPR	strategic petroleum reserve
TFEC	total final energy consumption
TPES	total primary energy supply
WEO	World Energy Outlook
WG	working group

Executive Summary

This study examines the quantitative status of energy security in each country to predict the future and to draw out policy implications for improving their specific situations.

MAIN ARGUMENT

Although the importance of energy security has already became common ground and shared among countries, the methodology to obtain an accurate and quantitative view of its status is not established with consensus. Accurate understanding of current situation in energy security is essential in developing and implementing better energy policy. From this point of view, lack of established assessment methodology is a matter of concern. This study aims to provide a possible way to have an accurate view of the energy security situation in the East Asia Summit (EAS) region.

The study developed and assessed some indices that can explain certain aspects of energy security called energy security index (ESI). The study then applied this methodology to examine future status by using energy supply-demand outlook and other relevant data. In analysing future status, the study employed two different scenarios—the business-as-usual scenario (BAU) and the alternative policy scenario (APS)—to conduct comparative analysis. Based on these analyses, the study derives policy implications for enhancing energy security in the region.

KEY FINDINGS

- Self-sufficiency tends to decline in many countries, thus becoming more vulnerable in terms of energy security.

- Primary energy/electricity supply mix depends on the unique conditions in each country. However, it can be noted that “diversity” is a key element to enhance energy security.

- If “more energy-efficient future scenario” is applied, many indicators show better energy security situation in the future.

POLICY IMPLICATIONS

- The newly developed indices, the ESI, could be a useful tool in generating an accurate picture of a country’s energy security situation, thus, it can provide support in formulating a new energy policy. However caution must also be taken when using ESI. Since changes in the number are backed by many underlying factors and assumptions, there is a need to exercise prudence in interpreting the data.

- If the region can utilise regionally available coal in a more efficient and cleaner way, it can take advantage of the abundance of this resource. A combined use of renewable energy will offset environmental load, and may provide better energy supply mix. However, before a large amount of renewable energy could be deployed, natural gas may be able to play an important role.

- If the region can strengthen mutual interdependence in energy security, each country can achieve a level of security that they would never be able to achieve independently. For instance, existing initiatives like the ASEAN Petroleum Security Agreement (APSA), ASEAN Power Grid (APG), or ASEAN Economic Community (AEC) could be vehicles to increase interdependence of energy security in the ASEAN region. Thus, this study recommends to accelerate, further strengthen, and expand these initiatives.

CHAPTER 1
Introduction

Background of the Study

In many East Asian countries, energy demand is expected to grow continuously in the long run, with high economic growth and social development driving this trend. It is also expected that energy production, particularly fossil fuel production, in the East Asian region will not be able to keep up with the speed of energy demand growth, and that the region will have to face rising energy import dependence. At the same time, it is important to note that there are emerging challenges on the energy supply side in the world energy market that include geopolitical risks, market power risks, natural disaster/accidental risks, underinvestment, resource nationalism, and so on. Given these background factors, the enhancement of energy security is becoming one of the top priorities for each East Asian country, as all of them have a common need to achieve sustainable economic growth and development.

It is also essential to recognise that East Asian countries have a wide range of diversity in such areas as energy resource endowment, economic development, industrial structure, technology development, and others. Under these circumstances, it is necessary to analyse the energy security situation and policy implications in each East Asian country, with due consideration to the diversity mentioned above.

Since East Asian countries have already deepened their economic and energy relationships in a bid to explore regional integration, it is very important to promote the enhancement of security, not only in each country but also in the East Asian region as a whole, through regional cooperation.
In recognition of the above, this study focused on the development of an energy security index (ESI) and the assessment of energy security policies for East Asian countries.

Objective

The first objective of the study is to develop an index that quantitatively indicates the country-by-country energy security situation, which could help policymakers to accurately gauge the energy security situation in their specific countries.

The second objective is to analyse the linkages between policies and the historical trends shown in the index, and thereby assess the impact of policies on the energy security situation.

The last objective is to offer policy recommendations to policymakers in East Asian countries on improving energy security based on an analysis that answer the following:

-What methods and approaches are effective for improving energy security?

-What kinds of regional cooperation are useful for improving energy security?

Summary of Research

Research was conducted in three stages over a three-year period. Table 1-1 presents a description of the research at each stage. Stage three, or the third year of the research was conducted in 2013.

Table 1-1: Time Line of the Study

1st year: Develop and calculate indicators (A) Development of energy security index (ESI) - Assume ESI to comprise several major indicators that reflect the principal components of energy security. (B) Data collection and calculation of ESI for each country - Necessary historical data to be collected for each indicator, and for each country. Publicly available statistics; IEA, IMF, BP, etc. National statistics; expect to be provided by each member of the working group

Timeframe; 1970 — latest available Transparency of the data - Calculating the ESI
2nd year: Analyse relationship between ESI and policy (C) Analysis of past energy security policy taken in each country - Past energy security policy examined (D) Assessing the effectiveness of past policy on the status of energy security - Quantitative assessment of past policy - Relationship between historical change of the index and past policy (E) Drawing useful lessons from past experiences - What can be the better approach/practice to be adopted - What will be required to actually implement the identified approach/practice, etc.
3rd year: Foresee the future **(**F) Estimate ESI for the future - Apply energy supply-demand outlook - Calculate future status of ESI (G) Recommendation for regional energy cooperation - How regional cooperation will best address the energy security

Note : BP = BP Statistical Review of World Energy, ESI = energy security index, IEA = International Energy Agency, IMF = International Monetary Fund.

Working Group Activities in 2011

In 2011, the working group (WG) meeting was held twice—in October 2011 and April 2012— both in Jakarta, Indonesia.

During the first meeting, the 2010 study plan was developed and each member provided information on their country's energy security. As an overview of the study, the significance and objectives were shared, and an overall plan of the multi-year project was presented. In this context, members confirmed the positioning of the work streams for the fiscal year. In the reports made by the WG members, changes in the energy supply and demand balance in their countries were described, along with changes in policy, the issues currently confronting their countries, and others. A preliminary estimation of ESI was also presented and this served as a basis for discussion. A wide range of views were exchanged during that discussion, on a variety of topics, including the selection of indicators and the data collection methods. Lastly, a request was made to WG members to provide the necessary information from their respective countries.

During the second meeting, the WG discussed the calculation results for the ESI. A variety of views were discussed and exchanged on the ESI, such as the relevance of the data utilised for calculating the indices and the indicators, which ought to be selected. Missing data were supplemented and data reliability was improved through the contribution of WG members. A very important achievement was the wider discussion on the approach for assessing the calculated indices. Accordingly, it was decided that the knowledge of the WG members and the discussion outcomes would be reflected in the study report.

Working Group Activities in 2012

In 2012, the WG meeting was held twice—November 2012 in Jakarta and April 2013 in Tokyo.

During the first meeting, the WG discussed the calculated index. Discussions revolved around the use of econometric modeling as one method for assessing the impact that policies in each country have had on changes in the index. A number of elements have caused the index to change, including macroeconomic conditions, industrial structure, and fluctuations in energy prices, but it was pointed out that analysis using econometric modeling would make it possible to break down the impact from each. There are limitations, however, posed by an econometric modeling analysis. In addition, at least 20 years worth of accurate data would be required for such an analysis, which would be extremely difficult to collect since the number of countries that could provide such data is very limited. It was also pointed out that government policies did have an effect on changes in the index and that some sort of correlation do exist.

WG members also talked about the energy policy of their countries, followed by a question-and-answer session. The difficulty of looking into past government policies, particularly among developing countries, was pointed out. In addition, WG members also noted the importance of policies on renewable energy and electricity, thus, confirming that the effects of these policies should be analysed appropriately.

Based from the discussions during the first meeting, an analysis was performed on the correlation between policy and ESI, and results were discussed at the second meeting. It was noted that there are a variety of elements affecting changes in the ESI and no single element could be used to explain all of the changes in ESI. Based on this, it was decided that consideration will be given to a variety of related elements during future analysis of the correlation between policy and ESI.

The impact of past government energy policies on the energy security situation was next discussed. Once again, the difficult nature of assessing past government policies was confirmed. In most countries, policies on the reduction of carbon dioxide (CO_2) emissions have only been enacted recently, hence, it is too early to measure their effects.

Working Group Activities in 2013

In 2013, the WG meeting was held twice—December 2013 in Jakarta and April 2013 in Kuala Lumpur.

The objective of the 2013 study was to calculate future ESIs. The main data source used for this study was the ERIA Energy Outlook released by the ERIA Working Group for the Analysis of Energy Saving Potential in East Asia (ERIA ESP WG).

At the first meeting, the WG discussed the (i) main data sources to calculate future ESIs, (ii) selection of ESIs, (iii) tentative results of selected ESIs, (iv) limitation of future ESI calculation, and (v) future energy plan of member countries. The following are the major opinions generated:

- As many of the ERIA member countries become net energy importers, diversification will be the key to future energy security of the region.

- As Middle East dependence increases, the security of transportation routes will need to be considered.

- It is implied that electricity transmission grid interconnection contributes to the promotion of electrification, the diversification of power supply, and reinforcing of energy security.

- There will not be enough power generated from renewables to replace conventional energy and the options grow even thinner when affordability is considered. Coal is the most economical, but it also carries with it major environmental problems.

At the second meeting, the WG discussed the methodology of calculating future self-sufficiency, and the baseline for scoring of ESIs. An expert presented his concept of energy security and the case study of energy security in China. The following are the major opinions generated;

- Considering the ASEAN Integration in 2015, it would be preferable to add the evaluation of the ASEAN average.

- It would be preferable to add the gross domestic product (GDP) per capita and total primary energy supply (TPES) per capita as economic indicators to make CO_2 relevant and ESIs easier to understand.

- Countries where an energy mix of coal and renewable energy/nuclear energy could be applicable are limited. This situation varies depending on the country. Coal, in particular, is low-priced, but the initial investment cost of power generation from coal is high. Thus, it is necessary to consider financing.

- For renewable energy, their levels of CO_2 emissions may be high over their life cycles. Thus, nuclear power is likely more suitable for CO_2 emission reduction.

CHAPTER 2

Summary Results of Earlier Study

Study in 2011

In 2011, when the study was in its first phase, an indicator that could explain the energy security situation in quantitative terms had been developed. Based on statistical information, the value of the indicator was calculated, and past changes in the situation of energy security were analysed.

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 for energy security ("who" "is doing what" to protect "with whom"), and how these points are recognised. 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 an affordable prices."

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

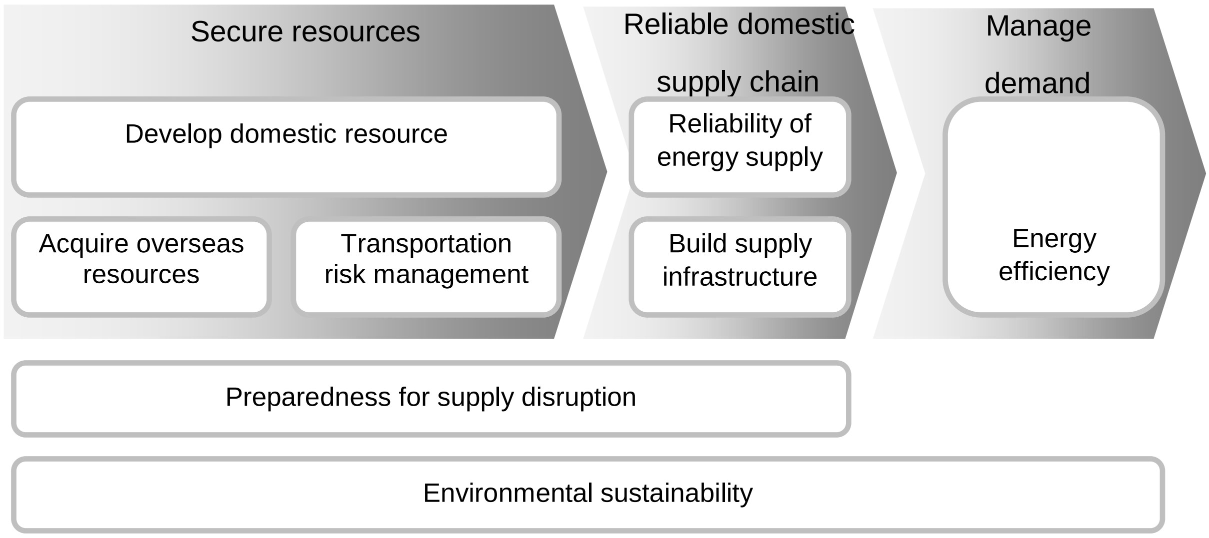
The principle is risk management and the improvement of the situation of energy security. Risk management includes the dispersion of risks (such as through the diversification of energy sources), the absorption of risks (such as the reserve margin of power generation capacities), and preparations against unavoidable supply disruptions (such as strategic reserves). The improvement of energy security includes developing domestic energy sources and enhancing resources acquisition in foreign countries.

The energy supply chain 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 that constitute the first stage of the supply chain. The “reliability of the energy supply” and “construction of the supply infrastructure” are required to “secure a reliable domestic supply chain” 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” is adopted as a major component of energy security.

Environmental sustainability has been added to the factors comprising energy security in light of heightened issues concerning the global environment. Most greenhouse gas emissions are produced by energy sources, and so it goes without saying that an important aspect to ponder when thinking about energy issues is to consider 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



Source: Authors.

Table 2-1 shows the components of energy security, evaluation item, and representing indices. For details on the definition of energy security, refer to the 2011 report.

Table 2-1: List of Energy Security Index

Components of Energy Security	Evaluation Item	Index (ESI)
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	2. Diversity of import source countries (oil, gas, and coal) 3. Diversity of energy sources of TPES/electricity 4. Middle East dependence

Components of Energy Security	**Evaluation Item**	**Index (ESI)**
	Middle East	for oil and gas
Transportation risk management	-	-
Securing a reliable domestic supply chain	5-1. Reliability of energy supply	5-1-1. Reserve margin of generation capacity 5-1-2. Power outage frequency/duration
	5-2. Build supply infrastructure	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

Note : CO_2 = carbon dioxide, GDP = gross domestic product, TFEC = average final energy consumption, TPES = average primary energy supply.
Source: Authors.

Table 2-2 presents the ESI calculation method. For the description of each individual ESI, refer to the 2011 report.

Table 2-2: Calculation of Energy Security Index

ESI	Calculation Method
Self-sufficiency	(Indigenous production)/(TPES)*100
Reserve/Production (R/P) ratio	(Reserve)/(Production)
Reserve/Consumption (R/C) ratio	(Reserve)/(Consumption)
Diversity of import source countries	HHI
Diversity of energy sources	HHI
Middle East dependence	(Imports from Middle East)/(Average imports) *100
Reserve margin of generation capacity	(Average generation capacity)/(Peak demand) *100
Power outage duration	(Accumulated duration of power outage) /(Average number for customer)
Power outage frequency	(Outage frequency per year) /(Average number of customers)
Commercial energy access ratio	(TPES – Non-commercial energy)/(TPES) * 100 where: Non-commercial energy = (Primary supply of solid biofuels) – (Input energy for transformation purpose)
TPES/GDP	(TPES)/(GDP)
TFEC/GDP	(TFEC)/(GDP)
Days of on-land oil stocks	(Average stock)/(Forward demand) where: Average stock = industry stock + government stock Forward demand = forward quarter average daily demand calculated by the IEA
CO_2 emissions/TPES	(CO_2 emissions)/(TPES)

CO_2 emissions/Fossil fuel	(CO_2 emissions)/(Primary supply of fossil fuel)
CO_2 emissions/GDP	(CO_2 emissions)/(GDP)
CO_2 emissions/Capita	(CO_2 emissions)/(Population)

Note : CO_2 = carbon dioxide, GDP = gross domestic product, IEA = International Energy Agency, HHI = Hirschmann-Herfindahl Index, TFEC = average final energy consumption, TPES = average primary energy supply.
Source: Authors.

For details pertaining to the data source of each individual ESI, refer to the 2011 report. The data sources used to calculate the ESI are as follows:

- Energy balance of OECD, non-OECD Countries (IEA)
- CO_2 emissions from fuel combustion (IEA)
- Coal information, oil information, and natural gas information (IEA)
- Monthly Oil Market Report (IEA)
- World Energy Outlook (IEA)
- BP Statistical Review of World Energy
- WG on Analysis on Energy Saving Potential in East Asia (ERIA)
- Statistic of the World Bank
- Statistics of the Japan Electric Power Information Center
- National statistics of countries

Its purpose is to analyse changes in energy security situations from a long-term perspective, thus, a 10-year period was used as a block and average values were gathered within the entire period observed. However, in the 2000s, there was a striking economic growth in East Asian countries in particular, and this had a great effect on the energy environment. For this reason, this period was split in several five-year periods.

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

By having numbers of each index changing throughout the assessment period, the study yielded the following results:

1. While there are limitations to obtaining data, it is possible to develop an index that quantitatively indicates the energy security situation. For example, in the case of the indicator for the diverseness of energy source, ERIA averages show a trend toward the concentrated use of a specific energy across the years. This finding is consistent with the expanded use of coal for power generation.
2. Energy security is comprised by a variety of elements. The perspective from which a country is assessed varies diversely, depending on its situation. There is, thus, no single absolutely correct indicator, and it is important to assess multiple perspectives through a combination of several indicators.
3. With the cooperation of WG members, it was possible to access data that are difficult to obtain through publicly known statistics, such as statistics issued by the International Energy Agency (IEA) and BP Statistical Review of World Energy (BP), as well as to confirm and review data. This was one of the major results of this study.
4. Calculating the index using the data obtained yielded ESI values that were widely distributed and reflected the diversity of the countries.
5. In the case of the self-sufficiency ratio, it was possible to quantitatively confirm that despite having no domestic resources, a country could improve its self-sufficiency ratio by expanding its use of nuclear energy, and as a result, could improve its performance in terms of ESI. It is important that such policies underpinning the changes in indicator performance are analysed.

6. For country analyses, ESI has made it possible to quantitatively assess how the energy security situation has evolved over each decade.
7. Some indicators have a trade-off relationship, and therefore, it may be difficult to improve performances across all indicators simultaneously. This is observed, for example, between self-sufficiency and the diverseness of energy source.
8. Country situations shown by ESI vary, depending on the country's environment, including resource endowment and the extent of energy demand increases. Nevertheless, a number of common trends were identified:
   - Many of the resource countries experienced decreases in the self-sufficiency ratio or R/P ratio. It is thought that new resource development has not caught up with the speed of energy demand increase.
   - On the supply of primary energy and diversity of energy sources, few countries performed well compared to the Organisation for Economic Co-operation and Development (OECD) average. It was observed that while increasing the use of domestic resources, such as coal and hydropower, is favorable for improving the self-sufficiency ratio, this also limits the diversification of energy sources.
   - While access to commercial energy is improving, at the same time, this is causing a further increase in energy demand, including electricity demand.
   - Although efficiency in energy utilisation is improving in many countries, some countries still have low efficiency compared with OECD averages and there is yet room for improvement.

Study in 2012

In 2012, the study investigated the correlation between calculated ESI and past policies that were actually implemented in each country. The transition of ESI and relevant policies in the past became the focus of the analysis.

Although the change of ESI can be explained by various elements, including policies and economic situation, a few specific policies were selected to simplify the assessment work. Since the purpose of the study is to find the core element of correlation between the ESI and policies, this procedure does not deteriorate the analysis.

Table 2-3 shows selected policies that were analysed.

Table 2-3: List of Policies

Policy Area	**Policies Analysed**
Coal	Coal mining (indigenous) Coal use promotion Import source country diversity
Crude oil	Crude oil E&P (indigenous) Refinery construction Import source country diversity Oil stocks (SPR) Alternative fuel promotion (other than oil)
Natural gas	Natural gas E&P (indigenous) Natural gas use promotion Import source country diversity
Nuclear	Nuclear development
Hydro	Hydro development
Geothermal, wind, others	Renewable energy development
Biofuels and waste	Renewable energy development
Electricity	Electrification Supply reliability
All energy	Energy conservation/efficiency
CO_2 emission	CO_2 emission reduction
Price and subsidy (including tax incentive)	Coal production subsidies Coal consumer price control(below international prices/import costs)

	Crude oil production subsidies Oil product consumer price control(below international prices/import costs) Natural gas production subsidies Natural gas consumer price control(below international prices/import costs) Electricity tariff control(below costs)

CO_2 = carbon dioxide, E&P = exploration and production, SPR = strategic petroleum reserve.

Source: Authors.

The correlation between ESI and policy is summarised in Table 2-4. Looking at the records of an assessment, in most cases there was a correlation between past policy and change of ESI, with a few exceptions. While there are ESIs directly affected by specific energy policy, there are others that are believed to be impacted by multiple factors, such as changes in industrial structure, economic activity, technology development, and market conditions (costs and price). Hence, there is a need to be careful in these assessments.

Table 2-4: Correlation between Policy and Energy Security Index (Summary)

	ESI	KHM	CHN	IDN	JPN	KOR	LAO	MYS	MMR	NZL	PHL	THA	VNM
1	TPES self-sufficiency	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
2	Coal self-sufficiency		No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes
3	Crude oil self-sufficiency							No	Yes	Yes	Yes	Yes	No
4	Natural gas self-sufficiency			No		Yes			Yes	No	Yes	No	Yes
5	Coal R/P		No	No	Yes	Yes				Yes	Yes	Yes	Yes
6	Crude oil R/P							No	Yes			No	Yes
7	Natural gas R/P			No				No	No		Yes	No	No
8	Coal R/C		No	Yes	Yes	Yes				Yes	Yes	Yes	Yes
9	Crude oil R/C			Yes				Yes	Yes			Yes	Yes
10	Natural gas R/C			Yes				Yes	No		Yes	Yes	Yes
11	Coal import source country diversity					Yes		Yes					
12	Crude oil import source country diversity		Yes		No	No							
13	Natural gas import source country diversity					Yes						No	
14	TPES diversity	Yes	No	Yes	Yes	Yes		Yes		Yes	Yes	Yes	Yes
1	Power generation fuel	Yes	No	Yes	Yes	Yes		Yes		Yes	Yes	No	Yes

5	diversity												
16	Crude oil Middle East dependence		No		No	No							
17	Natural gas Middle East dependence					Yes							
18	Reserve margin of generation capacity		Yes	No	Yes	No		Yes	-	No	Yes	Yes	Yes *
19	Power outage frequency			Yes	Yes	Yes		Yes		No			
20	Power outage duration			No	Yes	Yes		Yes		No			
21	Commercial energy access	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes
22	Electrification	Yes	Yes	Yes	-	-	Yes	Yes	Yes	-	Yes	Yes	Yes
23	TPES/GDP		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
24	TFEC/GDP		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
25	Days of on-land oil stocks				Yes	Yes			Yes	No		Yes	
2	CO_2 emissions/TPES	No	Yes	No	Yes	Yes	No	No	No	No	No	No	No

6													
27	CO_2 emissions/Fossil fuel	No	No	No	No	Yes	Yes	No	No	No	No	No	No
28	CO_2 emissions/GDP	No	Yes	No	Yes	Yes	No	No	No	No	No	No	No
29	CO_2 emissions/Population	No	Yes	No	No	No	No	No	No	No	No	No	No

Note : KHM = Cambodia, CHN = China, IDN = Indonesia, JPN= Japan, KOR = Korea, LAO = Laos, MYS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHL = Philippines, THA = Thailand, VNM = Viet Nam.

* Correction from 2012 report, from a comment by a WG member.

In 2012, the study delivered the following implications for the energy security of EAS countries:

1. Measuring the effects of policy is extremely important as a reference for future policy planning and for effectively allocating limited budgetary resources. In this sense, despite various restrictions, this research carries great significance because it attempts to qualitatively measure the existence of policy effects.

2. One ESI consists of multiple policy effects, making it difficult to qualitatively assess the effect of these policies on ESI changes. For example, changes in the TPES per gross domestic product (GDP) used to assess energy efficiency are affected by changes in energy consumption, as well as changes in industrial structure.

3. However, when examining both ESI changes averaged out over a long period of time, such as 5 or 10 years, and the existence of policy perceived to be correlated to such changes, assessments showed that a correlation existed between several policies and ESI, as follows:
   - Resource development promotion policy and R/C ratio,
   - Oil dependence reduction policy and diversity in primary energy as well as power supply,
   - Commercial energy supply policy or electrification rate improvement policy and commercial energy supply ratio or electrification rate,
   - Energy saving policy and energy efficiency, and
   - Oil stock policy and oil stock amounts.

4. Generally, policy requires a long period of time before it causes changes in the country's actual energy supply–demand situation. This is because investments in equipment and devices that use energy are typically large in nature, while such equipment and devices have a long service life, which means that it is difficult to change energy supply–demand situation over a short period of time.

   For example, several countries are implementing a policy on climate change, and such policy has only been rolled out recently. Consequently, enough time has yet to pass until such policy could make changes in the energy supply–demand situation, making it impossible to verify the effects.

5. Conversely, there are also policy effects that cannot be verified even if a sufficient amount of time has passed since the policy was implemented. One example is the dependence on the Middle East for oil supply. The study could not verify the declines in dependence despite the existence of policy for such purposes. This is believed to be due to geographic reasons, or the fact that large amounts of crude oil are existing in the Middle East and that there is no other supply source in the Asia- Pacific region that is large enough to replace the Middle East imports. Therefore, essentially, policy effects are difficult to obtain.

6. A combination of multiple indirect methods are believed to be useful toward achieving targets for which policy has a difficulty exerting effects. For example, on the Middle East dependence for oil supply as mentioned above, the fundamental purpose of policy is to avoid the serious geopolitical risks posed by the Middle East. This purpose can be achieved to some extent by implementing multiple layers of policy, including reducing the use of oil for which the country depends on Middle East imports, preparing for supply interruption risk with the use of oil stocks, and providing support aimed at long-term stability in the Middle East.

7. The strength of regulations on the energy industries or energy markets is an important element that determines the effects of energy policy. The strength of such regulations become weaker in the order of the following situations: (1) monopoly by state-owned enterprises (SOEs), (2) private sector companies play a leading role but business regulations are in place, and (3) private sector companies play a leading role and deregulation has been implemented (market oversight remains in place using environmental/safety regulations or government administration).

   Where SOEs have a monopoly over energy markets in which regulations are strong, this situation is believed to be the easiest way to reflect policy intention more directly in the market over a comparatively shorter period of time. In many of the countries studied, all or certain important parts of energy markets were monopolised by SOEs and this proved to be effective in implementing energy policy.

In situations with strong regulations, however, the screening and management ability of the market regulator, which is the government, largely determines market efficiency and the level of services provided to end consumers. Caution should also be heeded on the possibility that the heavy involvement of politics that typically occurs in such situations could inhibit policy execution.

8. Generally, it is believed that leaving the markets to open competition among private sector companies will result in more diverse services at a lower cost. However, it is important to note that private sector companies essentially do not take action beyond economic rationalities.

   For example, in selecting power sources, if attempting purely to fulfill economic rationalities, most private sector companies would choose subcritical pressure coal-fired power plants. However, this carries with it the potential to go against the requirements of energy security, which include risk dispersion through energy source diversification, reduced demand through improved energy efficiency, and environmental impact reductions. Energy security is a requirement of the nation that exceeds corporate behaviour. As such, it is impossible to completely eliminate the involvement of the national government in a country's energy markets.

   However, it has been proven that incorporating the capital, human resources, and innovation of private sector companies into energy markets will provide profits for the energy markets. Thus, an appropriate balance should be struck between the government and private sector companies depending on the unique situation of each country.

CHAPTER 3
Assessment of Future Energy Security Index

Data Source

In this section, future changes in the energy security index (ESI) are calculated. The following data sources were used in the calculation:

Main data source

- ERIA Outlook 2012

primary energy supply, final energy consumption, generation output, CO_2 Emission, GDP, population

Supplement data source (Production outlook)

- Outlook provided by WG members

- National Energy Outlook

- IEA World Energy Outlook 2013 (WEO, 2013)

- Energy balance provided by ERIA Outlook WG members

In the 2011 and 2012 studies, the Energy Balance table released by the IEA was used. For data consistency, it would be preferable to use IEA estimations even for future ESI calculations. However, IEA's future forecasts do not typically include the disclosure of forecasts for the respective ASEAN countries, making it difficult to carry out a full analysis. Hence, calculations of future ESI done for this study made use of the ERIA Outlook, which provides data in greater detail. Alongside with this, past ESI was recalculated based on publicly available ERIA figures in order to align the calculation criteria for both past and future ESIs.

Table 3-1 shows the main differences between IEA and ERIA data.

Table 3-1: Differences of Data between IEA Energy Balance and ERIA Outlook

Data	IEA Energy Balance	ERIA Outlook
Non-commercial energy	included	excluded
Crude oil and oil products	separated	integrated

Source: Authors.

OECD averages from 1971 to 2009 were used as baseline in the calculation of scores.

Selection of ESIs

Due to the unavailability of data, it is also difficult to calculate the future values for all ESIs adopted to show the situation in the past. The following show the selected ESIs:

Primary Index

- Self-sufficiency
- Diversity of TPES/power generation
- Energy efficiency
- CO_2 emissions

Reference Index

- Electrification

Discarded Index

- Commercial energy access ratio
- Reserve/production, reserve/consumption
- Diversity of import source countries, Middle East dependence
- Reserve margin of generation capacity
- Power outage
- On-land oil stocks

Since energy consumption is closely related to economic activity, the following ESIs were added as supplement indices in order to provide greater understanding of the ESIs.

- TPES/Capita
- GDP/Capita

Results of the 2013 Study

This section provides an overview of the calculation results of future ESIs, using the ERIA Outlook 2012 as the main data source.

In this section, the ESIs for Period 2000s-2 (i.e., 2006-2009) and 2020, 2035, were calculated for both business-as-usual (BAU) scenario and alternative policy scenario (APS). Scores were calculated based on the OECD Average (1971-2009) of 10. The annex also provides values for Period 1990s (1990-1999) and 2000s-1 (2000-2005).

A BAU scenario was developed for each country outlining future sectoral and economy-wide energy consumption assuming no significant changes to government policies. An APS was also designed to examine the potential impacts if additional energy efficiency goals, action plans, or policies were developed that are currently, or likely to be, under consideration. Increased uptake of renewable energy sources and nuclear energy was also considered in the APS. The difference between the BAU and APS represent potential energy savings.

Self-sufficiency

Self-sufficiency is calculated using indigenous production/TPES. As indigenous production is not included in the ERIA Outlook, calculations were made based on the data presented in Table 3-2. The following data was used for the denominator, TPES.

With to the availability of data, ESIs for Indonesia, Malaysia, and Myanmar were 2030, and ESIs for New Zealand were 2025.

Table 3-2: Calculation of Production

Country	Production data	TPES data
Australia	Fossil fuels: Australian energy projections (2011) Others: Calculation from Outlook (power generation)	Outlook
Brunei	Brunei Energy Balance	Brunei Energy Balance
Cambodia	Cambodia Energy Balance	Cambodia Energy Balance
China	Fossil fuels: WEO 2013 Others: Calculation from Outlook (power generation)	Outlook
India	Fossil fuels: WEO 2013 Others: Calculation from Outlook (power generation)	Outlook
Indonesia	Fossil fuels: Indonesia Energy Outlook 2010 Others: Calculation from Outlook (power generation)	Outlook
Japan	Fossil fuels: Regarded as none Others: Calculation from Outlook (power generation)	Outlook
Korea	Fossil fuels: Regarded as none Others: Calculation from Outlook (power generation)	Outlook
Laos	Laos Energy Balance	Laos Energy Balance
Malaysia	Coal, Natural gas: 2000s-2 data Crude oil: Malaysia Others: Calculation from Outlook (power generation)	Outlook
Myanmar	Fossil fuels: Myanmar Others: Calculation from Outlook (power generation)	Outlook
New Zealand	Coal: 2000s-2 data Crude oil: New Zealand Natural gas: New Zealand (medium price case) Others: Calculation from Outlook (power generation)	Outlook
Philippines	Philippines Energy Balance	Philippines Energy Balance
Singapore	Fossil fuels: Regarded as none Others: Calculation from Outlook (power generation)	Outlook
Thailand	Fossil fuels: Thailand Others: Calculation from Outlook (power generation)	Outlook
Vietnam	Fossil fuels: Vietnam Energy Balance Others: Calculation from Outlook (power generation)	Fossil fuels: Vietnam Energy Balance Others: Outlook

Source: Energy Outlook and Analysis of Energy Saving Potential in East Asia, ERIA, 2012.

1) BAU scenario

a. 2020/2000s-2

Self-sufficiency for ASEAN Average and ERIA Average will worsen. Looking at each of the respective countries, production volume of fossil fuels will increase for Australia, Brunei, Laos, and Myanmar, contributing to an improvement in self-sufficiency. However, the remaining countries will face a worsening situation in this aspect.

b. 2035/2020

As it is difficult to obtain 2035 forecasts of production volume for some countries, self-sufficiency was not calculated for ASEAN Average and ERIA Average. Looking at each of the respective countries, self-sufficiency will improve for Australia as a result of an increase in the production volume of fossil fuels, but worsen for the remaining countries. Self-sufficiency will worsen for Japan as a result of a fall in the level of nuclear power output.

2) APS scenario

a. 2020/2000s-2

While self-sufficiency will worsen for ASEAN Average and ERIA Average, the extent of the situation will be lesser compared with the BAU scenario. Looking at each of the respective countries—in addition to Australia, Brunei, Laos, and Myanmar for which self-sufficiency will improve under the BAU scenario—self-sufficiency will also improve for New Zealand. For New Zealand, this improvement is a result of the lower consumption of TPES in the APS scenario as compared to the BAU scenario.

b. 2035/2020

While self-sufficiency for Australia will improve in the BAU scenario, it will improve for India, Indonesia, Japan, Korea, and New Zealand in the APS scenario. For Japan and Korea, an increase in the level of nuclear power generation output will contribute to improvements in self-sufficiency.

Table 3-3: Results of Future Self-Sufficiency (including Nuclear)

Self-sufficiency (including Nuclear)

Country	2000s-2	BAU				APS			
		2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	254%	377%	444%	Improved	Improved	377%	444%	=BAU	
Brunei	624%	721%	619%	Improved	Worsened	721%	619%	=BAU	
Cambodia	16%	11%	12%	Worsened	Improved	11%	12%	=BAU	
China	92%	62%	53%	Worsened	Worsened	69%	68%	=BAU	
India	67%	38%	32%	Worsened	Worsened	44%	46%	Worsened	Improved
Indonesia	195%	126%	121%	Worsened	Worsened	148%	161%	Worsened	Improved
Japan	18%	17%	12%	Worsened	Worsened	21%	27%	Improved	Improved
Korea	20%	18%	19%	Worsened	Improved	23%	29%	Improved	Improved
Laos	80%	158%	100%	Improved	Worsened	188%	112%	=BAU	
Malaysia	134%	85%	53%	Worsened	Worsened	97%	65%	=BAU	
Myanmar	235%	248%	209%	Improved	Worsened	253%	234%	=BAU	
New Zealand	83%	79%	81%	Worsened	Improved	108%	113%	Improved	Improved
Philippines	52%	51%	39%	Worsened	Worsened	65%	65%	Improved	No Change
Singapore	0%	0%	1%	No Change	Improved	0%	1%	=BAU	
Thailand	55%	29%	21%	Worsened	Worsened	34%	27%	=BAU	
Vietnam	145%	81%	48%	Worsened	Worsened	88%	57%	=BAU	
ASEAN average	130%	84%		Worsened		94%		=BAU	
ERIA average	83%	63%		Worsened		70%		=BAU	
OECD average*1	72%								

*1 average of 1971-2009 *2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

Note :APS = alternative policy scenario, BAU = business-as-usual.
Source: Authors.

Table 3-4 presents a comparison with the OECD Average (average for 1971-2009: 72%). Larger values here show the better situation.

Table 3-4: Comparison (Self-sufficiency, including Nuclear)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	35.1	52.2	61.4	52.2	61.4
Brunei	86.3	99.7	85.6	99.7	85.6
Cambodia	2.2	1.5	1.7	1.5	1.7
China	12.8	8.6	7.4	9.5	9.5
India	9.3	5.3	4.4	6.2	6.4
Indonesia	27.0	17.5	16.8	20.4	22.3
Japan	2.5	2.3	1.7	2.9	3.8
Korea	2.7	2.5	2.6	3.2	4.1
Laos	11.1	21.8	13.8	25.9	15.5
Malaysia	18.5	11.8	7.4	13.4	9.0
Myanmar	32.6	34.3	28.9	35.0	32.4
New Zealand	11.4	10.9	11.2	15.0	15.6
Philippines	7.2	7.1	5.4	9.0	9.0
Singapore	0.0	0.1	0.1	0.1	0.1
Thailand	7.7	4.1	2.9	4.7	3.7
Vietnam	20.1	11.2	6.6	12.2	7.9
ASEAN average	18.0	11.6		13.0	
ERIA average	11.5	8.7		9.7	

OECD Total = 10

Note : APS = alternative policy scenario, BAU = business-as-usual.
Source: Authors.

For reference, please see the annex for Self-sufficiency (excluding Nuclear), Coal Self-sufficiency, Crude Oil Self-sufficiency, and Natural Gas Self-sufficiency.

Diversity of energy source

Two ESIs—diversity of TPES and diversity of power generation—will be used as indicators to study the diversity of energy sources, that is, to measure the dispersion of risks.

Diversity of TPES

1) BAU scenario

a. 2020/2000s-2

Although the diversity for ASEAN Average and ERIA Average will improve, looking at the respective countries, the diversity is expected to worsen for Laos, the Philippines, Singapore, and Viet Nam. A common reason behind this situation for Laos, the Philippines, and Viet Nam is the growth in coal consumption.

b. 2035/2020

Although there will be further improvements in the diversity for ASEAN Average and ERIA Average, looking at the respective countries, the diversity will worsen further in the Philippines and Viet Nam due to their increase of coal consumption. Although the diversity will improve from 2000s-2 to 2020 for Australia, Myanmar, and New Zealand, it will worsen from 2020 to 2035. Reasons for such a situation differ from country to country.

Country	**Reasons**
- Australia:	Increase in the amount of natural gas consumed, alongside with a decline in the amount of coal consumed.
- Myanmar:	Fall in the amount of biomass, etc., consumed as a result of economic growth, alongside with an increase in the amount of oil and natural gas consumed
- New Zealand:	Increase in the amount of geothermal energy consumed

2) APS scenario

a. 2020/2000s-2

In the APS scenario, the diversity for ASEAN Average and ERIA Average will improve further as compared with the BAU scenario. Looking at the respective countries, the Philippines, which will face a worsened situation in the diversity in the BAU scenario, will enjoy improvements in the diversity in the APS scenario.

b. 2035/2020

The diversity for ASEAN Average and ERIA Average will improve further in the BAU scenario. Looking at the respective countries, there will be a slight improvement for Viet Nam in the APS scenario, despite its worsened situation in the diversity in the BAU scenario. This improvement is a result of a greater volume of nuclear power generation output. Considering the current situation, the output volume appears to be high. Careful assessment is required in the nuclear use for Viet Nam. Japan, which will undergo a worse situation under the diversity in the BAU scenario, will see some diversity improvements in the APS scenario as a result of increases in nuclear power generation output and renewable energy.

Table 3-5: Results of Future Diversity of TPES

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	3,441	3,177	3,346	Improved	Worsened	3,177	3,346	=BAU	
Brunei	6,620	6,611	6,250	Improved	Improved	6,657	6,504	Worsened	Improved
Cambodia	7,733	3,719	3,783	Improved	Worsened	3,694	3,705	=BAU	
China	5,729	4,421	3,868	Improved	Improved	4,332	3,307	=BAU	
India	4,213	4,000	3,856	Improved	Improved	3,618	2,997	=BAU	
Indonesia	3,175	2,743	2,608	Improved	Improved	2,854	2,552	=BAU	
Japan	2,909	2,538	2,576	Improved	Worsened	2,145	1,855	Improved	Improved
Korea	3,216	2,668	2,591	Improved	Improved	2,593	2,517	=BAU	
Laos	2,959	4,014	3,559	Worsened	Improved	4,086	3,644	=BAU	
Malaysia	3,712	3,607	3,530	Improved	Improved	3,274	3,217	=BAU	
Myanmar	3,816	2,605	3,122	Improved	Worsened	2,604	3,033	=BAU	
New Zealand	2,463	2,128	2,322	Improved	Worsened	2,061	2,071	=BAU	
Philippines	2,593	2,719	3,090	Worsened	Worsened	2,541	2,522	Improved	Improved
Singapore	5,229	6,746	6,263	Worsened	Improved	6,809	6,369	=BAU	
Thailand	3,107	2,653	2,536	Improved	Improved	2,642	2,502	=BAU	
Vietnam	3,040	3,352	3,613	Worsened	Worsened	3,190	3,092	Worsened	Improved
ASEAN average	3,012	2,740	2,650	Improved	Improved	2,707	2,493	=BAU	
ERIA average	3,788	3,480	3,246	Improved	Improved	3,329	2,719	=BAU	
OECD average*1	2,934								

*1 average of 1971-2009

Note :TPES = total primary energy supply.
Source: Authors.

Table 3-6 is a comparison with the OECD Average (average for 1971-2009: 2,934). With Hirschmann-Herfindahl Index (HHI), the better situation is shown by lower values, but as inverse numbers have been used for HHI for the purpose of this scoring, the larger values here show the better situation.

Table 3-6: Comparison (Diversity of TPES)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	8.5	9.2	8.8	9.2	8.8
Brunei	4.4	4.4	4.7	4.4	4.5
Cambodia	3.8	7.9	7.8	7.9	7.9
China	5.1	6.6	7.6	6.8	8.9
India	7.0	7.3	7.6	8.1	9.8
Indonesia	9.2	10.7	11.3	10.3	11.5
Japan	10.1	11.6	11.4	13.7	15.8
Korea	9.1	11.0	11.3	11.3	11.7
Laos	9.9	7.3	8.2	7.2	8.1
Malaysia	7.9	8.1	8.3	9.0	9.1
Myanmar	7.7	11.3	9.4	11.3	9.7
New Zealand	11.9	13.8	12.6	14.2	14.2
Philippines	11.3	10.8	9.5	11.5	11.6
Singapore	5.6	4.3	4.7	4.3	4.6
Thailand	9.4	11.1	11.6	11.1	11.7
Vietnam	9.7	8.8	8.1	9.2	9.5
ASEAN average	9.7	10.7	11.1	10.8	11.8
ERIA average	7.7	8.4	9.0	8.8	10.8

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, TPES = total primary energy supply,

Source: Authors.

Diversity of Power generation

1) BAU scenario

a. 2020/2000s-2

While the diversity will improve for ASEAN Average and ERIA Average, the diversity will worsen for the Philippines as a result of an increase in coal-fired power generation output.

b. 2035/2020

While the diversity will worsen for ASEAN Average, it will improve further for ERIA Average. Looking at individual countries, many countries will face a worse off situation in the diversity. The main reason for this is the increase in the ratio of coal-fired power generation output, against the total amount of power output. For Australia, the amount of coal-fired power generation output as a proportion of total power output will fall while that of natural gas will rise, contributing to further improvements in the diversity.

2) APS scenario

a. 2020/2000s-2

The diversity for ASEAN Average and ERIA Average will improve further as compared to the BAU scenario. Viet Nam, which will undergo a worsened situation in the diversity in the BAU scenario, will undergo an improvement in the diversity in the APS scenario.

b. 2035/2020

The diversity for ASEAN Average will worsen in the BAU scenario, but improve in the APS scenario. The diversity for ERIA Average will improve further when compared with the BAU scenario. Looking at the respective countries, although the diversity is expected to worsen in the BAU scenario for India, Indonesia, Japan, Myanmar, and Thailand, it is expected to improve in the APS scenario. This is because the ratio of coal-fired power generation output against total power generation output will fall in these countries.

Table 3-7: Results of Future Diversity of Power Generation

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	6,351	3,730	2,728	Improved	Improved	3,730	2,728	=BAU	
Brunei	9,807	10,000	10,000	Worsened	No Change	9,546	9,132	Improved	Improved
Cambodia	9,201	5,308	5,446	Improved	Worsened	5,356	5,360	=BAU	
China	6,621	4,602	4,064	Improved	Improved	4,311	2,892	=BAU	
India	5,017	4,614	4,900	Improved	Worsened	3,787	3,032	Improved	Improved
Indonesia	2,955	2,547	2,842	Improved	Worsened	2,469	2,225	Improved	Improved
Japan	2,239	2,210	2,637	Improved	Worsened	2,145	1,855	Improved	Improved
Korea	3,280	3,311	3,413	Worsened	Worsened	3,300	3,397	=BAU	
Laos	10,000	5,911	6,640	Improved	Worsened	5,911	6,640	=BAU	
Malaysia	4,801	4,166	4,524	Improved	Worsened	3,794	3,844	=BAU	
Myanmar	4,590	3,741	3,794	Improved	Worsened	3,586	2,924	Improved	Improved
New Zealand	3,642	3,361	2,992	Improved	Improved	3,365	3,306	=BAU	
Philippines	2,327	3,831	5,099	Worsened	Worsened	3,507	3,828	=BAU	
Singapore	6,735	6,665	6,603	Improved	Improved	6,668	6,620	=BAU	
Thailand	5,155	4,971	5,101	Improved	Worsened	4,909	4,790	Improved	Improved
Vietnam	3,329	3,418	4,222	Worsened	Worsened	3,155	3,291	Improved	Worsened
ASEAN average	3,179	3,052	3,304	Improved	Worsened	2,908	2,736	Improved	Improved
ERIA average	4,211	3,717	3,694	Improved	Improved	3,332	2,503	=BAU	
OECD average*1	2,441								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual.
Source: Authors.

Table 3-8 presents a comparison with the OECD Average (average for 1971-2009: 2,441). With HHI, the better situation is shown by lower values, but as inverse numbers have been used for HHI for the purpose of this scoring, the larger values here show the better situation.

Table 3-8: Comparison (Diversity of Power Generation)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	3.8	6.5	8.9	6.5	8.9
Brunei	2.5	2.4	2.4	2.6	2.7
Cambodia	2.7	4.6	4.5	4.6	4.6
China	3.7	5.3	6.0	5.7	8.4
India	4.9	5.3	5.0	6.4	8.1
Indonesia	8.3	9.6	8.6	9.9	11.0
Japan	10.9	11.0	9.3	11.4	13.2
Korea	7.4	7.4	7.2	7.4	7.2
Laos	2.4	4.1	3.7	4.1	3.7
Malaysia	5.1	5.9	5.4	6.4	6.3
Myanmar	5.3	6.5	6.4	6.8	8.3
New Zealand	6.7	7.3	8.2	7.3	7.4
Philippines	10.5	6.4	4.8	7.0	6.4
Singapore	3.6	3.7	3.7	3.7	3.7
Thailand	4.7	4.9	4.8	5.0	5.1
Vietnam	7.3	7.1	5.8	7.7	7.4
ASEAN average	7.7	8.0	7.4	8.4	8.9
ERIA average	5.8	6.6	6.6	7.3	9.8

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual.
Source: Authors.

Energy efficiency

Total primary energy supply (TPES) per GDP and total final energy consumption (TFEC) per GDP are used as indicators to measure the situation of energy efficiency. If the growth rate for TPES and TFEC are lower than the growth rate of GDP, these values will be small. In other words, this will show improvements in energy efficiency.

TPES/GDP

1) BAU scenario

a. 2020/2000s-2

Energy efficiency for ASEAN Average and ERIA Average will improve. Although energy efficiency will improve for many countries, it will worsen for Cambodia, Laos, Singapore, and Viet Nam.

b. 2035/2020

Energy efficiency for ASEAN Average and ERIA Average will improve further, but TPES per GDP will worsen for Malaysia.

2) APS scenario

a. 2020/2000s-2

Energy efficiency for ASEAN Average and ERIA Average is higher when compared with the BAU scenario. Looking at individual countries, energy efficiency for Cambodia and Viet Nam, which will worsen in the BAU scenario, will improve in the APS scenario.

b. 2035/2020

Energy efficiency for ASEAN Average and ERIA Average is higher when compared with the BAU scenario. Looking at individual countries, Malaysia, which will suffer a worse situation in energy efficiency in the BAU scenario, will experience improvements in the APS scenario.

Table 3-9: Results of Future TPES/GDP

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.21	0.17	0.11	Improved	Improved	0.17	0.11	=BAU	
Brunei	0.48	0.41	0.33	Improved	Improved	0.36	0.23	=BAU	
Cambodia	0.19	0.21	0.19	Worsened	Improved	0.18	0.17	Improved	Improved
China	0.72	0.51	0.36	Improved	Improved	0.48	0.29	=BAU	
India	0.57	0.39	0.30	Improved	Improved	0.36	0.24	=BAU	
Indonesia	0.59	0.53	0.52	Improved	Improved	0.44	0.38	=BAU	
Japan	0.10	0.08	0.07	Improved	Improved	0.08	0.06	=BAU	
Korea	0.30	0.25	0.21	Improved	Improved	0.25	0.19	=BAU	
Laos	0.34	0.62	0.36	Worsened	Improved	0.60	0.34	=BAU	
Malaysia	0.50	0.41	0.43	Improved	Worsened	0.36	0.35	Improved	Improved
Myanmar	0.30	0.25	0.22	Improved	Improved	0.25	0.19	=BAU	
New Zealand	0.24	0.22	0.20	Improved	Improved	0.21	0.17	=BAU	
Philippines	0.32	0.20	0.15	Improved	Improved	0.19	0.15	=BAU	
Singapore	0.12	0.18	0.13	Worsened	Improved	0.18	0.13	=BAU	
Thailand	0.59	0.56	0.56	Improved	No Change	0.49	0.43	Improved	Improved
Vietnam	0.64	0.69	0.59	Worsened	Improved	0.63	0.54	Improved	Improved
ASEAN average	0.46	0.42	0.40	Improved	Improved	0.37	0.32	=BAU	
ERIA average	0.34	0.32	0.27	Improved	Improved	0.30	0.22	=BAU	
OECD average*1	0.22								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, GDP = gross domestic product, TPES = total primary energy supply,

Source: Authors.

Table 3-10 presents a comparison with the OECD Average (average for 1971-2009: 0.22). With TPES per GDP, the better situation is shown by lower values, but as inverse numbers have been used for TPES per GDP for the purpose of this scoring, the large values here show the better situation.

Table 3-10: Comparison (TPES/GDP)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	10.4	12.9	20.9	12.9	20.9
Brunei	4.6	5.4	6.8	6.1	9.6
Cambodia	11.4	10.7	11.7	12.0	12.9
China	3.1	4.3	6.2	4.7	7.6
India	3.9	5.6	7.4	6.2	9.4
Indonesia	3.7	4.2	4.3	5.0	5.8
Japan	22.6	26.4	33.1	27.8	37.9
Korea	7.3	8.7	10.4	9.0	11.4
Laos	6.4	3.6	6.2	3.7	6.5
Malaysia	4.4	5.4	5.2	6.1	6.3
Myanmar	7.4	8.8	10.2	8.9	11.5
New Zealand	9.2	10.0	11.2	10.6	13.4
Philippines	7.0	10.8	14.5	11.5	14.9
Singapore	17.8	12.0	16.6	12.2	17.1
Thailand	3.7	3.9	4.0	4.5	5.1
Vietnam	3.5	3.2	3.8	3.5	4.1
ASEAN average	4.8	5.3	5.5	6.0	6.8
ERIA average	6.6	6.9	8.2	7.4	10.1

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, GDP = gross domestic product, TPES = total primary energy supply,
Source: Authors.

TFEC/GDP

1) BAU scenario

a. 2020/2000s-2

While TPES per GDP will improve for the ASEAN Average, Australia, Indonesia, Malaysia, and Thailand, TFEC per GDP will worsen under the BAU scenario. This can be interpreted as an improvement in the efficiency for the transformation processes in these countries, such as in power generation. However, efficiency at the final consumption phases will worsen, such as in industry, transport, and residential uses. TPES per GDP will worsen for Cambodia, while TFEC per GDP will improve. This means that while primary energy supply—such as for power generation purposes—will increase for Cambodia, energy efficiency will improve at the final consumption phases.

b. 2035/2020

TFEC per GDP, which will worsen for ASEAN Average and Australia in 2020/2000s-2, will improve in 2035/2020. TFEC per GDP, however, will worsen further for Malaysia and Thailand in 2035/2020. This means that in 2035/2020, efficiency will improve for Australia at the final consumption phases, but will not improve for Malaysia and Thailand.

2) APS scenario

a. 2020/2000s-2

For Indonesia and Malaysia, TFEC per GDP will worsen in the BAU scenario, but will improve in the APS scenario. This is the result of predictions for improvements in efficiency at the final consumption phases in the APS scenario. As TFEC per GDP will improve for these two countries, it will also improve for ASEAN Average. On the other hand, APS scenario will worsen for Thailand.

b. 2035/2020

For 2035/2020 in the APS scenario, no countries will experience a worsened situation in TFEC per GDP.

Table 3-11: Results of Future TFEC/GDP

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.12	0.13	0.08	Worsened	Improved	0.13	0.08	=BAU	
Brunei	0.23	0.22	0.20	Improved	Improved	0.20	0.14	=BAU	
Cambodia	0.17	0.14	0.14	Improved	No Change	0.12	0.12	=BAU	
China	0.44	0.32	0.22	Improved	Improved	0.30	0.19	=BAU	
India	0.31	0.23	0.18	Improved	Improved	0.21	0.15	=BAU	
Indonesia	0.37	0.38	0.38	Worsened	No Change	0.33	0.31	Improved	Improved
Japan	0.06	0.05	0.04	Improved	Improved	0.05	0.04	=BAU	
Korea	0.20	0.16	0.13	Improved	Improved	0.16	0.12	=BAU	
Laos	0.23	0.25	0.22	Worsened	Improved	0.24	0.20	=BAU	
Malaysia	0.30	0.32	0.33	Worsened	Worsened	0.28	0.27	Improved	Improved
Myanmar	0.22	0.16	0.15	Improved	Improved	0.15	0.14	=BAU	
New Zealand	0.17	0.15	0.12	Improved	Improved	0.14	0.11	=BAU	
Philippines	0.17	0.11	0.09	Improved	Improved	0.10	0.08	=BAU	
Singapore	0.10	0.15	0.11	Worsened	Improved	0.15	0.11	=BAU	
Thailand	0.37	0.43	0.44	Worsened	Worsened	0.38	0.34	Worsened	Improved
Vietnam	0.50	0.50	0.40	No Change	Improved	0.47	0.38	Improved	Improved
ASEAN average	0.29	0.31	0.30	Worsened	Improved	0.27	0.25	Improved	Improved
ERIA average	0.20	0.20	0.17	No Change	Improved	0.19	0.15	Improved	Improved
OECD average*1	0.15								

*1 average of 1971-2009

Note : APS = alternative policy scenario, BAU = business-as-usual, GDP = gross domestic product, TFEC = total final energy consumption.
Source: Authors.

Table 3-12 presents a comparison with the OECD Average (average for 1971-2009: 0.15). With TFEC per GDP, the better situation is shown by lower values, but as inverse numbers have been used for TFEC per GDP for the purpose of this scoring, the large values here show the better situation.

Table 3-12: Comparison (TFEC/GDP)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	13.2	12.2	18.4	12.2	18.4
Brunei	6.8	7.0	7.7	7.8	11.0
Cambodia	9.3	11.2	11.4	12.6	13.2
China	3.6	4.9	7.0	5.1	8.0
India	5.0	6.9	8.6	7.3	10.3
Indonesia	4.2	4.0	4.0	4.7	5.1
Japan	23.9	28.3	36.1	29.8	41.4
Korea	7.8	9.6	11.6	9.9	12.7
Laos	6.7	6.2	7.0	6.6	7.7
Malaysia	5.2	4.9	4.6	5.6	5.8
Myanmar	6.9	10.0	10.5	10.5	11.4
New Zealand	9.0	10.4	12.7	10.8	14.1
Philippines	9.3	13.6	17.3	14.8	18.9
Singapore	15.8	10.4	14.1	10.5	14.4
Thailand	4.2	3.6	3.6	4.1	4.5
Vietnam	3.1	3.1	3.8	3.3	4.1
ASEAN average	5.3	5.0	5.2	5.7	6.3
ERIA average	7.6	7.6	9.0	8.0	10.4

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, GDP = gross domestic product, TFEC = total final energy consumption.
Source: Authors.

CO_2 emission

The evaluation of CO_2 emission looks at four ESIs: (i) CO_2 emission per TPES, (ii) CO_2 emission per fossil fuel primary supply, (iii) CO_2 emission per GDP, and (iv) CO_2 emission per population.

CO_2 emission per TPES depends mainly on the ratio of fossil fuels against TPES. Accordingly, if the ratio of fossil fuels against TPES will fall in the future, CO_2 emission per TPES will improve.

CO_2 emission per fossil fuel primary supply depends mainly on the allocation of coal and natural gas. For example, if the ratio of coal against TPES falls while that of natural gas increases, CO_2 emission per fossil fuel primary supply will improve.

CO_2 emission per GDP depends mainly on energy efficiency. Accordingly, if energy efficiency improves, CO_2 emission per GDP will improve.

CO_2 emission per population depends mainly on economic growth. Accordingly, if the economy expands and grows and the quality of life improves, energy consumption will also increase, resulting in a worsened CO_2 emission per population. Conversely, even if the economy grows, but energy efficiency also improves, and the consumption of low-carbon energy increases, CO_2 emission per population may be contained and the situation will not worsen.

CO_2 emission/TPES

1) BAU scenario

a. 2020/2000s-2

CO_2 emission/TPES will improve for ASEAN Average and ERIA Average. Looking at individual countries, it will worsen for Cambodia, Laos, Malaysia, the Philippines, and Viet Nam. The main factor for the worsened situation in these countries will be a rise in coal-fired power generation output.

b. 2035/2020

CO_2 emission/TPES will improve further for ERIA Average, but worsen for ASEAN Average. Looking at individual countries, it will worsen for Indonesia, Japan, Malaysia, Myanmar, the Philippines, Singapore, and Viet Nam. The main reason for the worsened situation will be an increase in the ratio of thermal power generation output alongside a fall in the share of nuclear power generation output for Japan, and of hydropower generation output for Myanmar. For Indonesia, Malaysia, the Philippines, and Viet Nam, the main factor would be the rise in the ratio of coal-fired power generation output.

2) APS scenario

a. 2020/2000s-2

CO_2 emission/TPES will improve for ASEAN Average and ERIA Average. Looking at individual countries, as for the BAU scenario, CO_2 emission/TPES will worsen for Cambodia, Laos, Malaysia, the Philippines, and Viet Nam.

b. 2035/2020

From 2020 to 2035, CO_2 emission/TPES for ERIA Average will improve, or better than in the BAU scenario. While energy efficiency will worsen in the BAU scenario for Japan, Malaysia, and Viet Nam, it will improve in the APS scenario.

Table 3-13: Results of Future CO_2 Emission/TPES

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.96	0.58	0.51	Improved	Improved	0.58	0.51	=BAU	
Brunei	0.62	0.57	0.57	Improved	No Change	0.55	0.55	Improved	
Cambodia	0.85	0.89	0.87	Worsened	Improved	0.92	0.87	=BAU	
China	0.92	0.85	0.81	Improved	Improved	0.83	0.72	=BAU	
India	0.85	0.84	0.84	Improved	No Change	0.80	0.74	Improved	Improved
Indonesia	0.69	0.66	0.68	Improved	Worsened	0.62	0.63	=BAU	
Japan	0.64	0.64	0.68	No Change	Worsened	0.60	0.54	Improved	Improved
Korea	0.61	0.58	0.57	Improved	Improved	0.52	0.44	=BAU	
Laos	0.45	1.26	0.97	Worsened	Improved	1.24	0.98	=BAU	
Malaysia	0.69	0.78	0.80	Worsened	Worsened	0.74	0.72	Worsened	Improved
Myanmar	0.57	0.57	0.66	No Change	Worsened	0.57	0.63	=BAU	
New Zealand	0.56	0.40	0.32	Improved	Improved	0.39	0.31	=BAU	
Philippines	0.55	0.66	0.76	Worsened	Worsened	0.61	0.62	=BAU	
Singapore	0.70	0.46	0.49	Improved	Worsened	0.46	0.48	=BAU	
Thailand	0.67	0.47	0.45	Improved	Improved	0.46	0.44	=BAU	
Vietnam	0.78	0.86	0.88	Worsened	Worsened	0.83	0.81	Worsened	Improved
ASEAN average	0.68	0.65	0.68	Improved	Worsened	0.62	0.63	=BAU	
ERIA average	0.82	0.79	0.77	Improved	Improved	0.76	0.68	=BAU	
OECD average*1	0.69								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, TPES = total primary energy supply,
Source: Authors.

Table 3-14 presents a comparison with the OECD Average (average for 1971-2009: 0.69). With CO_2 emission per TPES, the better situation is shown by lower values, but as inverse numbers have been used for CO_2 emission per TPES for the purpose of this scoring, the large values here show the better situation.

Table 3-14: Comparison (CO_2 Emission/TPES)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	7.2	12.0	13.5	12.0	13.5
Brunei	11.1	12.2	12.1	12.7	12.6
Cambodia	8.1	7.8	8.0	7.5	7.9
China	7.5	8.1	8.6	8.3	9.6
India	8.1	8.2	8.2	8.6	9.3
Indonesia	9.9	10.5	10.1	11.1	10.9
Japan	10.7	10.7	10.2	11.4	12.8
Korea	11.4	11.8	12.2	13.2	15.6
Laos	15.2	5.5	7.1	5.5	7.0
Malaysia	10.0	8.8	8.7	9.4	9.7
Myanmar	12.2	12.0	10.5	12.2	10.9
New Zealand	12.4	17.2	21.5	17.7	22.2
Philippines	12.5	10.4	9.1	11.2	11.1
Singapore	9.8	15.0	14.0	15.2	14.2
Thailand	10.3	14.5	15.2	14.8	15.8
Vietnam	8.9	8.1	7.9	8.3	8.5
ASEAN average	10.1	10.7	10.2	11.2	11.0
ERIA average	8.4	8.8	9.0	9.1	10.2

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, TPES = total primary energy supply,

Source: Authors.

CO_2 emission/fossil fuel primary supply

Table 3-15 presents the future CO_2 emission/fossil fuel primary supply under both the BAU and APS cases.

1) BAU scenario

a. 2020/2000s-2

CO_2 emission/fossil fuel primary supply will improve for ASEAN Average and ERIA Average. Looking at individual countries, it will worsen for Cambodia, India, Laos, Malaysia, Myanmar, the Philippines, and Viet Nam. The main factor behind this is the increase of coal-fired power generation output in these countries.

b. 2035/2020

CO_2 emission/fossil fuel primary supply will improve further for ERIA Average but will worsen for ASEAN Average. Looking at the individual countries, it will worsen for Indonesia, the Philippines, Singapore, and Viet Nam.

2) APS scenario

a. 2020/2000s-2

CO_2 emission/fossil fuel primary supply will improve for ASEAN Average and ERIA Average. Looking at individual countries, under the BAU scenario, it will worsen for Cambodia, India, Laos, Malaysia, Myanmar, the Philippines, and Viet Nam.

b. 2035/2020

Under the BAU scenario, while CO_2 emission/fossil fuel primary supply will improve for ERIA Average, this will worsen for ASEAN Average. While there were no changes for Cambodia in the BAU scenario, it is expected to worsen in the APS scenario. Also under BAU scenario, CO_2 emission/fossil fuel primary supply will worsen for Indonesia, the Philippines, Singapore, and Viet Nam.

Table 3-15: Results of Future CO_2 Emission/Fossil Fuel Primary Supply

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.89	0.61	0.56	Improved	Improved	0.61	0.56	=BAU	
Brunei	0.62	0.57	0.57	Improved	No Change	0.55	0.55	=BAU	
Cambodia	0.80	0.92	0.92	Worsened	No Change	0.92	0.93	Worsened	Worsened
China	0.96	0.92	0.90	Improved	Improved	0.92	0.87	=BAU	
India	0.88	0.90	0.90	Worsened	No Change	0.89	0.87	Worsened	Improved
Indonesia	0.78	0.78	0.81	No Change	Worsened	0.74	0.78	Improved	Worsened
Japan	0.78	0.78	0.78	No Change	No Change	0.78	0.76	No Change	Improved
Korea	0.75	0.72	0.71	Improved	Improved	0.69	0.64	=BAU	
Laos	0.17	1.10	1.03	Worsened	Improved	1.09	1.03	=BAU	
Malaysia	0.71	0.80	0.80	Worsened	No Change	0.77	0.76	Worsened	Improved
Myanmar	0.68	0.78	0.77	Worsened	Improved	0.77	0.77	Worsened	No Change
New Zealand	0.79	0.72	0.72	Improved	No Change	0.73	0.73	=BAU	
Philippines	0.85	0.92	0.94	Worsened	Worsened	0.92	0.93	=BAU	
Singapore	0.71	0.46	0.50	Improved	Worsened	0.46	0.49	=BAU	
Thailand	0.76	0.64	0.62	Improved	Improved	0.65	0.63	=BAU	
Vietnam	0.87	0.93	0.94	Worsened	Worsened	0.92	0.93	=BAU	
ASEAN average	0.77	0.76	0.79	Improved	Worsened	0.74	0.77	=BAU	
ERIA average	0.89	0.87	0.86	Improved	Improved	0.87	0.83	=BAU	
OECD average*1	0.79								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide,
Source: Authors.

Table 3-16 presents a comparison with the OECD Average (average for 1971-2009: 0.79). With CO_2 emission per fossil fuel primary supply, the better situation is shown by lower values, but as inverse numbers have been used for

CO_2 emission per fossil fuel primary supply for the purpose of this scoring, the large values here show the better situation.

Table 3-16: Comparison (CO_2 Emission/Fossil Fuel Primary Supply)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	8.9	13.0	14.2	13.0	14.2
Brunei	12.8	14.0	14.0	14.6	14.5
Cambodia	9.9	8.6	8.6	8.7	8.5
China	8.3	8.6	8.9	8.6	9.1
India	9.0	8.8	8.8	9.0	9.2
Indonesia	10.2	10.1	9.8	10.7	10.2
Japan	10.2	10.1	10.2	10.2	10.5
Korea	10.6	11.1	11.3	11.5	12.5
Laos	45.4	7.2	7.7	7.3	7.7
Malaysia	11.2	9.9	9.9	10.2	10.4
Myanmar	11.7	10.1	10.4	10.4	10.3
New Zealand	10.1	11.0	11.1	10.9	10.9
Philippines	9.3	8.6	8.4	8.7	8.5
Singapore	11.3	17.1	15.9	17.2	16.1
Thailand	10.4	12.4	12.8	12.3	12.6
Vietnam	9.1	8.6	8.5	8.6	8.6
ASEAN average	10.4	10.5	10.1	10.7	10.3
ERIA average	8.9	9.1	9.2	9.2	9.6

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide,
Source: Authors.

CO_2 emission/GDP

1) BAU scenario

a. 2020/2000s-2

CO_2 emission/GDP will improve for ASEAN Average and ERIA Average. Looking at individual countries, it is expected to worsen for Cambodia, Laos, and Viet Nam. TPES/GDP, which is an indicator of energy efficiency, will worsen for these countries. Through this, a close relationship can be noted between CO_2 emission/GDP and energy efficiency.

b. 2035/2020

Although CO_2 emission/GDP will improve further for ERIA Average, there are no changes for ASEAN Average. Looking at individual countries, it will worsen for Malaysia. This is tied in with the worsened situation of TPES/GDP (2035/2020, BAU scenario), which shows the energy efficiency for Malaysia.

2) APS scenario

a. 2020/2000s-2

Under the BAU scenario, CO_2 emission/GDP improves for ASEAN Average and ERIA Average. Looking at individual countries, while it worsens for Cambodia, Laos, and Viet Nam, the degree of the worsened situation is lesser than in the BAU scenario. Looking at TPES/GDP under the APS scenario, improvements are observed for Cambodia and Viet Nam.

b. 2035/2020

Although a worsened situation is observed for Malaysia under the BAU scenario, it will also undergo an improvement in the APS scenario.

Table 3-17: Results of Future CO_2 Emission/GDP

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.20	0.10	0.05	Improved	Improved	0.10	0.05	=BAU	
Brunei	0.30	0.23	0.19	Improved	Improved	0.20	0.13	=BAU	
Cambodia	0.16	0.18	0.16	Worsened	Improved	0.17	0.15	=BAU	
China	0.67	0.44	0.29	Improved	Improved	0.39	0.21	=BAU	
India	0.48	0.33	0.25	Improved	Improved	0.29	0.17	=BAU	
Indonesia	0.41	0.35	0.35	Improved	No Change	0.28	0.24	Improved	Improved
Japan	0.06	0.05	0.05	Improved	No Change	0.05	0.03	Improved	Improved
Korea	0.18	0.15	0.12	Improved	Improved	0.13	0.09	=BAU	
Laos	0.15	0.78	0.35	Worsened	Improved	0.75	0.33	=BAU	
Malaysia	0.34	0.32	0.34	Improved	Worsened	0.27	0.25	Improved	Improved
Myanmar	0.17	0.15	0.14	Improved	Improved	0.14	0.12	=BAU	
New Zealand	0.13	0.09	0.06	Improved	Improved	0.08	0.05	=BAU	
Philippines	0.18	0.14	0.12	Improved	Improved	0.12	0.09	=BAU	
Singapore	0.09	0.08	0.07	Improved	Improved	0.08	0.06	=BAU	
Thailand	0.36	0.27	0.25	Improved	Improved	0.23	0.19	=BAU	
Vietnam	0.50	0.59	0.52	Worsened	Improved	0.53	0.44	=BAU	
ASEAN average	0.31	0.27	0.27	Improved	No Change	0.23	0.20	Improved	Improved
ERIA average	0.28	0.25	0.21	Improved	Improved	0.23	0.15	=BAU	
OECD average*1	0.15								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product.
Source: Authors.

Table 3-18 shows a comparison with the OECD Average (average for 1971-2009: 0.15). With CO_2 emission per GDP, the better situation is shown by lower values, but as inverse numbers have been used for CO_2 emission per GDP for the purpose of this scoring, the large values here show the better situation.

Table 3-18: Comparison (CO_2 Emission/GDP)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	7.5	15.5	28.3	15.5	28.3
Brunei	5.1	6.6	8.3	7.7	12.1
Cambodia	9.3	8.3	9.3	9.0	10.2
China	2.3	3.5	5.3	3.9	7.3
India	3.2	4.6	6.1	5.3	8.8
Indonesia	3.7	4.4	4.3	5.5	6.4
Japan	24.2	28.3	33.8	31.8	48.6
Korea	8.3	10.3	12.6	11.9	17.9
Laos	10.1	2.0	4.4	2.0	4.6
Malaysia	4.4	4.7	4.5	5.7	6.1
Myanmar	8.9	10.5	10.7	10.9	12.5
New Zealand	11.4	17.2	24.1	18.8	29.7
Philippines	8.7	11.3	13.1	12.9	16.5
Singapore	17.4	18.0	23.3	18.4	24.4
Thailand	4.2	5.7	6.1	6.7	8.0
Vietnam	3.1	2.6	3.0	2.9	3.5
ASEAN average	5.0	5.6	5.6	6.7	7.5
ERIA average	5.5	6.0	7.4	6.7	10.2

Score is calculated by inverse of ESI, OECD Total = 10

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide.
Source: Authors.

CO_2 emission/population

<u>1) BAU scenario</u>

<u>a. 2020/2000s-2</u>

CO_2 emission/population will improve for three countries—Australia, Brunei, and New Zealand. The reason is clearly shown in the comparison with the supplement index for GDP per capital (see Table 3-22). For countries with a high annual growth rate for GDP per capita, CO_2 emission/population tends to worsen.

b. 2035/2020

CO_2 emission/population will improve for Australia, Brunei, Laos, and New Zealand.

2) APS scenario

a. 2020/2000s-2

Under the BAU scenario, Japan will undergo a worsened situation in CO_2 emission/population, but will improve in the APS scenario. This can mostly be attributed to a decline in the share for thermal power generation output in the APS scenario, and conversely, an increase in the share for nuclear power generation output, which will result in a significant decline in CO_2 emissions.

b. 2035/2020

In addition to the four countries that experienced improvements in the BAU scenario—Australia, Brunei, Laos, and New Zealand—improvements are also observed for China, Japan, and Korea.

Table 3-19: Results of Future CO_2 Emission/Population

Country	2000s-2	BAU				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	4.99	3.22	2.51	Improved	Improved	3.22	2.51	=BAU	
Brunei	5.31	4.20	4.17	Improved	Improved	3.60	2.83	=BAU	
Cambodia	0.08	0.14	0.20	Worsened	Worsened	0.13	0.19	=BAU	
China	1.29	2.13	2.67	Worsened	Worsened	1.93	1.92	Worsened	Improved
India	0.34	0.55	0.90	Worsened	Worsened	0.47	0.62	=BAU	
Indonesia	0.43	0.63	1.20	Worsened	Worsened	0.50	0.82	=BAU	
Japan	2.51	2.54	2.80	Worsened	Worsened	2.26	1.95	Improved	Improved
Korea	2.79	3.43	4.02	Worsened	Worsened	2.98	2.84	Worsened	Improved
Laos	0.07	0.74	0.73	Worsened	Improved	0.71	0.70	=BAU	
Malaysia	1.72	2.22	3.29	Worsened	Worsened	1.85	2.42	=BAU	
Myanmar	0.06	0.11	0.26	Worsened	Worsened	0.11	0.22	=BAU	
New Zealand	2.10	1.65	1.37	Improved	Improved	1.50	1.11	=BAU	
Philippines	0.21	0.30	0.43	Worsened	Worsened	0.26	0.34	=BAU	
Singapore	2.62	4.02	4.48	Worsened	Worsened	3.93	4.28	=BAU	
Thailand	0.93	1.09	1.63	Worsened	Worsened	0.93	1.22	No Change	Worsened
Vietnam	0.31	0.76	1.68	Worsened	Worsened	0.68	1.43	=BAU	
ASEAN average	0.48	0.70	1.20	Worsened	Worsened	0.59	0.90	=BAU	
ERIA average	0.91	1.32	1.70	Worsened	Worsened	1.18	1.23	=BAU	
OECD average*1	2.91								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide.
Source: Authors.

Table 3-20 presents a comparison with the OECD Average (average for 1971-2009: 2.91). With CO_2 emission per population, the better situation is shown by lower values, but as inverse numbers have been used for CO_2 emission per population for the purpose of this scoring, the large values here show the better situation.

Table 3-20: Comparison (CO_2 Emission/Population)

Country	2000s-2	BAU		APS	
		2020	2035	2020	2035
Australia	5.8	9.0	11.6	9.0	11.6
Brunei	5.5	6.9	7.0	8.1	10.3
Cambodia	354.9	204.7	142.8	223.3	156.7
China	22.6	13.6	10.9	15.1	15.1
India	85.8	53.2	32.4	61.7	47.0
Indonesia	66.8	45.9	24.2	58.1	35.6
Japan	11.6	11.4	10.4	12.9	14.9
Korea	10.4	8.5	7.2	9.8	10.2
Laos	413.5	39.5	39.6	41.0	41.5
Malaysia	16.9	13.1	8.8	15.7	12.0
Myanmar	450.1	265.1	113.3	274.6	131.8
New Zealand	13.8	17.7	21.2	19.4	26.2
Philippines	138.5	98.3	67.0	112.9	84.3
Singapore	11.1	7.2	6.5	7.4	6.8
Thailand	31.1	26.8	17.9	31.3	23.8
Vietnam	92.7	38.2	17.3	43.1	20.4
ASEAN average	60.8	41.5	24.3	49.2	32.3
ERIA average	32.0	22.0	17.1	24.7	23.7

Score is calculated by inverse of ESI, OECD Total = 10

Note: APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide.
Source: Authors.

Electrification (for reference)

The degree of economic development varies among ERIA member countries, and there are countries where the supply of electricity does not yet extend across the entire country. In these countries, electrification is positioned as an important policy goal. In this section, the current status of electrification and future electrification goals are analysed as reference data.

Table 3-21 shows the current status of electrification in ERIA member countries, based on the electrification database of the IEA World Energy Outlook (WEO).

Table 3-21: Current Status of Electrification

Country	2000 (WEO 2002)		2005 (WEO 2006)		2009 (WEO 2011)		2010 (WEO 2012)		2011 (WEO 2013)	
	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)
Australia	100.0%		100.0%		100.0%		100.0%		100.0%	
Brunei	99.2%	0.0	99.2%	0.0	99.7%	0.0	99.7%	0.0	99.7%	0.0
Cambodia	15.8%	10.3	20.1%	10.9	24.0%	11.3	31.1%	10.3	34.0%	9.4
China	98.6%	17.6	99.4%	8.5	99.4%	8.0	99.7%	3.9	99.8%	2.5
India	43.0%	579.1	55.5%	487.2	75.0%	288.8	75.0%	292.9	75.3%	306.1
Indonesia	53.4%	98.0	54.0%	101.2	64.5%	81.6	73.0%	62.8	72.9%	65.7
Japan	100.0%		100.0%		100.0%		100.0%		100.0%	
Korea	100.0%		100.0%		100.0%		100.0%		100.0%	
Laos					55.0%	2.6	63.0%	2.2	78.0%	1.3
Malaysia	96.9%	0.7	97.8%	0.6	99.4%	0.2	99.4%	0.2	99.5%	0.1
Myanmar	5.0%	45.3	11.3%	45.1	13.0%	43.5	48.8%	25.8	48.8%	24.7
New Zealand	100.0%		100.0%		100.0%		100.0%		100.0%	
Philippines	87.4%	9.5	80.5%	16.2	89.7%	9.5	83.3%	15.6	70.2%	28.3
Singapore	100.0%		100.0%		100.0%		100.0%		100.0%	
Thailand	82.1%	10.9	99.0%	0.6	99.3%	0.5	87.7%	8.4	99.0%	0.7
Vietnam	75.8%	19.0	84.2%	13.2	95.1%*	2.1	95.9%*	2.1	96.4%*	2.1
ERIA Total	73.5%	790.4	78.2%	683.5	86.3%	448.1	87.1%	424.2	87.2%	440.9

Note : Electrification rate is regarded as 100% in OECD Countries
Source: IEA World Energy Outlook and Electricity of Vietnam.

Table 3-22 shows countries that have established electrification targets, and their respective target values. As there is a possibility for varying definitions of electrification in WEO and in the respective countries, it is important to note the consistency with Table 3-21, as provided above.

Table 3-22: Electrification Target

Country	2015	2020	2025	2030	2035
	Electrification rate	Electrification rate	Electrification rate	Electrification rate	Electrification rate
Cambodia					100%
China	100%				
Laos	80%	90%			
Malaysia	98.41%				
Myanmar	34%	45%	60%	80%	
Thailand	100%				
Vietnam		100%			

Source: Authors.

Supplement Index

There is a close relationship between energy consumption and factors such as population and economic activities. In this section, the study looks mainly at TPES per population and GDP per population as supplement indices, in order to gain a better understanding of ESIs that are related to CO_2 emission.

TPES/Population

1) BAU scenario

a. 2020/2000s-2

Only Brunei showed a decline in TPES/population.

b. 2035/2020

In addition to Brunei, Australia also experienced a decline in its number.

2) APS scenario

a. 2020/2000s-2

Although Brunei was the only country to experience a decline under the BAU scenario, Japan and New Zealand also experienced declines under the APS scenario.

b. 2035/2020

Although Australia and Brunei were the only countries to experience a decline in the BAU scenario, Japan and New Zealand also experienced a decline in the APS scenario.

Table 3-23: TPES/Population

Country	2000s-2	BAU 2020	BAU 2035	BAU 2020/2000s-2	BAU 2035/2020	APS 2020	APS 2035	APS 2020/2000s-2	APS 2035/2020
Australia	5.19	5.59	4.91	Increased	Decreased	5.59	4.91	=BAU	
Brunei	8.57	7.40	7.33	Decreased	Decreased	6.60	5.17	=BAU	
Cambodia	0.10	0.16	0.24	Increased	Increased	0.14	0.21	=BAU	
China	1.40	2.50	3.32	Increased	Increased	2.33	2.68	=BAU	
India	0.40	0.65	1.06	Increased	Increased	0.58	0.84	=BAU	
Indonesia	0.63	0.96	1.76	Increased	Increased	0.80	1.29	=BAU	
Japan	3.90	3.95	4.14	Increased	Increased	3.75	3.61	Decreased	Decreased
Korea	4.59	5.87	7.09	Increased	Increased	5.68	6.44	=BAU	
Laos	0.15	0.58	0.76	Increased	Increased	0.57	0.71	=BAU	
Malaysia	2.50	2.83	4.13	Increased	Increased	2.51	3.39	=BAU	
Myanmar	0.11	0.19	0.39	Increased	Increased	0.19	0.35	=BAU	
New Zealand	3.78	4.10	4.28	Increased	Increased	3.85	3.57	Decreased	Decreased
Philippines	0.38	0.44	0.57	Increased	Increased	0.42	0.55	=BAU	
Singapore	3.73	8.76	9.11	Increased	Increased	8.64	8.83	=BAU	
Thailand	1.39	2.29	3.59	Increased	Increased	1.99	2.80	=BAU	
Vietnam	0.40	0.89	1.92	Increased	Increased	0.81	1.76	=BAU	
ASEAN average	0.70	1.08	1.77	Increased	Increased	0.96	1.43	=BAU	
ERIA average	1.10	1.68	2.22	Increased	Increased	1.55	1.81	=BAU	
OECD average*1	4.21								

*1 average of 1971-2009

Note :APS = alternative policy scenario, BAU = business-as-usual, TPES = total primary energy supply.
Source: Authors.

GDP/population

There are no distinctions between BAU and APS scenarios for GDP per population. This section compares the annual average rate of growth for GDP per population.

a. 2020/2000s-2

Looking at individual countries, China showed the highest average annual rate of growth at 8.0%, followed by India at 7.4%, and Laos and Viet Nam at 6.1%.

b. 2035/2020

Looking at individual countries, Viet Nam showed the highest average annual rate of growth at 6.4%, followed by Myanmar at 6.0%.

Table 3-24: Gross Domestic Product/Population

Country	1990s	2000s-1	2000s-2	2020	2035	Annual growth rate	
						2020/2000s-2	2035/2020
Australia	18.6	22.6	24.4	32.6	46.4	2.5%	2.4%
Brunei	18.6	18.2	17.8	18.2	22.5	0.2%	1.4%
Cambodia	0.2	0.3	0.5	0.8	1.2	3.7%	3.2%
China	0.6	1.2	1.9	4.9	9.2	8.0%	4.3%
India	0.4	0.5	0.7	1.6	3.6	7.4%	5.3%
Indonesia	0.8	0.9	1.1	1.8	3.4	4.6%	4.3%
Japan	35.3	37.5	39.8	47.1	61.9	1.4%	1.8%
Korea	8.7	12.6	15.1	23.1	33.2	3.6%	2.4%
Laos	0.3	0.4	0.5	0.9	2.1	6.1%	5.5%
Malaysia	3.4	4.2	5.0	6.9	9.7	2.7%	2.3%
Myanmar	0.1	0.3	0.4	0.8	1.8	5.9%	6.0%
New Zealand	12.3	14.7	15.7	18.5	21.6	1.4%	1.0%
Philippines	0.9	1.0	1.2	2.2	3.7	5.1%	3.6%
Singapore	18.5	24.2	29.9	47.4	68.3	3.9%	2.5%
Thailand	1.8	2.2	2.6	4.1	6.4	3.9%	3.1%
Vietnam	0.3	0.5	0.6	1.3	3.3	6.1%	6.4%
ASEAN average	1.0	1.3	1.6	2.6	4.4	4.3%	3.6%
ERIA average	2.4	2.8	3.3	5.2	8.2	3.8%	3.1%
OECD average	20.2	23.4	24.9	35.7	45.7	3.0%	1.6%

Note : 2020/2000s-2 is calculated as 2020/2008
Source: Authors.

CHAPTER 4
Country Analysis

Methodology

Among self-sufficiency (including nuclear), diversity of TPES, diversity of power generation, TPES per GDP, and CO_2-related ESIs, CO_2 emission per GDP was selected and compared with the OECD Average (average for 1971-2009). The scores were then charted using a radar graph.

The radar graph took 2000s-2 as the starting point, and looked at how ESIs change for 2020 under the BAU scenario and for 2035 under the APS scenario.

Country Analysis

In this section, the major characteristics of the EISs of each member country are described.

For all calculated scores described in the following chapters, the larger score shows better conditions. Accordingly, if the circle for 2020 and 2035 are wider than the circle for 2000s-2, as shown by the dotted line, future ESIs are expected to improve. As the OECD Average is taken to be 10, if the circle in the radar graph expands beyond 10, it means that the scores exceed the OECD Average.

Australia
Australia is characterised by increases in the production of coal and natural gas, and high energy efficiency.

2000s-2

Coal and natural gas contribute significantly to Australia's self-sufficiency levels. The country's self-sufficiency score is more than three times higher when compared to the OECD Average. Australia's energy consumption mainly came from fossil fuels and less from renewable energy. As a result, the diversity of TPES and diversity of power generation are below the OECD Average. The TPES per GDP is equal to the OECD Average and CO_2 emission per GDP is below the OECD Average.

2020, 2035

As the production volume of coal and natural gas are expected to increase significantly, Australia's self-sufficiency rate will improve further and the score will reach more than six times that of the OECD Average for 2035.

Australia's renewable energy supply is not expected to increase significantly, hence, the diversity of TPES will remain below the OECD Average. While coal-fired power generation output will decline, in contrast, natural gas-fired power generation output will increase in Australia. The result will lead to an improved diversity of power generation but will remain below the OECD Average.

Improvement of energy efficiency will contribute to an improved TPES per GDP and the score will be twice that of the OECD Average.

The combination of a decrease in coal consumption and improvement of energy efficiency will lead to an improved CO_2 emission per GDP, and the score will improve to approximately three times higher than the OECD Average for 2035.

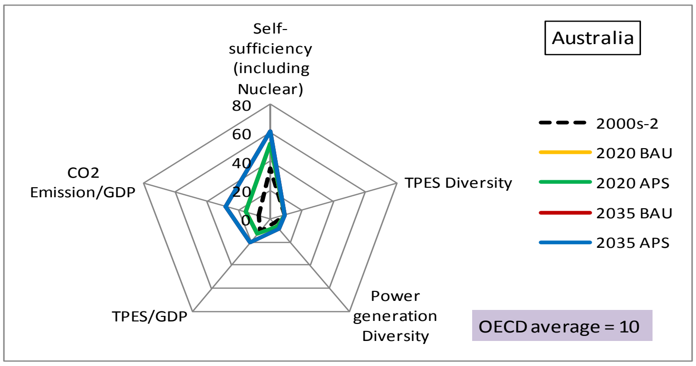
Table 4-1: Major ESIs in Australia in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	35	52	52	61	61
TPES Diversity	9	9	9	9	9
Power generation Diversity	4	7	7	9	9
TPES/GDP	10	13	13	21	21
CO2 Emission/GDP	7	15	15	28	28

Note : APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, ESI = energy security index, GDP = gross domestic product, TPES = total primary energy supply.

Source: Authors.

Figure 4-1: Major ESIs in Australia in Comparison with OECD Average



Note : APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Brunei

Brunei is characterised by natural resource endowment.

<u>2000s-2</u>

Since Brunei is an exporting country of crude oil and natural gas, the self-sufficiency rate is very high. In contrast, the diversity of TPES, diversity of power generation, TPES per GDP, and CO_2 emission per GDP are below the OECD Average.

<u>2020, 2035</u>

As natural gas production is expected to increase to almost twice the current level, self-sufficiency will improve in 2020, but worsen after 2020 until 2030 due to the increase in TPES.

As no renewable energy is expected to be produced, the diversity of TPES and diversity of power generation for Brunei will remain below the OECD Average.

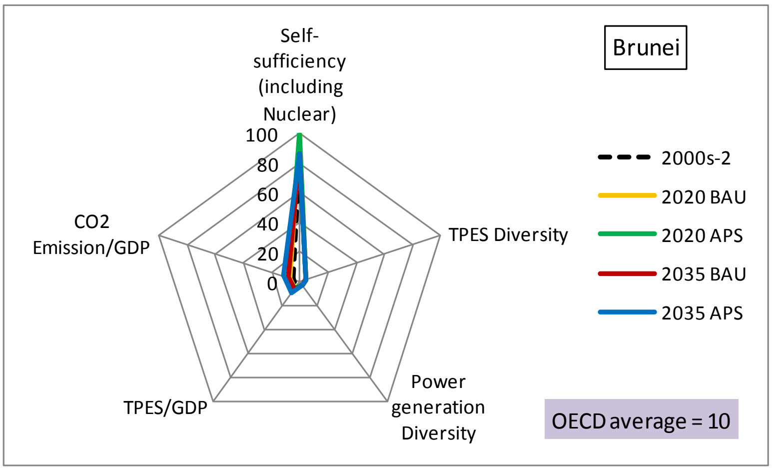
In 2035, energy efficiency will improve and the score will reach the OECD Average in an APS scenario. The result will contribute to the improvement in CO_2 emission per GDP.

Table 4-2: Major ESIs in Brunei in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	86	100	100	86	86
TPES Diversity	4	4	4	5	5
Power generation Diversity	2	2	3	2	3
TPES/GDP	5	5	6	7	10
CO2 Emission/GDP	5	7	8	8	12

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-2: Major ESIs in Brunei in Comparison with OECD average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Cambodia

Cambodia is characterised by the promotion of electrification and the introduction of coal-fired power generation.

2000s-2

As Cambodia does not engage in the indigenous production of fossil fuels, it has a low level of self-sufficiency. The country depends mainly on petroleum for primary energy and hydropower generation for its electricity needs. As such, it has low scores for both diversity of TPES and diversity of power generation. On the other hand, its TPES per GDP exceeds the OECD

Average, and CO_2 emission per GDP is also close to the OECD Average level.

<u>2020, 2035</u>

In 2020 and 2035, there is no indigenous production of fossil fuels, nor nuclear power. Hence, self-sufficiency remains low. While Cambodia has plans to import electricity from neighbouring countries to improve electrification—which is positioned as a priority policy—electricity imports are a factor for its failure to attain improvements in self-sufficiency. To attain energy security, the decision to prioritise either self-sufficiency or electrification is likely to rely on an assessment of whether there are significant risks to importing electricity. With the ASEAN economic integration by 2015, ASEAN menbers seem to be strengthening their relationships with neighbouring countries. Taking this into consideration, it can be said that energy security risks arising from the imports of electricity are small.

As Cambodia has newly introduced coal-fired power generation, both diversity of TPES and diversity of power generation will improve.

TPES per GDP will improve further over the period 2000s-2. However, it is important to note that non-commercial energy has not been included in TPES here.

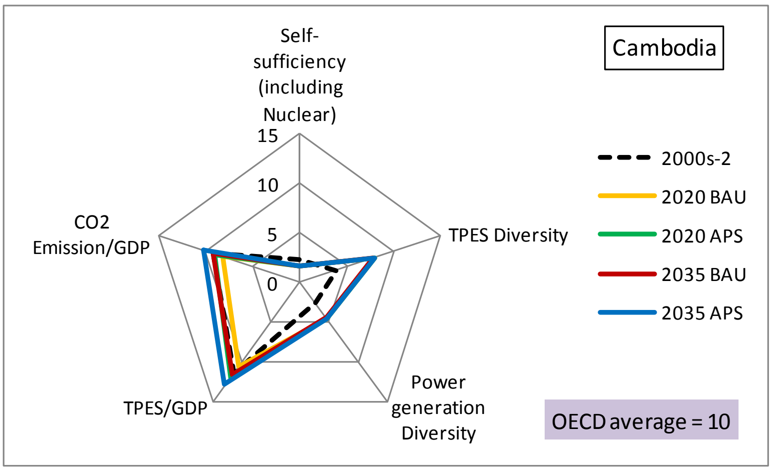
CO_2 emission per GDP will worsen under the 2020 BAU scenario, but will reach OECD Average levels under the 2035 APS scenario.

Table 4-3: Major ESIs in Cambodia in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	2	2	2	2	2
TPES Diversity	4	8	8	8	8
Power generation Diversity	3	5	5	4	5
TPES/GDP	11	11	12	12	13
CO2 Emission/GDP	9	8	9	9	10

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-3: Major ESIs in Cambodia in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

China

China is characterised by high energy consumption and increase in coal production.

2000s-2

Since China consumes plenty of coal, the country's self-sufficiency rate has been worsening, but still exceeds the OECD Average.

As China depends heavily on coal for TPES and power generation, the diversity of TPES and diversity of power generation are below the OECD Average.

TPES per GDP is below the OECD Average. CO_2 emission per GDP is also below the OECD Average due to the large consumption of coal.

2020, 2035

Fossil fuel production is estimated by making reference to the WEO 2013 data. Despite the increase in fossil fuels, nuclear, and hydropower production, self-sufficiency for China will worsen due to the high increase in energy consumption, hence, the score will be below the OECD Average.

Increase in natural gas supply will contribute to the improvement in TPES diversity and the score will reach close to the OECD Average in 2035 in an APS scenario. Increase in natural gas-fired power generation, nuclear power generation, and hydropower generation outputs will lead to changed power generation structure to improve the diversity of power generation.

Energy efficiency will improve and TPES per GDP score will reach the OECD Average in 2035 in an APS scenario.

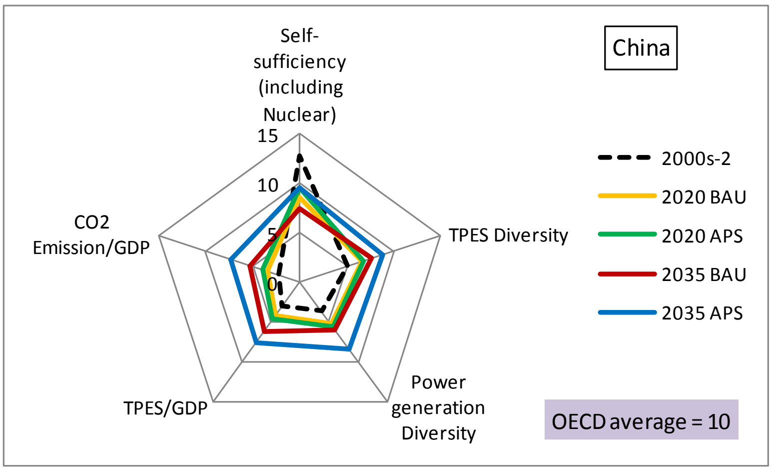
A combination of improvement in energy efficiency and an increase in low-carbon power generation output—such as natural gas, nuclear, and hydro—will contribute to improving CO_2 emission/GDP.

Table 4-4: Major ESIs in China in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	13	9	9	7	9
TPES Diversity	5	7	7	8	9
Power generation Diversity	4	5	6	6	8
TPES/GDP	3	4	5	6	8
CO2 Emission/GDP	2	4	4	5	7

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-4: Major ESIs in China in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

India

India is characterised by high energy consumption and an increase in coal production.

2000s-2

Although India is ranked as the third largest coal producer in the world, the country's self-sufficiency score is below the OECD Average mainly due to an increase in import dependence on crude oil and natural gas.

As India heavily depends on coal for TPES and power generation, the diversity of TPES and diversity of power generation are below the OECD Average.

TPES per GDP is below the OECD Average. CO_2 emission per GDP is also below the OECD Average due to the large consumption of coal.

2020, 2035

Fossil fuel production is estimated by making reference to the WEO 2013 data. While coal and natural gas production are expected to increase, crude oil production is expected to decrease. The results lead to a worsened self-sufficiency score.

Increase in natural gas and nuclear will contribute to an improved diversity of TPES, hence, the score will reach the OECD Average in 2035 in an APS scenario. Increase in natural gas-fired power generation, nuclear power generation, and hydropower generation outputs will contribute to an improved diversity of power generation.

Energy efficiency will improve and the score will reach close to the OECD Average in 2035 in an APS scenario.

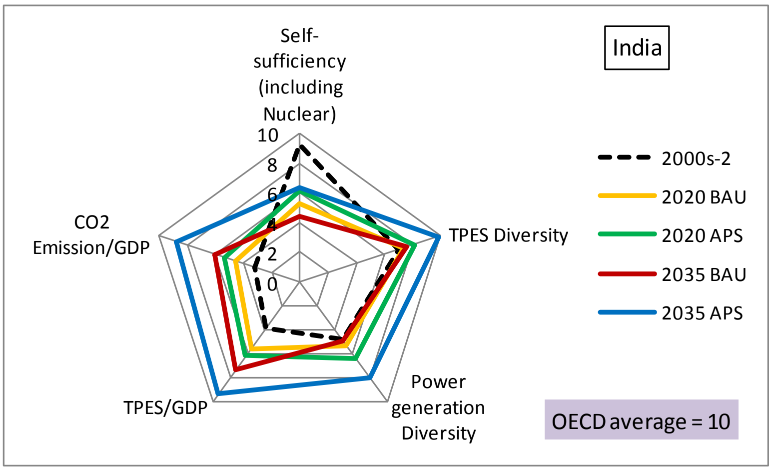
A combined improvement in energy efficiency and increase in low-carbon power generation output—such as natural gas, nuclear, and hydro—will contribute to the improvement in CO_2 emission per GDP, and the score will reach close to the OECD Average in 2035 in an APS scenario.

Table 4-5: Major ESIs in India in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	9	5	6	4	6
TPES Diversity	7	7	8	8	10
Power generation Diversity	5	5	6	5	8
TPES/GDP	4	6	6	7	9
CO2 Emission/GDP	3	5	5	6	9

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-5: Major ESIs in India in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Indonesia

Indonesia is characterised by an acceleration of coal production and geothermal power.

2000s-2

As Indonesia has rich and abundant natural resources, the country has a high degree of self-sufficiency. While it does not use nuclear energy and utilises few hydropower, the use of geothermal power brings its diversity of TPES and diversity of power generation levels close to the OECD Average. On the other hand, the TPES per GDP and CO_2 emission per GDP are below the OECD Average.

2020, 2035

Self-sufficiency forecasts are for 2030. While production volumes for crude oil and natural gas are expected to decline, the production volume of coal is expected to increase. For this reason, the score will fall below 2000s-2 levels. However, high levels of self-sufficiency are maintained until 2020 and 2030. In an APS scenario, there are plans to introduce nuclear power, contributing marginally to improvements in self-sufficiency.

Indonesia will have low oil ratio, while the ratio of coal will be on the rise. As such, both diversity of TPES and diversity of power generation are expected to improve. In an APS scenario, the introduction of nuclear power and increases in hydropower and geothermal power will contribute to generating the score that exceeds the OECD Average.

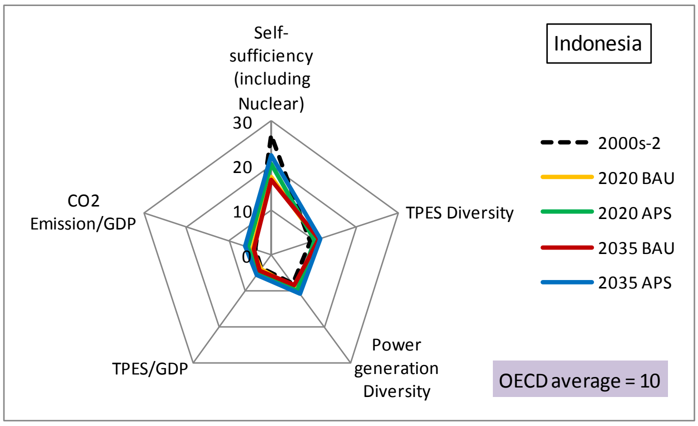
For TPES per GDP and CO_2 emission per GDP, while there are no changes in the BAU scenario, scores will remain lower than the OECD Average in the APS scenario. Despite this, there will be improvements when compared to the BAU scenario. On CO_2 emission in an APS scenario, the decline in fossil fuels consumption volume will be a contributing factor, as compared to a BAU scenario,

Table 4-6: Major ESIs in Indonesia in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	27	17	20	17	22
TPES Diversity	9	11	10	11	12
Power generation Diversity	8	10	10	9	11
TPES/GDP	4	4	5	4	6
CO2 Emission/GDP	4	4	6	4	6

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-6: Major ESIs in Indonesia in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Japan

Japan is characterised by high energy efficiency, and future situation in nuclear power contributes to major differences in ESI for the country.

<u>2000s-2</u>

Although Japan has little natural resources, the country has raised its self-sufficiency level through the use of nuclear power. However, its self-sufficiency still falls far below the OECD Average.

During the oil shock that hit the world in the 1970s, the country's share of oil was extremely high. However, as a result of increasing diversification of energy sources thereafter, the diversity of TPES and diversity of power generation rose above the OECD Average in 2000s-2.

Also as a result of promoting energy conservation policies, the TPES per GDP and CO_2 emission per GDP are above the OECD Average.

<u>2020, 2035</u>

In Japan, the production of fossil fuels is not forecasted even in the future. In the BAU scenario, the amount of nuclear power generation output for 2035 will decline significantly. As such, self-sufficiency will suffer a major setback. However, as the decline in nuclear power generation output is smaller in the APS scenario than in the BAU scenario, when combined with the decline in TPES, self-sufficiency exceeds 2000s-2 significantly. Nevertheless, it stands at a low level in comparison with the OECD Average.

Although the ratio of nuclear power declines, the increase in coal and natural gas will drive improvements in the diversity of TPES and diversity of power generation. As nuclear power is expected to increase in the APS scenario, the diversity will improve further when compared with the BAU scenario. The increase in renewable energy in the APS scenario also contributes to improvements in the diversity.

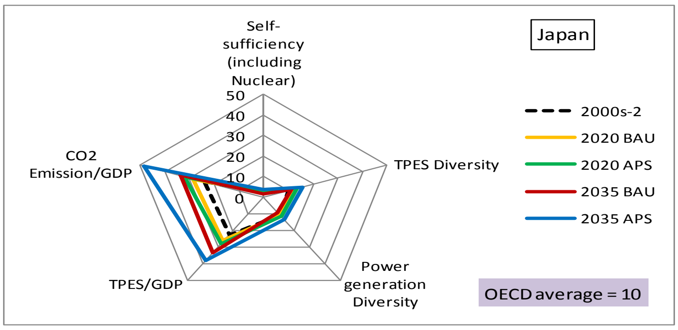
Compared with the OECD Average in 2035 in the APS scenario, scores are approximately four times for TPES per GDP, and five times for CO_2 emission per GDP.

Table 4-7: Major ESIs in Japan in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	3	2	3	2	4
TPES Diversity	10	12	14	11	16
Power generation Diversity	11	11	11	9	13
TPES/GDP	23	26	28	33	38
CO2 Emission/GDP	24	28	32	34	49

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-7: Major ESIs in Japan in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Korea

Korea is characterised by a high proportion of nuclear power.

2000s-2

Although Korea has little natural resources, the country has raised its self-sufficiency level through the use of nuclear power. However, the self-sufficiency level is still far below that of the OECD Average. Although Korea used to have an extremely high ratio of oil in the past, the diversification of energy sources thereafter has brought its diversity of TPES closer to the OECD Average in 2000s-2. Both TPES per GDP and CO_2 emission per GDP are below the OECD Average.

2020, 2035

Even in the future, fossil fuel production is not forecasted for the country. As Korea does not use much hydropower and renewable energy, self-sufficiency is highly dependent upon the amount of nuclear power generation output.

In Korea, the share of oil is expected to decline. In addition, coal will increase in the BAU scenario while nuclear power will increase in the APS scenario. As such, the diversity of TPES will increase above the OECD Average. However, the diversity of power generation will stay at below the OECD average due to the increasing polarisation of nuclear power and coal power generation.

TPES per GDP will exceed OECD Average in 2035 in the APS scenario. On CO_2 emission per GDP, the score for 2035 in an APS scenario is approximately twice that of the OECD Average.

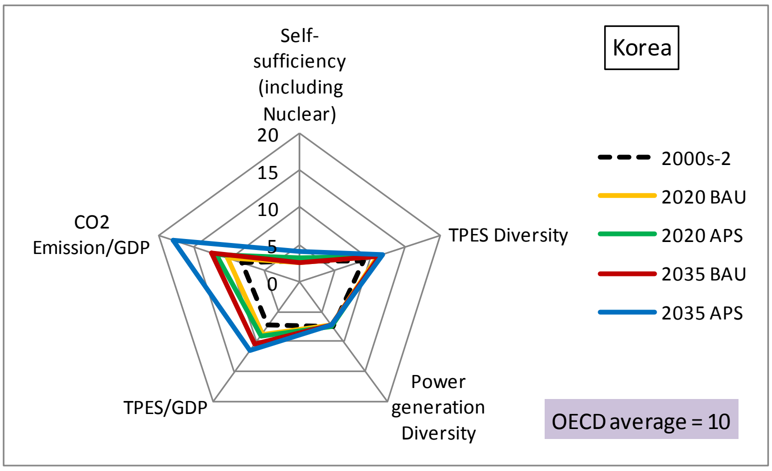
Table 4-8: Major ESIs in Korea in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	3	2	3	3	4
TPES Diversity	9	11	11	11	12
Power generation Diversity	7	7	7	7	7
TPES/GDP	7	9	9	10	11
CO2 Emission/GDP	8	10	12	13	18

Note : APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.

Source: Authors.

Figure 4-8: Major ESIs in Korea in Comparison with OECD Average



Source: Authors.

Laos

Laos is characterised by the introduction of coal-fired power generation and electricity exports.

<u>2000s-2</u>

While Laos is engaged in the production of coal, the production level cannot contribute significantly to improvements in self-sufficiency. This is the same for hydropower. However, the country's self-sufficiency level exceeds the OECD Average. It depends solely upon hydro for power generation, and has no diversity. The TPES per GDP falls below the OECD Average. The CO_2 emission per GDP is on par with the OECD Average.

<u>2020, 2035</u>

Even in the future, Laos is not expected to increase its production of fossil fuels, thus, its self-sufficiency will depend largely on hydro. As export of electricity is expected to increase, self-sufficiency in 2020 will double. However, in 2035, as a result of an increase in domestic electricity demand, self-sufficiency will fall.

As Laos will introduce and expand coal-fired power generation use in the future, both diversity of TPES and diversity of power generation will improve after 2020.

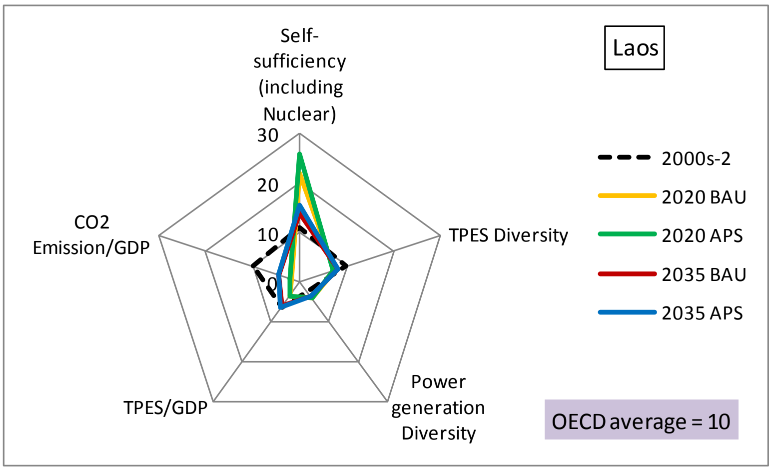
The TPES per GDP shows improvements for 2035 in an APS scenario, as compared to the OECD Average. However, CO_2 emission per GDP will worsen as a result of the introduction of coal-fired power generation.

Table 4-9: Major ESIs in Laos in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	11	22	26	14	16
TPES Diversity	10	7	7	8	8
Power generation Diversity	2	4	4	4	4
TPES/GDP	6	4	4	6	7
CO2 Emission/GDP	10	2	2	4	5

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-9: Major ESIs in Laos in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Malaysia

For Malaysia, production volumes for coal and natural gas will have a major impact on the country's future situation.

2000s-2

Crude oil and natural gas contribute significantly to Malaysia's self-sufficiency levels. Its self-sufficiency score is approximately twice that of the OECD Average. While Malaysia's energy consumption had mainly come from oil and natural gas, in recent years, consumption of coal is on the rise.

As a result, the diversity of TPES is close to the OECD Average. Diversity of power generation, TPES per GDP, and CO_2 emission per GDP are below the OECD Average.

<u>2020, 2035</u>

As a production outlook data is limited, the future production of coal and natural gas is considered to be at the same level as in 2000s-2. For this reason, depending on the production of coal and natural gas, there is a likelihood that future ESIs may change significantly. Self-sufficiency is based on forecasts for 2030. Malaysia's self-sufficiency exceeds the OECD Average in 2020, but falls below the OECD Average in 2030 in an APS scenario, where the introduction of nuclear power is anticipated.

As a result of the increase in coal, both diversity of TPES and diversity of power generation will improve. However, they will remain below the OECD Average.

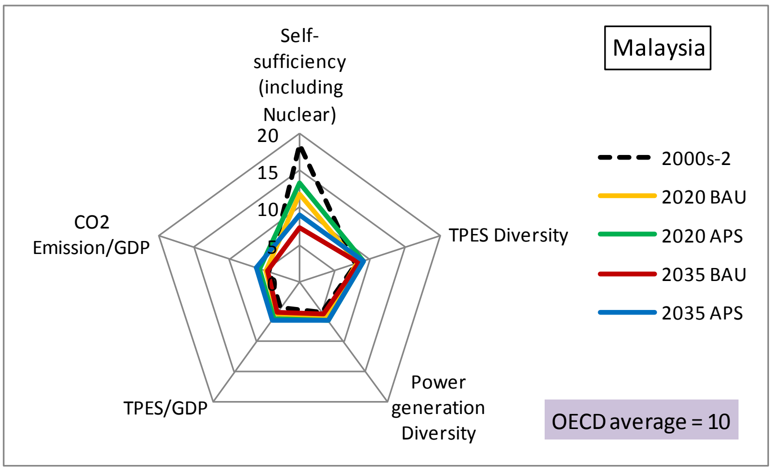
While TPES per GDP will improve, it remains below the OECD Average. In the APS scenario, the introduction of nuclear power is anticipated, and CO_2 emission per GDP will improve. However, it falls below the OECD Average.

Table 4-10: Major ESIs in Malaysia in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	18	12	13	7	9
TPES Diversity	8	8	9	8	9
Power generation Diversity	5	6	6	5	6
TPES/GDP	4	5	6	5	6
CO2 Emission/GDP	4	5	6	4	6

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-10: Major ESIs in Malaysia in Comparison with OECD Average



Note : APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Myanmar

Myanmar is characterised by increases in the production of crude oil and natural gas.

2000s-2

Natural gas in Myanmar contributes significantly to self-sufficiency, and the country's self-sufficiency score is three times that of the OECD Average. Myanmar's energy consumption comes mainly from oil and natural gas, and both diversity of TPES and diversity of power generation are below the OECD Average. The CO_2 emission per GDP is close to the OECD Average.

2020, 2035

Self-sufficiency is based on forecasts for 2030. Myanmar's self-sufficiency will be dependent upon the production volume of fossil fuels. As the production of coal, crude oil, and natural gas are expected to increase, Myanmar's self-sufficiency score will maintain at approximately three times that of the OECD Average.

As a result of the increase in coal consumption, the diversity of TPES will be at about the same level as the OECD Average. Although the diversity of power generation is expected to increase, it will be remain below the OECD Average.

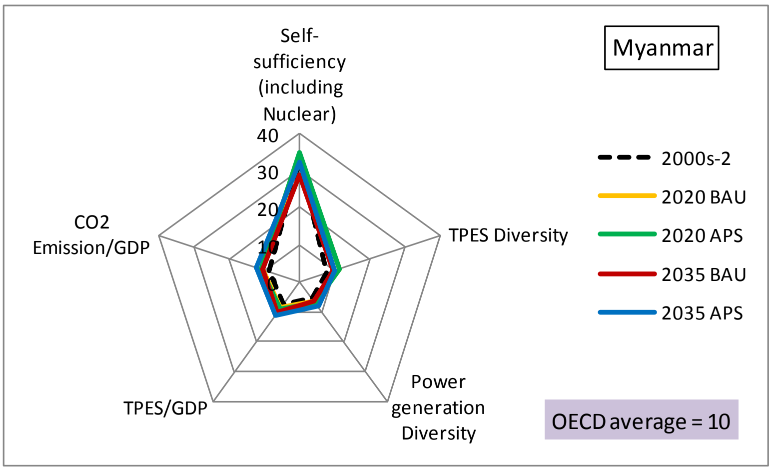
The TPES per GDP will exceed the OECD Average for 2035 in the APS scenario. The CO_2 emission per GDP will improve and exceed the OECD Average even in the BAU scenario.

Table 4-11: Major ESIs in Myanmar in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	33	34	35	29	32
TPES Diversity	8	11	11	9	10
Power generation Diversity	5	7	7	6	8
TPES/GDP	7	9	9	10	11
CO2 Emission/GDP	9	11	11	11	12

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-11: Major ESIs in Myanmar in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

New Zealand

New Zealand is characterised by an acceleration of renewable energy.

<u>2000s-2</u>

New Zealand produces coal, crude oil, and natural gas and has hydropower and geothermal power. Hence, although self-sufficiency is not 100%, the score exceeds the OECD Average. While the diversity of TPES exceeds the

OECD Average, as hydropower makes up a large proportion of power generation, its score falls below the OECD Average. The TPES per GDP is close to the OECD Average, while CO_2 emission per GDP exceeds the OECD Average.

<u>2020, 2035</u>

Due to difficulties in obtaining the coal production outlook data, the future production volume for coal is taken to be the same as for 2000s-2. In addition, self-sufficiency is based on forecasts for 2025. New Zealand's self-sufficiency will exceed 100% due to slight increases in the production volumes of crude oil and natural gas, and a significant increase in geothermal power in the APS scenario.

The diversity of TPES will improve as a result of greater use of renewable energy. Although the diversity of power generation improves, it will remain below the OECD Average.

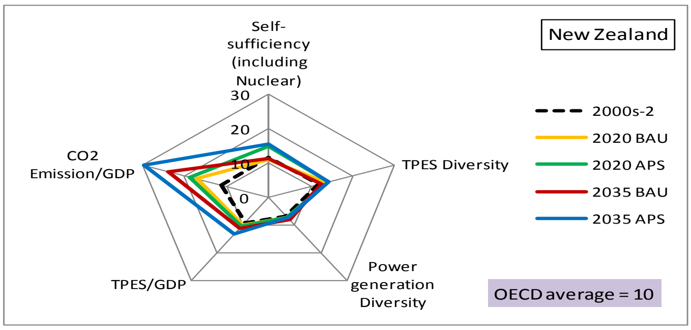
The TPES per GDP will be above the OECD Average even under a BAU scenario. As a result of greater power generation in renewable energy, the score for CO_2 emission per GDP is three times that of the OECD Average for 2035 in an APS scenario.

Table 4-12: Major ESIs in New Zealand in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	11	11	15	11	16
TPES Diversity	12	14	14	13	14
Power generation Diversity	7	7	7	8	7
TPES/GDP	9	10	11	11	13
CO2 Emission/GDP	11	17	19	24	30

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-12: Major ESIs in New Zealand in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Philippines

The Philippines is characterised by an acceleration of coal-fired power generation and renewable energy.

2000s-2

With the exception of nuclear power, the Philippines is engaged in the production of a wide range of energy. Self-sufficiency is at 52%, below the OECD Average. As it uses a wide range of energy excluding nuclear power, the diversity of power generation and diversity of TPES are above the OECD Average. The TPES per GDP falls below the OECD Average, but CO_2 emission per GDP is close to the OECD Average due to the widespread use of renewable energy.

2020, 2035

While self-sufficiency declines in the BAU scenario, the production volume of fossil fuels will increase in the APS scenario. Increases will be also seen for hydropower, geothermal power, and other forms of renewable energy. As such, the score of self-sufficiency will be close to the OECD Average for 2035 in the APS scenario.

As a result of these changes, the diversity of TPES will improve further above the OECD Average in the APS scenario. On the other hand, as coal-fired power generation output will increase significantly, the diversity of power generation will worsen and will fall below the OECD Average.

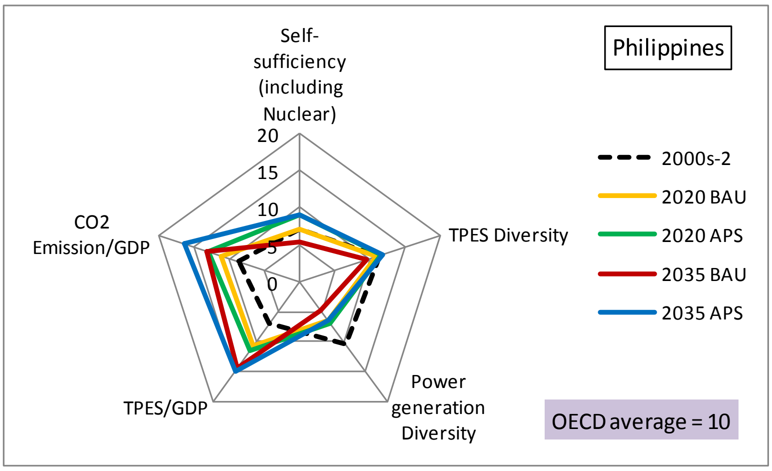
The TPES per GDP will improve above the OECD Average even under the BAU scenario. As a result of the increase in the generation of renewable energy, the CO_2 emission per GDP will improve above the OECD Average.

Table 4-13: Major ESIs in the Philippines in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	7	7	9	5	9
TPES Diversity	11	11	12	9	12
Power generation Diversity	10	6	7	5	6
TPES/GDP	7	11	12	14	15
CO2 Emission/GDP	9	11	13	13	16

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-13: Major ESIs in the Philippines in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Singapore

Singapore is characterised by high energy efficiency.

2000s-2

Singapore produces no indigenous energy. The country's primary energy source and power generation fuel are oil and natural gas.

Singapore is ranked as one of the highest energy-efficient country in the EAS region. The TPES per GDP score is almost twice that of the OECD Average.

Despite the absence of renewable energy supply in Singapore, the CO_2 emission per GDP score is higher or almost twice that of the OECD Average due to high energy efficiency and no coal consumption.

<u>2020, 2035</u>

As renewable energy is expected to be produced more in Singapore, self-sufficiency will improve slightly.

As the supply structure of TPES and power generation will not change much in the future, the diversity of TPES and power generation will remain at current status.

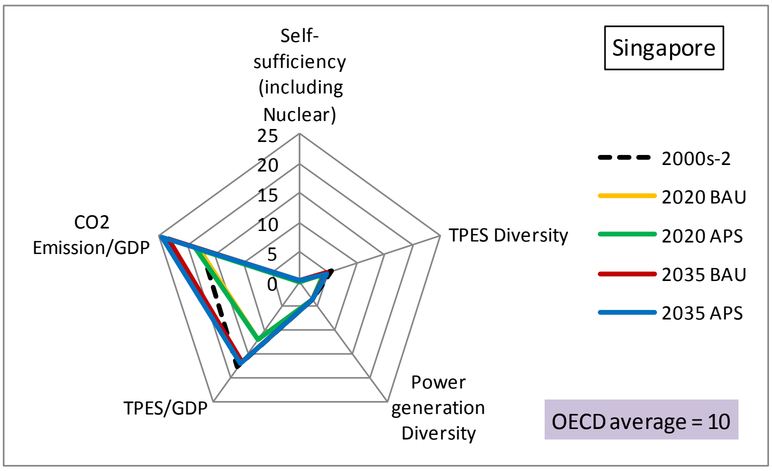
Energy efficiency in Singapore will worsen in 2020 then improve in 2035 but the score will be below the 2000s-2 level.

Table 4-14: Major ESIs in Singapore in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	0	0	0	0	0
TPES Diversity	6	4	4	5	5
Power generation Diversity	4	4	4	4	4
TPES/GDP	18	12	12	17	17
CO2 Emission/GDP	17	18	18	23	24

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-14: Major ESIs in Singapore in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Thailand

Thailand is characterised by a high ratio of natural gas.

2000s-2

Thailand produces a wide range of energy with the exception of nuclear power and geothermal energy. Self-sufficiency is at 55%, falling below the OECD Average. Although it does not have nuclear power and geothermal energy, the diversity of TPES is close to the OECD Average. As natural gas makes up a large portion of power generation, the diversity of power generation falls below the OECD Average. TPES per GDP and CO_2 emission per GDP fall below the OECD Average.

2020, 2035

Despite increases in the production of natural gas and newly introduced nuclear power and geothermal power, the fall in the production of crude oil and increase in TPES will have a negative impact on self-sufficiency.

On the other hand, as a result of the introduction of nuclear and geothermal power, the diversity of TPES will exceed the OECD Average. Although nuclear power and geothermal power are added to the power generation mix, the power generation output will be small, and the share of natural gas will remain high. Hence, the diversity of power generation will fall below the OECD Average.

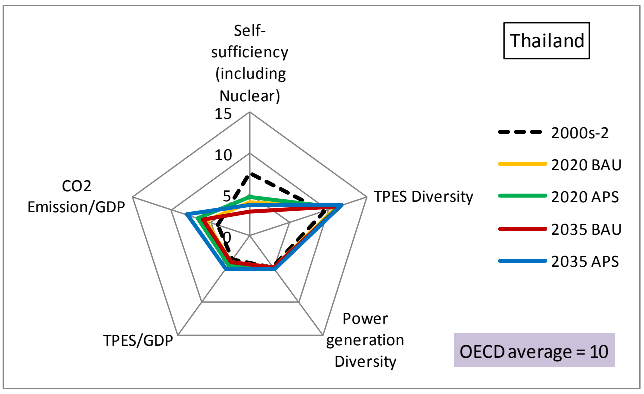
Despite improvements in TPES per GDP, the score will be below the OECD Average. As a result of the introduction of nuclear power and geothermal power, as well as increases in hydropower, CO_2 emission per GDP will improve, but fall below the OECD Average.

Table 4-15: Major ESIs in Thailand in Comparison with the Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	8	4	5	3	4
TPES Diversity	9	11	11	12	12
Power generation Diversity	5	5	5	5	5
TPES/GDP	4	4	5	4	5
CO2 Emission/GDP	4	6	7	6	8

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Figure 4-15: Major ESIs in Thailand in Comparison with OECD Average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Source: Authors.

Viet Nam

Viet Nam is characterised by an increase in the consumption of coal.

2000s-2

Viet Nam is a fossil fuel-producing country, and its self-sufficiency score is twice that of the OECD Average. Although it does not have nuclear and geothermal power, the diversity of TPES is on par with the OECD Average. As it does not have nuclear power and renewable energy, the diversity of power generation is below the OECD Average. TPES per GDP and CO_2 emission per GDP fall below OECD Average.

2020, 2035

Despite increases in coal production and the newly introduced nuclear power, the increase in TPES will worsen self-sufficiency, and will fall below the OECD Average.

Despite the introduction of nuclear power and increases in coal production, the diversity of TPES will fall below the OECD Average due to the increase of TPES. Even in power generation, despite the addition of nuclear power, the generation output will be low, and the share of coal will increase. As such, the diversity of power generation will fall below the OECD Average.

Despite improvements in TPES per GDP, it will fall below the OECD Average. Although nuclear power is newly introduced and there are increases in hydropower, as the consumption of coal increases significantly, CO_2 emission per GDP will fall below the OECD Average.

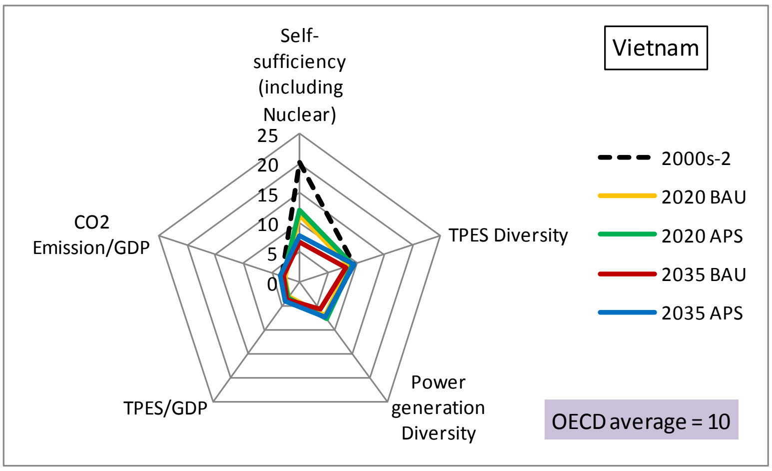
Table 4-16: Major ESIs in Viet Nam in Comparison with OECD Average

Selected ESIs	2000s-2	2020 BAU	2020 APS	2035 BAU	2035 APS
Self-sufficiency (including Nuclear)	20	11	12	7	8
TPES Diversity	10	9	9	8	9
Power generation Diversity	7	7	8	6	7
TPES/GDP	3	3	4	4	4
CO2 Emission/GDP	3	3	3	3	3

Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.

Source: Authors.

Figure 4-16: Major ESIs in Viet Nam in Comparison with OECD average



Note :APS = alternative policy scenario, BAU = business-as-usual, CO_2 = carbon dioxide, GDP = gross domestic product, ESI = energy security index, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.

Source: Authors.

CHAPTER 5
Discussions and Policy Implications

Discussions

In this study, self-sufficiency rate, diversity of total primary energy supply (TPES) and power generation, energy efficiency, and carbon dioxide (CO_2) emission were selected as the primary index. An assessment was then conducted to find out the changes that the index could undergo in the future.

Worsening trend in self-sufficiency

The first observation obtained from this assessment is that self-sufficiency performance is expected to worsen in many countries in the East Asia Summit (EAS) region, with some exceptions. This trend is also observed in countries that are currently energy exporters, such as Brunei, Indonesia, and Malaysia. In particular, non- Organisation for Economic Co-operation and Development (OECD) countries are expected to continue experiencing a high level of economic growth in the future, and consequently, energy demand is forecast to grow steadily. Under such circumstances, there would naturally be limitations to the extent to which countries can maintain a high rate of self-sufficiency.

The rise in import dependency contributes to greater vulnerability in energy security. What can be done to keep such risks from mounting, or to suppress these risks? The first thing that should be done is to develop fossil fuel resources available domestically as far as possible, within economically rational limits. The reason for this is the strong possibility that fossil fuels may continue to be the main energy source for the time range leading up to 2035 that this study analysed, if energy density level and supply stability were to be considered..

Another important measure that should be taken is the expansion of the use of renewable energy, beginning with hydropower. For hydropower, there is still ample room for significant development in areas such as parts of the Mekong River Basin. Among the numerous renewable energy, small hydropower is also expected to provide stable output at a low cost. Biomass and geothermal are also attractive energy sources in areas where they are available for use. Other energy sources such as solar and wind are still under consideration in view of the need to achieve a balance with economic viability.

In countries with high levels of energy demand, nuclear is also one of the possible choices. While safety considerations are one of the most important premises in utilising nuclear, nuclear is an attractive option if countries were to consider factors such as the low import risks, high energy supply volume and density, and low levels of air pollutant emissions including CO_2 emissions.

Even if various measures such as the aforementioned are implemented, it is not an easy task to achieve a 100% self-sufficiency rate. If it becomes unavoidable to import energy, regardless of how low the import volumes are, it would then be important to put in place measures aimed at reducing import risks. In short, these measures would focus on the keyword “diversification.”

First, there is a need to diversify energy sources that are used. In the 1970s, approximately 75% of Japan’s energy supply was dependent on oil. For that reason, the country suffered significant economic setbacks during the two oil crises that struck in the 1970s. While there are no energy sources with zero risks, it is vital to ensure that the risks accompanying each energy source are not excessive. This can be achieved by combining energy sources that come with different forms of risks.

Second, it is important to ensure the “diversification” of partner countries involved in the import of energy. The degree of risks that accompany each import source country need to be considered. For example, in a situation where the import source country is a stable country in all aspects including politics, economy, and culture; is not engaged in any bilateral conflict; and is highly likely to remain a stable ally over the long-term, the risks would not be significant. On the other hand, if the import partner were a country with unstable domestic politics, or is in a situation where the country may become unstable in the near future, there would be significant risks in relying on that country for imports.

Third, it is also important to prepare for the possibility of supply disruptions. Energy is an indispensable element in maintaining the life of citizens, economic activity, and society. As such, energy supply cannot be disrupted even momentarily. However, even in the past few years, events such as the Russia-Ukraine conflict and the Arab Spring have caused delays in the export of natural gas and crude oil. These experiences show that sudden disruption in the flow of energy imports is entirely possible as a result of unforeseen circumstances. Under such circumstances, it is vital to conduct a full review into how countries can secure alternative energy suppliers, and to undertake necessary preparations. One of these methods is to maintain oil stocks. Another method is to conclude agreements with neighbouring countries that provide for flexible arrangements on complementing energy supplies during times of emergency. Alternatively, it is also possible to arrange with the energy exporter for the supply of larger volumes than agreed upon during times of emergency. In considering the various methods available, it is important to put in place measures to maintain a stable energy supply to the country at the lowest cost possible.

Finally, it is important to implement demand-side measures. While all of the aforementioned have been supply-side measures, it is also important to reduce energy consumption itself in order to improve energy security. It is relatively easier to implement measures and obtain results in the industrial sector particularly in sectors that are exposed to international competition. In these sectors, the reduction of manufacturing costs, including energy costs, is directly related to the competitiveness of the company. As such, the motivation to improve energy conservation/efficiency functions naturally in companies. Conversely, in the commercial or residential sector where the scale of energy costs is difficult to visualise, or in situations where the energy bills are set at low levels as a result of subsidies and other policies, it becomes difficult to promote energy-saving measures. Changing the mindset of each individual consumer is an important element in promoting energy conservation/efficiency; however, it is also important to provide an economic incentive for energy-saving campaigns to succeed.

Mixed view for TPES/power generation diversity

Different trends can be observed in different countries when it comes to the diversity of TPES and power generation.
The first of these trends is characterised by Australia and New Zealand, with policies arising from or as a result of the impact of climate change. In response to the issue of climate change, Australia has been moving toward the use of natural gas, while New Zealand has achieved progress in utilising geothermal energy. These moves are effective in reducing the CO_2 emissions. On the other hand, as these measures increase the countries' dependence on a specific energy source, the result is a perceived worsening of the situation, as shown in the indicators that show "Diversity." What must be noted here is the fact that Australia is a producer of natural gas, while New Zealand is a producer of geothermal. "Diversification" signifies a diversity in the country's dependence on imports. In this sense, both countries need not be overly concerned about the "worse off" situation of their "Diversification" indicators when placed against this background.

Japan's "Diversification" indicators have also been assessed to be worse off. The reason is the expected fall in the nuclear generation output. It could be described as a clear example of a situation that is a direct reflection of policy changes. Although Japan has achieved progress in diversifying its energy source over the past 30 years, it has now arrived at the watershed of that policy. To Japan, which depends on imports for the larger part of its energy supply, nuclear is an important tool toward realising the diversification of its energy sources. The choice of whether or not to make use of nuclear is an important element that can determine the state of energy security in Japan in the future.

Despite a gradual increase in diversity among many countries, dramatic improvements have not been observed. The use of rich energy supplies produced by the country, or the use of cheap energy sources, are rational choices from the perspective of energy security and economic viability. For that reason, it is not easy to change the high level of dependence that Laos has on hydropower, or that Viet Nam has on coal, just to name a few examples. Furthermore, energy supply and power plants typically enjoy long service life spans. This makes it difficult to change energy utilisation methods in the short term.

Improvements in the energy efficiency

For most countries, energy efficiency is expected to improve going forward. One of the factors behind this is the increase in the proportion of high value-added industries resulting from changes in industrial structure. While it may be difficult to reduce TPES amidst a situation of growing population and economic growth, it is nevertheless possible to improve energy efficiency. By sustaining such measures, it may be possible to dampen the rise in energy demand, or in other words, to suppress the increase in the volume of energy imports.

CO_2 emission reduction

The quantity of CO_2 emissions takes on different aspects depending on the indicators that are used to assess emissions. While it is difficult to reduce TPES, except in some countries, an increase in the amount of CO_2 emissions would be inevitable based on the premise of the current energy supply structure, which focuses on fossil fuels. Tackling the climate change is a common issue shared by countries around the world, and no country can avoid taking its part of that responsibility. What needs to be done in this respect is to increase the use of low-carbon energy as far as possible, and to improve the energy efficiency as far as possible.

Among fossil fuels, low-carbon energy refers to oil rather than coal, and natural gas rather than oil. Nuclear and renewable energy are options that are even cleaner than fossil fuels. As earlier explained, each energy source has its own merits and demerits, and there are varied ways of combining these energy sources. Each country has the authority to decide on what kind of energy mix it may wish to achieve; however, it is vital to take into consideration the issue of climate change in such discussions and debates.

The energy efficiency has already been discussed in the previous section. If energy were used in a highly efficient manner, it would be possible to minimise the amount of fossil fuels consumed, and thereby contribute to reducing CO_2 emissions.

Effect of an APS scenario

In estimating future ESIs, the alternative policy scenario (APS) scenario, which projects further improvements in energy efficiency, has been adopted in addition to the business-as-usual (BAU) scenario. This takes into account policy measures and technological innovation, and can be considered as additional measures to the existing system being employed in various fields.

Many ESIs perform better in future scenarios presented by APS scenario rather than by BAU scenario. That is to say, the various energy efficiency policies established hypothetically under an APS scenario are believed to be able to contribute to improvements in energy security. Accordingly, countries can use the future scenarios presented by the APS scenario as a point of reference in considering future policies for the countries.

Policy Implications

Effectiveness of ESI

In this study, the past three years were spent gaining a quantitative understanding of the energy security situation, analysing the results, and developing ESIs. In the 2012 research, the study concluded that there was a correlation between ESIs and policies. Consequently, the study found that the ESIs developed as part of this research is an effective tool in measuring the status of energy security. While no one can deny the importance of energy security, there are few methods that can be used to obtain an accurate grasp of the situation. Although ESIs are restricted by the available data and by other factors, these can be useful in providing policymakers with a quantitative grasp of the energy security situation. By harnessing this in an effective manner, it would be possible to uncover the energy security flaws of a country, or to assess the effects of policies implemented in the past. The ability to carry out such work would facilitate a more accurate grasp of the environment surrounding the country, and lead to the formulation of new policies.

However, caution must also be taken in using ESIs. The individual indicators present a part of the overall energy security situation, and the numbers themselves do not lie. Nevertheless, changes in the statistics are backed by many underlying factors, so there is a need to exercise prudence in interpreting the numbers. One of the examples that we can use here is the aforementioned expansion in the use of geothermal in New Zealand. While this policy contributes to a worsened situation in the performance of indicators that show "Diversification," it also contributes to improvements in indicators that show "Self-sufficiency" and "CO_2 emissions." Depending on the situation that a country finds itself in, the focus would be placed on different indicators. Hence, even while taking note or referring to these ESIs, it is important to explore the direction that the country should take in considering its own situation, and to formulate the necessary policies accordingly.

A second key point would be to periodically reevaluate ESIs, and to feed these changes back into policies. The various cross-sections of energy security shown by ESIs cannot change over the short term of, for instance, one or two years. For example, after the oil crises in the 1970s, Japan took an extremely long time of 20 to 30 years before it arrived at the energy mix it was using before the great East Japan earthquake. This means that long periods of time are required for certain policies to penetrate society, and to actually change the energy supply structure. Hence, short-term changes that take place over one or two years should not be traced using ESIs. Rather, ESIs should be used to evaluate changes in units of 5 or 10 years, and the necessary reviews and revisions carried out based on these assessments.

Possible options for energy mix

Based on analyses conducted using ESIs, what are the specific recommendations that can be raised with the aim of improving regional energy security?

One of the possible recommendations is related to energy supply and power generation mix. A direction that countries should aim toward in the long term could be achieving a mixture of coal and renewables, or with nuclear.

From the perspective of the self-sufficiency rate, apart from the fact that renewable energy and nuclear are domestically produced energy sources, there are relatively rich coal resources in the EAS region. This means that expanding the use of coal can contribute to improving the self-sufficiency rate for many countries. Even if the country does not possess any coal resources, it faces little risk in importing coal from countries within the same EAS region as they share common interests. This would be safer than increasing oil usage, for example, which would leave the country no choice but to be dependent on the Middle East.

In this study, the importance of diversifying energy sources has been repeatedly pointed out. However, as the need for diversification is based on the premise of a high level of import dependency, if a combination of coal with renewable energy or nuclear can contribute to improving the self-sufficiency rate, then greater dependence on these forms of energy would not pose any problems.

From the perspective of economic viability, it is needless to state that coal has more advantages in comparison with other fossil fuels. On nuclear, as in the case of Japan, even though a large reserve fund has been allocated in preparation for a large-scale accident, nuclear remains highly competitive today as compared to oil-fired thermal power, solar, and wind. Costs vary significantly depending on the type of renewable energy. At this point in time, hydropower, geothermal, and biomass are good choices of energy source.

The emission of CO_2 and air pollutants is a problem caused by the use of coal. Thus, in addition to using coal in the most efficient manner possible, it is also necessary to introduce an adequate amount of renewable energy and nuclear in order to offset the incremental emissions of CO_2 and other substances that arise from the use of coal.

As generally observed, the combination of coal and renewable energy or nuclear is typically perceived as being able to contribute to energy security in many ways. However, its viability should be assessed on a country-by-country basis. For example, since Myanmar has rich resources of natural gas and hydropower, the combination of coal with either option is suitable for the country, and it would be practical to use coal partially for the purpose of risk diversification. In the case of Thailand, opposition from citizens makes it extremely difficult to develop new coal-fired thermal power plants, so it would be more practical for the country to opt for a mix that focuses on the use of natural gas.

Another point that should be considered is the time line. Expanding the use of coal can be achieved over a relatively shorter period of time, but it would require a longer lead-time to increase the use of renewable energy or nuclear to a sufficient extent. In the case of nuclear, it is necessary to first have a certain scale of demand, and to undergo a process of winning over the consensus of the citizens. As such, the number of countries that can adopt nuclear may be limited. Hence, in the short to medium term, it would be more practical to diversify risks by using natural gas while focusing on strengthening the use of renewable energy and enhancing the efficiency of coal-fired thermal power generation.

To achieve such changes in energy mix, it is important to formulate plans with a long-term perspective, and to have strong political and administrative will in order to bring the plans to fruition.

Importance of regional approach

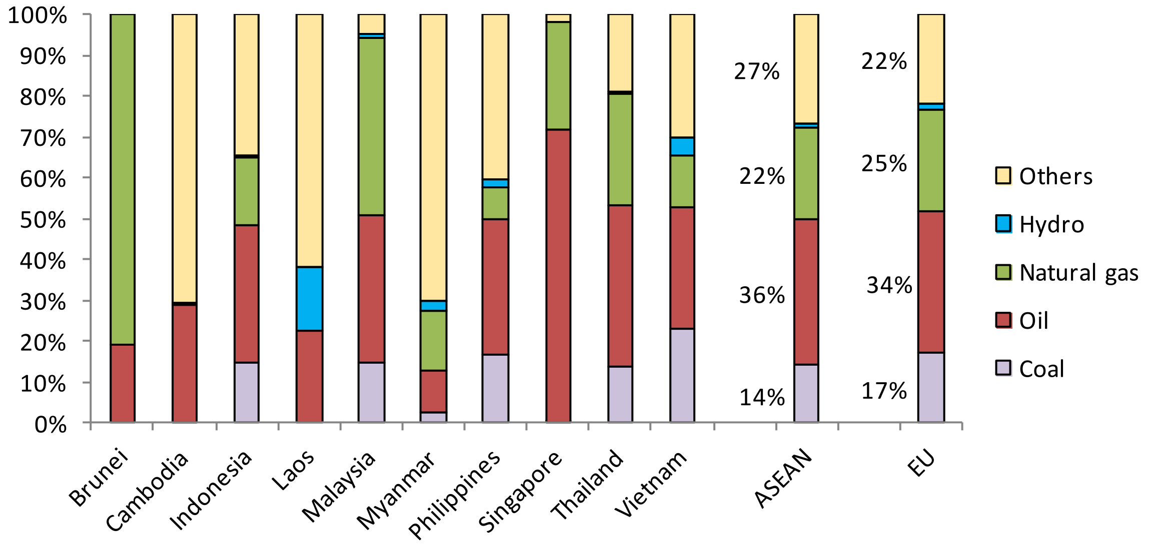
Another point that should be raised is the importance and meaning of regional cooperation. Figure 5-1 uses the example of the ASEAN to illustrate the mix of TPES. As shown in the figure, despite significant imbalance and variations in energy sources used by each country, the overall picture for ASEAN as a region is a relatively balanced one.

The same trend is observed for the European Union (EU). The EU is a collective of countries of various sizes, from large to small, with significant variances in their respective energy sources. From the perspective of energy security, this may not be an ideal situation. However, the EU is a collective of countries that share interests, and the Union itself is well balanced. That is to say, it has an energy supply structure with risks that are diversified. In other words, countries belonging to the EU can achieve a level of energy security through regional cooperation that they would never be able to achieve independently.

Similarly, the ASEAN is a collective of countries that share common interests, and is also a group premised on mutual interdependence. Based on this premise, it would be possible to build an even stronger energy security system. It would be even more ideal if this system could be expanded to include the EAS framework.

Oftentimes, energy security is established in the unit of a single country. Mutual distrust between countries lies at the root of this trend. EAS countries, which are also located in Asia, are positioned in an environment that allows them to share interests easily. By eliminating the distrust among countries and considering matters and issues as a region, it would then become possible to strengthen energy security. Conversely, it would also be possible to achieve the effect of improving and strengthening relationships of trust between EAS countries by strengthening mutual interdependence with the aim of improving energy security.

Figure 5-1: Primary Energy Supply Mix (2006-2010)



Source: International Energy Agency (2013), Energy Balance, 2013. Laos.

As shown through this study, policy assessments using ESIs can contribute, even in small ways, to changes in the practical world, and to strengthening regional energy security.

ANNEX
Future ESIs and Evaluations

1-1: Self-Sufficiency (including Nuclear)

Self-sufficiency (including Nuclear)

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	212%	256%	254%	377%	444%	Improved	Improved	377%	444%	=BAU	
Brunei	797%	837%	624%	721%	619%	Improved	Worsened	721%	619%	=BAU	
Cambodia	29%	21%	16%	11%	12%	Worsened	Improved	11%	12%	=BAU	
China	102%	97%	92%	62%	53%	Worsened	Worsened	69%	68%	=BAU	
India	79%	71%	67%	38%	32%	Worsened	Worsened	44%	46%	Worsened	Improved
Indonesia	198%	172%	195%	126%	121%	Worsened	Worsened	148%	161%	Worsened	Improved
Japan	19%	19%	18%	17%	12%	Worsened	Worsened	21%	27%	Improved	Improved
Korea	17%	19%	20%	18%	19%	Worsened	Improved	23%	29%	Improved	Improved
Laos	68%	97%	80%	158%	100%	Improved	Worsened	188%	112%	=BAU	
Malaysia	186%	157%	134%	85%	53%	Worsened	Worsened	97%	65%	=BAU	
Myanmar	93%	211%	235%	248%	209%	Improved	Worsened	253%	234%	=BAU	
New Zealand	87%	80%	83%	79%	81%	Worsened	Improved	108%	113%	Improved	Improved
Philippines	36%	43%	52%	51%	39%	Worsened	Worsened	65%	65%	Improved	No Change
Singapore	0%	0%	0%	0%	1%	No Change	Improved	0%	1%	=BAU	
Thailand	54%	53%	55%	29%	21%	Worsened	Worsened	34%	27%	=BAU	
Vietnam	148%	160%	145%	81%	48%	Worsened	Worsened	88%	57%	=BAU	
ASEAN average	131%	123%	130%	84%		Worsened		94%		=BAU	
ERIA average	81%	81%	83%	63%		Worsened		70%		=BAU	
OECD average*1	72%	72%	72%								

*1 average of 1971-2009

*2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	29.3	35.4	35.1	52.2	61.4	52.2	61.4
Brunei	110.2	115.7	86.3	99.7	85.6	99.7	85.6
Cambodia	4.1	2.9	2.2	1.5	1.7	1.5	1.7
China	14.1	13.4	12.8	8.6	7.4	9.5	9.5
India	10.9	9.8	9.3	5.3	4.4	6.2	6.4
Indonesia	27.3	23.8	27.0	17.5	16.8	20.4	22.3
Japan	2.6	2.6	2.5	2.3	1.7	2.9	3.8
Korea	2.3	2.6	2.7	2.5	2.6	3.2	4.1
Laos	9.4	13.4	11.1	21.8	13.8	25.9	15.5
Malaysia	25.7	21.7	18.5	11.8	7.4	13.4	9.0
Myanmar	12.8	29.2	32.6	34.3	28.9	35.0	32.4
New Zealand	12.1	11.0	11.4	10.9	11.2	15.0	15.6
Philippines	5.0	5.9	7.2	7.1	5.4	9.0	9.0
Singapore	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Thailand	7.4	7.3	7.7	4.1	2.9	4.7	3.7
Vietnam	20.5	22.1	20.1	11.2	6.6	12.2	7.9
ASEAN average	18.1	17.0	18.0	11.6		13.0	
ERIA average	11.2	11.2	11.5	8.7		9.7	

OECD Total = 10

1-2: Self-Sufficiency (excluding Nuclear)

Self-sufficiency (excluding Nuclear)

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	212%	256%	254%	377%	444%	Improved	Improved	377%	444%	=BAU	
Brunei	797%	837%	624%	721%	619%	Improved	Worsened	721%	619%	=BAU	
Cambodia	29%	21%	16%	11%	12%	Worsened	Improved	11%	12%	=BAU	
China	101%	96%	91%	59%	49%	Worsened	Worsened	64%	62%	=BAU	
India	79%	71%	67%	35%	28%	Worsened	Worsened	39%	37%	Worsened	Improved
Indonesia	198%	172%	195%	126%	121%	Worsened	Worsened	148%	160%	Worsened	Improved
Japan	19%	19%	18%	4%	7%	Worsened	Worsened	4%	13%	Improved	Improved
Korea	17%	19%	20%	1%	1%	Worsened	No Change	1%	2%	Worsened	Improved
Laos	68%	97%	80%	158%	100%	Improved	Worsened	188%	112%	=BAU	
Malaysia	186%	157%	134%	85%	53%	Worsened	Worsened	97%	64%	=BAU	
Myanmar	93%	211%	235%	248%	209%	Improved	Worsened	253%	234%	=BAU	
New Zealand	87%	80%	83%	79%	81%	Worsened	Improved	108%	113%	Improved	Improved
Philippines	36%	43%	52%	51%	39%	Worsened	Worsened	65%	65%	Improved	
Singapore	0%	0%	0%	0%	1%	No Change	Improved	0%	1%	=BAU	
Thailand	54%	53%	55%	29%	19%	Worsened	Worsened	34%	25%	=BAU	
Vietnam	148%	160%	145%	79%	44%	Worsened	Worsened	86%	49%	=BAU	
ASEAN average	131%	123%	130%	84%		Worsened		94%		=BAU	
ERIA average	76%	77%	80%	59%		Worsened		64%		=BAU	
OECD average*1	64%	64%	64%								

*1 average of 1971-2009

*2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	33.2	40.1	39.8	59.1	69.6	59.1	69.6
Brunei	124.9	131.2	97.8	113.1	97.1	113.1	97.1
Cambodia	4.6	3.3	2.5	1.7	1.9	1.7	1.9
China	15.9	15.1	14.3	9.2	7.6	10.1	9.7
India	12.4	11.1	10.5	5.5	4.4	6.1	5.8
Indonesia	31.0	27.0	30.6	19.8	19.0	23.2	25.0
Japan	3.0	2.9	2.9	0.6	1.1	0.7	2.0
Korea	2.6	2.9	3.1	0.1	0.2	0.1	0.2
Laos	10.6	15.2	12.6	24.8	15.7	29.4	17.6
Malaysia	29.1	24.6	20.9	13.4	8.4	15.2	10.0
Myanmar	14.6	33.1	36.9	38.9	32.7	39.6	36.7
New Zealand	13.7	12.5	13.0	12.4	12.7	17.0	17.7
Philippines	5.6	6.7	8.1	8.0	6.1	10.2	10.2
Singapore	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Thailand	8.4	8.3	8.7	4.6	3.0	5.3	3.9
Vietnam	23.2	25.1	22.8	12.4	7.0	13.5	7.7
ASEAN average	20.5	19.3	20.4	13.1		14.7	
ERIA average	11.9	12.0	12.5	9.2		10.1	

OECD Total = 10

1-3: Coal Self-Sufficiency

Coal Self-sufficiency

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	321%	378%	412%	1086%	2252%	Improved	Improved	1086%	2252%	=BAU	
Brunei											
Cambodia											
China	103%	107%	102%	70%	59%	Worsened	Worsened	76%	81%	Worsened	Improved
India	97%	91%	87%	38%	33%	Worsened	Worsened	45%	52%	Worsened	Improved
Indonesia	364%	395%	515%	408%	406%	Worsened	Worsened	548%	652%	Improved	Improved
Japan	4%	1%	0%								
Korea	13%	4%	2%								
Laos	24669%	14877%	2435%								
Malaysia	8%	6%	9%	4%	3%	Worsened	Worsened	5%	4%	=BAU	
Myanmar	93%	625%	542%	170%	158%	Worsened	Worsened	155%	194%	Worsened	Improved
New Zealand	165%	179%	172%	266%	293%	Improved	Improved	266%	325%	Improved	Improved
Philippines	31%	19%	30%	43%	20%	Improved	Worsened	57%	55%	Improved	Worsened
Singapore											
Thailand	82%	59%	37%	20%	12%	Worsened	Worsened	23%	15%	=BAU	
Vietnam	139%	173%	214%	90%	55%	Worsened	Worsened	104%	69%	=BAU	
ASEAN average	171%	203%	260%	181%		Worsened		215%		=BAU	
ERIA average	101%	106%	106%	78%		Worsened		87%		=BAU	
OECD average*1	96%	96%	96%								

*1 average of 1971-2009

*2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	33.5	39.5	43.2	113.7	235.7	113.7	235.7
Brunei							
Cambodia							
China	10.8	11.2	10.7	7.4	6.2	8.0	8.5
India	10.1	9.6	9.1	3.9	3.4	4.7	5.4
Indonesia	38.1	41.3	53.8	42.7	42.4	57.4	68.2
Japan	0.4	0.1	0.0				
Korea	1.4	0.5	0.2				
Laos	2,581.4	1,556.8	254.8				
Malaysia	0.8	0.6	1.0	0.4	0.3	0.5	0.4
Myanmar	9.8	65.4	56.7	17.8	16.6	16.2	20.3
New Zealand	17.2	18.7	18.0	27.8	30.6	27.8	34.0
Philippines	3.2	2.0	3.1	4.5	2.1	6.0	5.7
Singapore							
Thailand	8.5	6.2	3.9	2.1	1.2	2.4	1.6
Vietnam	14.5	18.1	22.4	9.4	5.8	10.9	7.2
ASEAN average	17.9	21.3	27.2	19.0		22.5	
ERIA average	10.6	11.1	11.1	8.2		9.1	

OECD Total = 10

1-4: Crude Oil Self-Sufficiency

Crude oil Self-sufficiency

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	87%	93%	64%	32%	13%	Worsened	Worsened	32%	13%	=BAU	
Brunei	2918%	1672%	1375%	1023%	802%	Worsened	Worsened	1023%	802%	=BAU	
Cambodia											
China	96%	64%	52%	32%	20%	Worsened	Worsened	33%	24%	=BAU	
India	44%	32%	27%	16%	6%	Worsened	Worsened	17%	8%	=BAU	
Indonesia	182%	102%	73%	28%	12%	Worsened	Worsened	29%	14%	=BAU	
Japan	0%	0%	0%								
Korea	0%	1%	1%								
Laos											
Malaysia	196%	162%	144%	58%	29%	Worsened	Worsened	73%	38%	=BAU	
Myanmar	51%	47%	66%	166%	116%	Improved	Worsened	171%	125%	=BAU	
New Zealand	48%	26%	35%	74%	86%	Improved	Improved	78%	95%	=BAU	
Philippines	1%	3%	7%	0%	0%	Worsened	No Change	53%	52%	Improved	Worsened
Singapore											
Thailand	17%	27%	38%	18%	12%	Worsened	Worsened	22%	16%	=BAU	
Vietnam	177%	183%	121%	62%	33%	Worsened	Worsened	65%	35%	=BAU	
ASEAN average	108%	84%	74%	33%		Worsened		40%		=BAU	
ERIA average	48%	41%	37%	24%		Worsened		26%		=BAU	
OECD average*1	46%	46%	46%								

*1 average of 1971-2009

*2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	18.8	20.0	13.8	6.9	2.8	6.9	2.8
Brunei	629.4	360.6	296.5	220.7	172.9	220.7	172.9
Cambodia							
China	20.7	13.9	11.3	6.8	4.3	7.2	5.2
India	9.5	6.8	5.8	3.4	1.4	3.7	1.8
Indonesia	39.2	22.0	15.8	6.1	2.5	6.2	3.0
Japan	0.1	0.1	0.1				
Korea	0.0	0.1	0.1				
Laos							
Malaysia	42.3	34.9	31.0	12.5	6.3	15.7	8.1
Myanmar	10.9	10.2	14.3	35.9	25.1	36.9	26.9
New Zealand	10.2	5.5	7.6	16.0	18.6	16.9	20.4
Philippines	0.3	0.7	1.5	0.0	0.0	11.5	11.3
Singapore							
Thailand	3.7	5.9	8.2	4.0	2.6	4.7	3.5
Vietnam	38.2	39.5	26.1	13.5	7.2	14.1	7.5
ASEAN average	23.2	18.2	16.0	7.2		8.6	
ERIA average	10.3	8.8	8.0	5.2		5.7	

OECD Total = 10

1-5: Natural Gas Self-Sufficiency

Natural gas Self-sufficiency

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035*2	2020/2000s-2	2035/2020	2020	2035*2	2020/2000s-2	2035/2020
Australia	143%	145%	147%	346%	402%	Improved	Improved	346%	402%	=BAU	
Brunei	462%	545%	418%	632%	560%	Improved	Worsened	632%	560%	=BAU	
Cambodia											
China	105%	107%	100%	49%	48%	Worsened	Improved	70%	72%	=BAU	
India	100%	94%	76%	75%	56%	Worsened	Worsened	75%	58%	=BAU	
Indonesia	207%	216%	207%	40%	4%	Worsened	Worsened	50%	5%	=BAU	
Japan	4%	4%	4%								
Korea	0%	0%	0%								
Laos											
Malaysia	186%	157%	134%	199%	128%			203%	147%		
Myanmar	133%	411%	349%	596%	449%	Improved	Worsened	618%	591%	=BAU	
New Zealand	100%	100%	101%	96%	81%	Worsened	Worsened	108%	90%	Improved	Worsened
Philippines	100%	100%	100%	90%	73%	Worsened	Worsened	50%	50%	Worsened	
Singapore											
Thailand	100%	75%	73%	72%	42%	Worsened	Worsened	87%	58%	Improved	Worsened
Vietnam	100%	108%	109%	92%	34%	Worsened	Worsened	101%	39%	=BAU	
ASEAN average	190%	167%	149%	101%		Worsened		116%		=BAU	
ERIA average	97%	92%	86%	67%		Worsened		82%		=BAU	
OECD average*1	84%	84%	84%								

*1 average of 1971-2009

*2 Indonesia, Malaysia, Myanmar: 2030, New Zealand: 2025

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	16.9	17.1	17.4	41.0	47.5	41.0	47.5
Brunei	54.7	64.5	49.5	74.9	66.3	74.9	66.3
Cambodia							
China	12.4	12.7	11.8	5.8	5.7	8.2	8.5
India	11.8	11.2	9.0	8.9	6.6	8.9	6.9
Indonesia	24.6	25.6	24.5	4.7	0.4	5.9	0.6
Japan	0.5	0.4	0.5				
Korea	0.0	0.0	0.0				
Laos							
Malaysia	22.0	18.6	15.8	23.6	15.1	24.0	17.4
Myanmar	15.7	48.7	41.3	70.6	53.2	73.2	70.0
New Zealand	11.8	11.8	11.9	11.3	9.6	12.8	10.6
Philippines	11.8	11.8	11.8	10.6	8.6	5.9	5.9
Singapore							
Thailand	11.8	8.9	8.6	8.5	5.0	10.3	6.9
Vietnam	11.8	12.7	12.9	10.9	4.0	11.9	4.6
ASEAN average	22.5	19.8	17.7	11.9		13.8	
ERIA average	11.5	10.9	10.1	8.0		9.7	

OECD Total = 10

2-1: Diversity of TPES

HHI of TPES Diversity

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	3,540	3,554	3,441	3,177	3,346	Improved	Worsened	3,177	3,346	=BAU	
Brunei	7,647	6,160	6,620	6,611	6,250	Improved	Improved	6,657	6,504	Worsened	Improved
Cambodia	6,546	7,295	7,733	3,719	3,783	Improved	Worsened	3,694	3,705	=BAU	
China	6,161	5,525	5,729	4,421	3,868	Improved	Improved	4,332	3,307	=BAU	
India	4,284	4,133	4,213	4,000	3,856	Improved	Improved	3,618	2,997	=BAU	
Indonesia	3,898	3,435	3,175	2,743	2,608	Improved	Improved	2,854	2,552	=BAU	
Japan	3,543	3,156	2,909	2,538	2,576	Improved	Worsened	2,145	1,855	Improved	Improved
Korea	4,357	3,597	3,216	2,668	2,591	Improved	Improved	2,593	2,517	=BAU	
Laos	3,361	2,939	2,959	4,014	3,559	Worsened	Improved	4,086	3,644	=BAU	
Malaysia	4,425	4,012	3,712	3,607	3,530	Improved	Improved	3,274	3,217	=BAU	
Myanmar	3,222	3,628	3,816	2,605	3,122	Improved	Worsened	2,604	3,033	=BAU	
New Zealand	2,520	2,549	2,463	2,128	2,322	Improved	Worsened	2,061	2,071	=BAU	
Philippines	4,106	3,105	2,593	2,719	3,090	Worsened	Worsened	2,541	2,522	Improved	Improved
Singapore	9,008	6,986	5,229	6,746	6,263	Worsened	Improved	6,809	6,369	=BAU	
Thailand	3,536	3,380	3,107	2,653	2,536	Improved	Improved	2,642	2,502	=BAU	
Vietnam	3,370	3,174	3,040	3,352	3,613	Worsened	Worsened	3,190	3,092	Worsened	Improved
ASEAN average	3,841	3,368	3,012	2,740	2,650	Improved	Improved	2,707	2,493	=BAU	
ERIA average	3,598	3,522	3,788	3,480	3,246	Improved	Improved	3,329	2,719	=BAU	
OECD average*1	2,934	2,934	2,934								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	8.3	8.3	8.5	9.2	8.8	9.2	8.8
Brunei	3.8	4.8	4.4	4.4	4.7	4.4	4.5
Cambodia	4.5	4.0	3.8	7.9	7.8	7.9	7.9
China	4.8	5.3	5.1	6.6	7.6	6.8	8.9
India	6.9	7.1	7.0	7.3	7.6	8.1	9.8
Indonesia	7.5	8.5	9.2	10.7	11.3	10.3	11.5
Japan	8.3	9.3	10.1	11.6	11.4	13.7	15.8
Korea	6.7	8.2	9.1	11.0	11.3	11.3	11.7
Laos	8.7	10.0	9.9	7.3	8.2	7.2	8.1
Malaysia	6.6	7.3	7.9	8.1	8.3	9.0	9.1
Myanmar	9.1	8.1	7.7	11.3	9.4	11.3	9.7
New Zealand	11.6	11.5	11.9	13.8	12.6	14.2	14.2
Philippines	7.1	9.5	11.3	10.8	9.5	11.5	11.6
Singapore	3.3	4.2	5.6	4.3	4.7	4.3	4.6
Thailand	8.3	8.7	9.4	11.1	11.6	11.1	11.7
Vietnam	8.7	9.2	9.7	8.8	8.1	9.2	9.5
ASEAN average	7.6	8.7	9.7	10.7	11.1	10.8	11.8
ERIA average	8.2	8.3	7.7	8.4	9.0	8.8	10.8

Score is calculated by inverse of ESI

OECD Total = 10

2-2: Diversity of Power Generation

HHI of Power generation Diversity

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	6,782	6,517	6,351	3,730	2,728	Improved	Improved	3,730	2,728	=BAU	
Brunei	9,832	9,825	9,807	10,000	10,000	Worsened	No Change	9,546	9,132	Improved	Improved
Cambodia	10,000	9,287	9,201	5,308	5,446	Improved	Worsened	5,356	5,360	=BAU	
China	6,008	6,388	6,621	4,602	4,064	Improved	Improved	4,311	2,892	=BAU	
India	5,204	5,227	5,017	4,614	4,900	Improved	Worsened	3,787	3,032	Improved	Improved
Indonesia	2,518	2,729	2,955	2,547	2,842	Improved	Worsened	2,469	2,225	Improved	Improved
Japan	2,146	2,227	2,239	2,210	2,637	Improved	Worsened	2,145	1,855	Improved	Improved
Korea	2,870	3,164	3,280	3,311	3,413	Worsened	Worsened	3,300	3,397	=BAU	
Laos	10,000	10,000	10,000	5,911	6,640	Improved	Worsened	5,911	6,640	=BAU	
Malaysia	3,957	5,508	4,801	4,166	4,524	Improved	Worsened	3,794	3,844	=BAU	
Myanmar	4,341	4,131	4,590	3,741	3,794	Improved	Worsened	3,586	2,924	Improved	Improved
New Zealand	5,176	4,173	3,642	3,361	2,992	Improved	Improved	3,365	3,306	=BAU	
Philippines	3,209	2,196	2,327	3,831	5,099	Worsened	Worsened	3,507	3,828	=BAU	
Singapore	6,599	4,975	6,735	6,665	6,603	Improved	Improved	6,668	6,620	=BAU	
Thailand	3,242	5,218	5,155	4,971	5,101	Improved	Worsened	4,909	4,790	Improved	Improved
Vietnam	4,660	3,372	3,329	3,418	4,222	Worsened	Worsened	3,155	3,291	Improved	Worsened
ASEAN average	2,634	2,983	3,179	3,052	3,304	Improved	Worsened	2,908	2,736	Improved	Improved
ERIA average	2,913	3,631	4,211	3,717	3,694	Improved	Improved	3,332	2,503	=BAU	
OECD average*1	2,441	2,441	2,441								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	3.6	3.7	3.8	6.5	8.9	6.5	8.9
Brunei	2.5	2.5	2.5	2.4	2.4	2.6	2.7
Cambodia	2.4	2.6	2.7	4.6	4.5	4.6	4.6
China	4.1	3.8	3.7	5.3	6.0	5.7	8.4
India	4.7	4.7	4.9	5.3	5.0	6.4	8.1
Indonesia	9.7	8.9	8.3	9.6	8.6	9.9	11.0
Japan	11.4	11.0	10.9	11.0	9.3	11.4	13.2
Korea	8.5	7.7	7.4	7.4	7.2	7.4	7.2
Laos	2.4	2.4	2.4	4.1	3.7	4.1	3.7
Malaysia	6.2	4.4	5.1	5.9	5.4	6.4	6.3
Myanmar	5.6	5.9	5.3	6.5	6.4	6.8	8.3
New Zealand	4.7	5.8	6.7	7.3	8.2	7.3	7.4
Philippines	7.6	11.1	10.5	6.4	4.8	7.0	6.4
Singapore	3.7	4.9	3.6	3.7	3.7	3.7	3.7
Thailand	7.5	4.7	4.7	4.9	4.8	5.0	5.1
Vietnam	5.2	7.2	7.3	7.1	5.8	7.7	7.4
ASEAN average	9.3	8.2	7.7	8.0	7.4	8.4	8.9
ERIA average	8.4	6.7	5.8	6.6	6.6	7.3	9.8

Score is calculated by inverse of ESI

OECD Total = 10

3-1: TPES/GDP

TPES/GDP

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.24	0.21	0.21	0.17	0.11	Improved	Improved	0.17	0.11	=BAU	
Brunei	0.40	0.38	0.48	0.41	0.33	Improved	Improved	0.36	0.23	=BAU	
Cambodia	0.20	0.20	0.19	0.21	0.19	Worsened	Improved	0.18	0.17	Improved	Improved
China	1.04	0.75	0.72	0.51	0.36	Improved	Improved	0.48	0.29	=BAU	
India	0.69	0.63	0.57	0.39	0.30	Improved	Improved	0.36	0.24	=BAU	
Indonesia	0.57	0.65	0.59	0.53	0.52	Improved	Improved	0.44	0.38	=BAU	
Japan	0.11	0.11	0.10	0.08	0.07	Improved	Improved	0.08	0.06	=BAU	
Korea	0.35	0.33	0.30	0.25	0.21	Improved	Improved	0.25	0.19	=BAU	
Laos	0.30	0.30	0.34	0.62	0.36	Worsened	Improved	0.60	0.34	=BAU	
Malaysia	0.48	0.50	0.50	0.41	0.43	Improved	Worsened	0.36	0.35	Improved	Improved
Myanmar	0.51	0.35	0.30	0.25	0.22	Improved	Improved	0.25	0.19	=BAU	
New Zealand	0.31	0.27	0.24	0.22	0.20	Improved	Improved	0.21	0.17	=BAU	
Philippines	0.42	0.40	0.32	0.20	0.15	Improved	Improved	0.19	0.15	=BAU	
Singapore	0.27	0.19	0.12	0.18	0.13	Worsened	Improved	0.18	0.13	=BAU	
Thailand	0.54	0.61	0.59	0.56	0.56	Improved	No Change	0.49	0.43	Improved	Improved
Vietnam	0.45	0.58	0.64	0.69	0.59	Worsened	Improved	0.63	0.54	Improved	Improved
ASEAN average	0.48	0.50	0.46	0.42	0.40	Improved	Improved	0.37	0.32	=BAU	
ERIA average	0.29	0.31	0.34	0.32	0.27	Improved	Improved	0.30	0.22	=BAU	
OECD average*1	0.22	0.22	0.22								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	9.2	10.4	10.4	12.9	20.9	12.9	20.9
Brunei	5.5	5.8	4.6	5.4	6.8	6.1	9.6
Cambodia	11.0	11.0	11.4	10.7	11.7	12.0	12.9
China	2.1	3.0	3.1	4.3	6.2	4.7	7.6
India	3.2	3.5	3.9	5.6	7.4	6.2	9.4
Indonesia	3.9	3.4	3.7	4.2	4.3	5.0	5.8
Japan	20.4	20.6	22.6	26.4	33.1	27.8	37.9
Korea	6.4	6.7	7.3	8.7	10.4	9.0	11.4
Laos	7.3	7.3	6.4	3.6	6.2	3.7	6.5
Malaysia	4.7	4.4	4.4	5.4	5.2	6.1	6.3
Myanmar	4.3	6.4	7.4	8.8	10.2	8.9	11.5
New Zealand	7.1	8.2	9.2	10.0	11.2	10.6	13.4
Philippines	5.3	5.5	7.0	10.8	14.5	11.5	14.9
Singapore	8.1	11.5	17.8	12.0	16.6	12.2	17.1
Thailand	4.1	3.6	3.7	3.9	4.0	4.5	5.1
Vietnam	4.9	3.8	3.5	3.2	3.8	3.5	4.1
ASEAN average	4.6	4.4	4.8	5.3	5.5	6.0	6.8
ERIA average	7.6	7.2	6.6	6.9	8.2	7.4	10.1

Score is calculated by inverse of ESI

OECD Total = 10

3-2: TFEC/GDP

TEFC/GDP

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.14	0.12	0.12	0.13	0.08	Worsened	Improved	0.13	0.08	=BAU	
Brunei	0.09	0.10	0.23	0.22	0.20	Improved	Improved	0.20	0.14	=BAU	
Cambodia	0.17	0.18	0.17	0.14	0.14	Improved	No Change	0.12	0.12	=BAU	
China	0.72	0.46	0.44	0.32	0.22	Improved	Improved	0.30	0.19	=BAU	
India	0.41	0.34	0.31	0.23	0.18	Improved	Improved	0.21	0.15	=BAU	
Indonesia	0.34	0.42	0.37	0.38	0.38	Worsened	No Change	0.33	0.31	Improved	Improved
Japan	0.07	0.07	0.06	0.05	0.04	Improved	Improved	0.05	0.04	=BAU	
Korea	0.25	0.22	0.20	0.16	0.13	Improved	Improved	0.16	0.12	=BAU	
Laos	0.18	0.20	0.23	0.25	0.22	Worsened	Improved	0.24	0.20	=BAU	
Malaysia	0.28	0.31	0.30	0.32	0.33	Worsened	Worsened	0.28	0.27	Improved	Improved
Myanmar	0.28	0.23	0.22	0.16	0.15	Improved	Improved	0.15	0.14	=BAU	
New Zealand	0.23	0.20	0.17	0.15	0.12	Improved	Improved	0.14	0.11	=BAU	
Philippines	0.24	0.22	0.17	0.11	0.09	Improved	Improved	0.10	0.08	=BAU	
Singapore	0.09	0.10	0.10	0.15	0.11	Worsened	Improved	0.15	0.11	=BAU	
Thailand	0.32	0.39	0.37	0.43	0.44	Worsened	Worsened	0.38	0.34	Worsened	Improved
Vietnam	0.35	0.45	0.50	0.50	0.40	No Change	Improved	0.47	0.38	Improved	Improved
ASEAN average	0.28	0.31	0.29	0.31	0.30	Worsened	Improved	0.27	0.25	Improved	Improved
ERIA average	0.19	0.19	0.20	0.20	0.17	No Change	Improved	0.19	0.15	Improved	Improved
OECD average*1	0.15	0.15	0.15								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	10.7	12.7	13.2	12.2	18.4	12.2	18.4
Brunei	16.8	16.2	6.8	7.0	7.7	7.8	11.0
Cambodia	9.3	8.7	9.3	11.2	11.4	12.6	13.2
China	2.2	3.4	3.6	4.9	7.0	5.1	8.0
India	3.7	4.6	5.0	6.9	8.6	7.3	10.3
Indonesia	4.5	3.7	4.2	4.0	4.0	4.7	5.1
Japan	21.3	21.6	23.9	28.3	36.1	29.8	41.4
Korea	6.3	6.9	7.8	9.6	11.6	9.9	12.7
Laos	8.5	7.8	6.7	6.2	7.0	6.6	7.7
Malaysia	5.5	5.0	5.2	4.9	4.6	5.6	5.8
Myanmar	5.5	6.8	6.9	10.0	10.5	10.5	11.4
New Zealand	6.6	7.7	9.0	10.4	12.7	10.8	14.1
Philippines	6.4	7.1	9.3	13.6	17.3	14.8	18.9
Singapore	16.3	16.0	15.8	10.4	14.1	10.5	14.4
Thailand	4.8	4.0	4.2	3.6	3.6	4.1	4.5
Vietnam	4.4	3.4	3.1	3.1	3.8	3.3	4.1
ASEAN average	5.5	4.9	5.3	5.0	5.2	5.7	6.3
ERIA average	8.1	8.2	7.6	7.6	9.0	8.0	10.4

Score is calculated by inverse of ESI

OECD Total = 10

4-1: CO_2 Emission/TPES

CO2 Emission/TPES

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.96	1.04	0.96	0.58	0.51	Improved	Improved	0.58	0.51	=BAU	
Brunei	0.54	0.55	0.62	0.57	0.57	Improved	No Change	0.55	0.55	Improved	
Cambodia	0.83	0.90	0.85	0.89	0.87	Worsened	Improved	0.92	0.87	=BAU	
China	0.96	0.92	0.92	0.85	0.81	Improved	Improved	0.83	0.72	=BAU	
India	0.87	0.84	0.85	0.84	0.84	Improved	No Change	0.80	0.74	Improved	Improved
Indonesia	0.63	0.71	0.69	0.66	0.68	Improved	Worsened	0.62	0.63	=BAU	
Japan	0.64	0.64	0.64	0.64	0.68	No Change	Worsened	0.60	0.54	Improved	Improved
Korea	0.66	0.62	0.61	0.58	0.57	Improved	Improved	0.52	0.44	=BAU	
Laos	0.34	0.57	0.45	1.26	0.97	Worsened	Improved	1.24	0.98	=BAU	
Malaysia	0.64	0.67	0.69	0.78	0.80	Worsened	Worsened	0.74	0.72	Worsened	Improved
Myanmar	0.54	0.59	0.57	0.57	0.66	No Change	Worsened	0.57	0.63	=BAU	
New Zealand	0.52	0.56	0.56	0.40	0.32	Improved	Improved	0.39	0.31	=BAU	
Philippines	0.56	0.56	0.55	0.66	0.76	Worsened	Worsened	0.61	0.62	=BAU	
Singapore	0.55	0.58	0.70	0.46	0.49	Improved	Worsened	0.46	0.48	=BAU	
Thailand	0.67	0.68	0.67	0.47	0.45	Improved	Improved	0.46	0.44	=BAU	
Vietnam	0.75	0.78	0.78	0.86	0.88	Worsened	Worsened	0.83	0.81	Worsened	Improved
ASEAN average	0.63	0.67	0.68	0.65	0.68	Improved	Worsened	0.62	0.63	=BAU	
ERIA average	0.81	0.80	0.82	0.79	0.77	Improved	Improved	0.76	0.68	=BAU	
OECD average*1	0.69	0.69	0.69								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	7.2	6.7	7.2	12.0	13.5	12.0	13.5
Brunei	12.9	12.6	11.1	12.2	12.1	12.7	12.6
Cambodia	8.3	7.7	8.1	7.8	8.0	7.5	7.9
China	7.2	7.5	7.5	8.1	8.6	8.3	9.6
India	8.0	8.2	8.1	8.2	8.2	8.6	9.3
Indonesia	11.0	9.8	9.9	10.5	10.1	11.1	10.9
Japan	10.8	10.8	10.7	10.7	10.2	11.4	12.8
Korea	10.5	11.1	11.4	11.8	12.2	13.2	15.6
Laos	20.5	12.0	15.2	5.5	7.1	5.5	7.0
Malaysia	10.8	10.3	10.0	8.8	8.7	9.4	9.7
Myanmar	12.8	11.7	12.2	12.0	10.5	12.2	10.9
New Zealand	13.4	12.3	12.4	17.2	21.5	17.7	22.2
Philippines	12.4	12.4	12.5	10.4	9.1	11.2	11.1
Singapore	12.5	11.9	9.8	15.0	14.0	15.2	14.2
Thailand	10.3	10.2	10.3	14.5	15.2	14.8	15.8
Vietnam	9.2	8.9	8.9	8.1	7.9	8.3	8.5
ASEAN average	11.0	10.3	10.1	10.7	10.2	11.2	11.0
ERIA average	8.5	8.6	8.4	8.8	9.0	9.1	10.2

Score is calculated by inverse of ESI

OECD Total = 10

4-2: CO_2 Emission/Fossil Fuel Primary Supply

CO2 Emission/Fossil fuel primary supply

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.88	0.94	0.89	0.61	0.56	Improved	Improved	0.61	0.56	=BAU	
Brunei	0.54	0.55	0.62	0.57	0.57	Improved	No Change	0.55	0.55	=BAU	
Cambodia	0.80	0.81	0.80	0.92	0.92	Worsened	No Change	0.92	0.93	Worsened	Worsened
China	0.98	0.95	0.96	0.92	0.90	Improved	Improved	0.92	0.87	=BAU	
India	0.90	0.88	0.88	0.90	0.90	Worsened	No Change	0.89	0.87	Worsened	Improved
Indonesia	0.68	0.79	0.78	0.78	0.81	No Change	Worsened	0.74	0.78	Improved	Worsened
Japan	0.78	0.78	0.78	0.78	0.78	No Change	No Change	0.78	0.76	No Change	Improved
Korea	0.76	0.75	0.75	0.72	0.71	Improved	Improved	0.69	0.64	=BAU	
Laos	0.09	0.19	0.17	1.10	1.03	Worsened	Improved	1.09	1.03	=BAU	
Malaysia	0.67	0.70	0.71	0.80	0.80	Worsened	No Change	0.77	0.76	Worsened	Improved
Myanmar	0.71	0.69	0.68	0.78	0.77	Worsened	Improved	0.77	0.77	Worsened	No Change
New Zealand	0.71	0.75	0.79	0.72	0.72	Improved	No Change	0.73	0.73	=BAU	
Philippines	0.83	0.85	0.85	0.92	0.94	Worsened	Worsened	0.92	0.93	=BAU	
Singapore	0.55	0.58	0.71	0.46	0.50	Improved	Worsened	0.46	0.49	=BAU	
Thailand	0.80	0.76	0.76	0.64	0.62	Improved	Improved	0.65	0.63	=BAU	
Vietnam	0.93	0.89	0.87	0.93	0.94	Worsened	Worsened	0.92	0.93	=BAU	
ASEAN average	0.71	0.76	0.77	0.76	0.79	Improved	Worsened	0.74	0.77	=BAU	
ERIA average	0.88	0.87	0.89	0.87	0.86	Improved	Improved	0.87	0.83	=BAU	
OECD average*1	0.79	0.79	0.79								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	9.0	8.5	8.9	13.0	14.2	13.0	14.2
Brunei	14.8	14.5	12.8	14.0	14.0	14.6	14.5
Cambodia	9.9	9.8	9.9	8.6	8.6	8.7	8.5
China	8.1	8.3	8.3	8.6	8.9	8.6	9.1
India	8.8	9.0	9.0	8.8	8.8	9.0	9.2
Indonesia	11.7	10.1	10.2	10.1	9.8	10.7	10.2
Japan	10.2	10.2	10.2	10.1	10.2	10.2	10.5
Korea	10.4	10.6	10.6	11.1	11.3	11.5	12.5
Laos	87.0	41.9	45.4	7.2	7.7	7.3	7.7
Malaysia	11.8	11.4	11.2	9.9	9.9	10.2	10.4
Myanmar	11.1	11.5	11.7	10.1	10.4	10.4	10.3
New Zealand	11.2	10.5	10.1	11.0	11.1	10.9	10.9
Philippines	9.6	9.4	9.3	8.6	8.4	8.7	8.5
Singapore	14.4	13.7	11.3	17.1	15.9	17.2	16.1
Thailand	9.9	10.4	10.4	12.4	12.8	12.3	12.6
Vietnam	8.6	9.0	9.1	8.6	8.5	8.6	8.6
ASEAN average	11.2	10.5	10.4	10.5	10.1	10.7	10.3
ERIA average	9.1	9.1	8.9	9.1	9.2	9.2	9.6

Score is calculated by inverse of ESI

OECD Total = 10

4-3: CO_2 Emission/GDP

CO2 Emission/GDP

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	0.23	0.22	0.20	0.10	0.05	Improved	Improved	0.10	0.05	=BAU	
Brunei	0.22	0.21	0.30	0.23	0.19	Improved	Improved	0.20	0.13	=BAU	
Cambodia	0.17	0.18	0.16	0.18	0.16	Worsened	Improved	0.17	0.15	=BAU	
China	1.00	0.69	0.67	0.44	0.29	Improved	Improved	0.39	0.21	=BAU	
India	0.60	0.53	0.48	0.33	0.25	Improved	Improved	0.29	0.17	=BAU	
Indonesia	0.36	0.46	0.41	0.35	0.35	Improved	No Change	0.28	0.24	Improved	Improved
Japan	0.07	0.07	0.06	0.05	0.05	Improved	No Change	0.05	0.03	Improved	Improved
Korea	0.23	0.21	0.18	0.15	0.12	Improved	Improved	0.13	0.09	=BAU	
Laos	0.10	0.17	0.15	0.78	0.35	Worsened	Improved	0.75	0.33	=BAU	
Malaysia	0.30	0.34	0.34	0.32	0.34	Improved	Worsened	0.27	0.25	Improved	Improved
Myanmar	0.28	0.21	0.17	0.15	0.14	Improved	Improved	0.14	0.12	=BAU	
New Zealand	0.16	0.15	0.13	0.09	0.06	Improved	Improved	0.08	0.05	=BAU	
Philippines	0.23	0.22	0.18	0.14	0.12	Improved	Improved	0.12	0.09	=BAU	
Singapore	0.15	0.11	0.09	0.08	0.07	Improved	Improved	0.08	0.06	=BAU	
Thailand	0.32	0.38	0.36	0.27	0.25	Improved	Improved	0.23	0.19	=BAU	
Vietnam	0.34	0.45	0.50	0.59	0.52	Worsened	Improved	0.53	0.44	=BAU	
ASEAN average	0.29	0.33	0.31	0.27	0.27	Improved	No Change	0.23	0.20	Improved	Improved
ERIA average	0.23	0.24	0.28	0.25	0.21	Improved	Improved	0.23	0.15	=BAU	
OECD average*1	0.15	0.15	0.15								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	6.6	6.9	7.5	15.5	28.3	15.5	28.3
Brunei	7.1	7.3	5.1	6.6	8.3	7.7	12.1
Cambodia	9.1	8.4	9.3	8.3	9.3	9.0	10.2
China	1.5	2.2	2.3	3.5	5.3	3.9	7.3
India	2.5	2.9	3.2	4.6	6.1	5.3	8.8
Indonesia	4.3	3.3	3.7	4.4	4.3	5.5	6.4
Japan	22.1	22.3	24.2	28.3	33.8	31.8	48.6
Korea	6.7	7.4	8.3	10.3	12.6	11.9	17.9
Laos	15.0	8.8	10.1	2.0	4.4	2.0	4.6
Malaysia	5.0	4.5	4.4	4.7	4.5	5.7	6.1
Myanmar	5.5	7.4	8.9	10.5	10.7	10.9	12.5
New Zealand	9.5	10.1	11.4	17.2	24.1	18.8	29.7
Philippines	6.6	6.8	8.7	11.3	13.1	12.9	16.5
Singapore	10.1	13.8	17.4	18.0	23.3	18.4	24.4
Thailand	4.7	4.0	4.2	5.7	6.1	6.7	8.0
Vietnam	4.5	3.4	3.1	2.6	3.0	2.9	3.5
ASEAN average	5.2	4.6	5.0	5.6	5.6	6.7	7.5
ERIA average	6.5	6.2	5.5	6.0	7.4	6.7	10.2

Score is calculated by inverse of ESI

OECD Total = 10

4-4: CO_2 Emission/Population

CO2 Emission/Population

Country	1990s	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	4.33	4.96	4.99	3.22	2.51	Improved	Improved	3.22	2.51	=BAU	
Brunei	4.00	3.82	5.31	4.20	4.17	Improved	Improved	3.60	2.83	=BAU	
Cambodia	0.04	0.06	0.08	0.14	0.20	Worsened	Worsened	0.13	0.19	=BAU	
China	0.63	0.81	1.29	2.13	2.67	Worsened	Worsened	1.93	1.92	Worsened	Improved
India	0.22	0.27	0.34	0.55	0.90	Worsened	Worsened	0.47	0.62	=BAU	
Indonesia	0.28	0.40	0.43	0.63	1.20	Worsened	Worsened	0.50	0.82	=BAU	
Japan	2.44	2.57	2.51	2.54	2.80	Worsened	Worsened	2.26	1.95	Improved	Improved
Korea	2.00	2.59	2.79	3.43	4.02	Worsened	Worsened	2.98	2.84	Worsened	Improved
Laos	0.03	0.06	0.07	0.74	0.73	Worsened	Improved	0.71	0.70	=BAU	
Malaysia	1.04	1.43	1.72	2.22	3.29	Worsened	Worsened	1.85	2.42	=BAU	
Myanmar	0.04	0.05	0.06	0.11	0.26	Worsened	Worsened	0.11	0.22	=BAU	
New Zealand	1.97	2.22	2.10	1.65	1.37	Improved	Improved	1.50	1.11	=BAU	
Philippines	0.21	0.23	0.21	0.30	0.43	Worsened	Worsened	0.26	0.34	=BAU	
Singapore	2.80	2.69	2.62	4.02	4.48	Worsened	Worsened	3.93	4.28	=BAU	
Thailand	0.58	0.82	0.93	1.09	1.63	Worsened	Worsened	0.93	1.22	No Change	Worsened
Vietnam	0.10	0.21	0.31	0.76	1.68	Worsened	Worsened	0.68	1.43	=BAU	
ASEAN average	0.30	0.42	0.48	0.70	1.20	Worsened	Worsened	0.59	0.90	=BAU	
ERIA average	0.57	0.69	0.91	1.32	1.70	Worsened	Worsened	1.18	1.23	=BAU	
OECD average*1	2.91	2.91	2.91								

*1 average of 1971-2009

vs. OECD averagel (average of 1971-2009)

Country	1990s	2000s-1	2000s-2	BAU		APS	
				2020	2035	2020	2035
Australia	6.7	5.9	5.8	9.0	11.6	9.0	11.6
Brunei	7.3	7.6	5.5	6.9	7.0	8.1	10.3
Cambodia	697.8	460.7	354.9	204.7	142.8	223.3	156.7
China	45.9	35.9	22.6	13.6	10.9	15.1	15.1
India	130.9	107.4	85.8	53.2	32.4	61.7	47.0
Indonesia	105.5	73.2	66.8	45.9	24.2	58.1	35.6
Japan	11.9	11.3	11.6	11.4	10.4	12.9	14.9
Korea	14.6	11.2	10.4	8.5	7.2	9.8	10.2
Laos	1,068.5	456.2	413.5	39.5	39.6	41.0	41.5
Malaysia	27.9	20.4	16.9	13.1	8.8	15.7	12.0
Myanmar	786.5	550.2	450.1	265.1	113.3	274.6	131.8
New Zealand	14.7	13.1	13.8	17.7	21.2	19.4	26.2
Philippines	139.2	126.4	138.5	98.3	67.0	112.9	84.3
Singapore	10.4	10.8	11.1	7.2	6.5	7.4	6.8
Thailand	50.1	35.6	31.1	26.8	17.9	31.3	23.8
Vietnam	282.5	138.6	92.7	38.2	17.3	43.1	20.4
ASEAN average	95.4	69.5	60.8	41.5	24.3	49.2	32.3
ERIA average	51.0	42.4	32.0	22.0	17.1	24.7	23.7

Score is calculated by inverse of ESI

OECD Total = 10

5: Electrification (Reference)

Country	2000 (WEO 2002)		2005 (WEO 2006)		2009 (WEO 2011)		2010 (WEO 2012)		2011 (WEO 2013)	
	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)	Electrification rate	Population without electricity (million)
Australia	100.0%		100.0%		100.0%		100.0%		100.0%	
Brunei	99.2%	0.0	99.2%	0.0	99.7%	0.0	99.7%	0.0	99.7%	0.0
Cambodia	15.8%	10.3	20.1%	10.9	24.0%	11.3	31.1%	10.3	34.0%	9.4
China	98.6%	17.6	99.4%	8.5	99.4%	8.0	99.7%	3.9	99.8%	2.5
India	43.0%	579.1	55.5%	487.2	75.0%	288.8	75.0%	292.9	75.3%	306.1
Indonesia	53.4%	98.0	54.0%	101.2	64.5%	81.6	73.0%	62.8	72.9%	65.7
Japan	100.0%		100.0%		100.0%		100.0%		100.0%	
Korea	100.0%		100.0%		100.0%		100.0%		100.0%	
Laos					55.0%	2.6	63.0%	2.2	78.0%	1.3
Malaysia	96.9%	0.7	97.8%	0.6	99.4%	0.2	99.4%	0.2	99.5%	0.1
Myanmar	5.0%	45.3	11.3%	45.1	13.0%	43.5	48.8%	25.8	48.8%	24.7
New Zealand	100.0%		100.0%		100.0%		100.0%		100.0%	
Philippines	87.4%	9.5	80.5%	16.2	89.7%	9.5	83.3%	15.6	70.2%	28.3
Singapore	100.0%		100.0%		100.0%		100.0%		100.0%	
Thailand	82.1%	10.9	99.0%	0.6	99.3%	0.5	87.7%	8.4	99.0%	0.7
Vietnam	75.8%	19.0	84.2%	13.2	95.1%*	2.1	95.9%*	2.1	96.4%*	2.1
ERIA Total	73.5%	790.4	78.2%	683.5	86.3%	448.1	87.1%	424.2	87.2%	440.9

Elecrification rate is regarded as 100% in OECD Countries

* Source: Electricity of Vietnam

Target

Country	2015	2020	2025	2030	2035
	Electrification rate	Electrification rate	Electrification rate	Electrification rate	Electrification rate
Australia					
Brunei					
Cambodia					100%
China	100%				
India					
Indonesia					
Japan					
Korea					
Laos	80%	90%			
Malaysia	98.41%				
Myanmar	34%	45%	60%	80%	
New Zealand					
Philippines					
Singapore					
Thailand	100%				
Vietnam		100%			

6-1: TPES/Population (Supplement Index)

TPES/Population

Country	1990	2000s-1	2000s-2	BAU				APS			
				2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	2035/2020
Australia	4.50	4.79	5.19	5.59	4.91	Increased	Decreased	5.59	4.91	=BAU	
Brunei	7.47	6.95	8.57	7.40	7.33	Decreased	Decreased	6.60	5.17	=BAU	
Cambodia	0.05	0.07	0.10	0.16	0.24	Increased	Increased	0.14	0.21	=BAU	
China	0.66	0.88	1.40	2.50	3.32	Increased	Increased	2.33	2.68	=BAU	
India	0.26	0.32	0.40	0.65	1.06	Increased	Increased	0.58	0.84	=BAU	
Indonesia	0.44	0.56	0.63	0.96	1.76	Increased	Increased	0.80	1.29	=BAU	
Japan	3.82	4.02	3.90	3.95	4.14	Increased	Increased	3.75	3.61	Decreased	Decreased
Korea	3.04	4.19	4.59	5.87	7.09	Increased	Increased	5.68	6.44	=BAU	
Laos	0.08	0.11	0.15	0.58	0.76	Increased	Increased	0.57	0.71	=BAU	
Malaysia	1.63	2.13	2.50	2.83	4.13	Increased	Increased	2.51	3.39	=BAU	
Myanmar	0.07	0.09	0.11	0.19	0.39	Increased	Increased	0.19	0.35	=BAU	
New Zealand	3.83	3.95	3.78	4.10	4.28	Increased	Increased	3.85	3.57	Decreased	Decreased
Philippines	0.38	0.41	0.38	0.44	0.57	Increased	Increased	0.42	0.55	=BAU	
Singapore	5.08	4.65	3.73	8.76	9.11	Increased	Increased	8.64	8.83	=BAU	
Thailand	0.87	1.21	1.39	2.29	3.59	Increased	Increased	1.99	2.80	=BAU	
Vietnam	0.14	0.27	0.40	0.89	1.92	Increased	Increased	0.81	1.76	=BAU	
ASEAN average	0.48	0.62	0.70	1.08	1.77	Increased	Increased	0.96	1.43	=BAU	
ERIA average	0.71	0.85	1.10	1.68	2.22	Increased	Increased	1.55	1.81	=BAU	
OECD average*1	4.21	4.21	4.21								

*1 average of 1971-2009

6-2: GDP/Population (Supplement Index)

GDP/Population

Country	1990s	2000s-1	2000s-2	2020	2035	Annual growth rate	
						2020/2000s-2	2035/2020
Australia	18.6	22.6	24.4	32.6	46.4	2.5%	2.4%
Brunei	18.6	18.2	17.8	18.2	22.5	0.2%	1.4%
Cambodia	0.2	0.3	0.5	0.8	1.2	3.7%	3.2%
China	0.6	1.2	1.9	4.9	9.2	8.0%	4.3%
India	0.4	0.5	0.7	1.6	3.6	7.4%	5.3%
Indonesia	0.8	0.9	1.1	1.8	3.4	4.6%	4.3%
Japan	35.3	37.5	39.8	47.1	61.9	1.4%	1.8%
Korea	8.7	12.6	15.1	23.1	33.2	3.6%	2.4%
Laos	0.3	0.4	0.5	0.9	2.1	6.1%	5.5%
Malaysia	3.4	4.2	5.0	6.9	9.7	2.7%	2.3%
Myanmar	0.1	0.3	0.4	0.8	1.8	5.9%	6.0%
New Zealand	12.3	14.7	15.7	18.5	21.6	1.4%	1.0%
Philippines	0.9	1.0	1.2	2.2	3.7	5.1%	3.6%
Singapore	18.5	24.2	29.9	47.4	68.3	3.9%	2.5%
Thailand	1.8	2.2	2.6	4.1	6.4	3.9%	3.1%
Vietnam	0.3	0.5	0.6	1.3	3.3	6.1%	6.4%
ASEAN average	1.0	1.3	1.6	2.6	4.4	4.3%	3.6%
ERIA average	2.4	2.8	3.3	5.2	8.2	3.8%	3.1%
OECD average	20.2	23.4	24.9				