

# Chapter 3

## Assessment of Future Energy Security Index

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# 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<sub>2</sub> 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**

<b>Data</b>	<b>IEA Energy Balance</b>	<b>ERIA Outlook</b>
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<sub>2</sub> 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.

<b><u>Country</u></b>	<b><u>Reasons</u></b>
-----------------------	-----------------------

- |                |  |
|----------------|--|
| - 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<sub>2</sub> emission

The evaluation of CO<sub>2</sub> emission looks at four ESIs: (i) CO<sub>2</sub> emission per TPES, (ii) CO<sub>2</sub> emission per fossil fuel primary supply, (iii) CO<sub>2</sub> emission per GDP, and (iv) CO<sub>2</sub> emission per population.

CO<sub>2</sub> 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<sub>2</sub> emission per TPES will improve.

CO<sub>2</sub> 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<sub>2</sub> emission per fossil fuel primary supply will improve.

CO<sub>2</sub> emission per GDP depends mainly on energy efficiency. Accordingly, if energy efficiency improves, CO<sub>2</sub> emission per GDP will improve.

CO<sub>2</sub> 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<sub>2</sub> emission per population. Conversely, even if the economy grows, but energy efficiency also improves, and the consumption of low-carbon energy increases, CO<sub>2</sub> emission per population may be contained and the situation will not worsen.

*CO<sub>2</sub> emission/TPES*

### **1) BAU scenario**

#### **a. 2020/2000s-2**

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emission/TPES will improve for ASEAN Average and ERIA Average. Looking at individual countries, as for the BAU scenario, CO<sub>2</sub> emission/TPES will worsen for Cambodia, Laos, Malaysia, the Philippines, and Viet Nam.

### b. 2035/2020

From 2020 to 2035, CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> = 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<sub>2</sub> emission per TPES, the better situation is shown by lower values, but as inverse numbers have been used for CO<sub>2</sub> emission per TPES for the purpose of this scoring, the large values here show the better situation.

**Table 3-14: Comparison (CO<sub>2</sub> 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<sub>2</sub> = carbon dioxide, TPES = total primary energy supply,

*Source*: Authors.

### *CO<sub>2</sub> emission/fossil fuel primary supply*

Table 3-15 presents the future CO<sub>2</sub> emission/fossil fuel primary supply under both the BAU and APS cases.

#### **1) BAU scenario**

##### a. 2020/2000s-2

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emission/fossil fuel primary supply will worsen for Indonesia, the Philippines, Singapore, and Viet Nam.

**Table 3-15: Results of Future CO<sub>2</sub> 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<sub>2</sub> = carbon dioxide,  
*Source*: Authors.

Table 3-16 presents a comparison with the OECD Average (average for 1971-2009: 0.79). With CO<sub>2</sub> emission per fossil fuel primary supply, the better situation is shown by lower values, but as inverse numbers have been used for

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> = carbon dioxide, *Source*: Authors.

## *CO<sub>2</sub> emission/GDP*

### **1) BAU scenario**

#### a. 2020/2000s-2

CO<sub>2</sub> 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<sub>2</sub> emission/GDP and energy efficiency.

#### b. 2035/2020

Although CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> = 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<sub>2</sub> emission per GDP, the better situation is shown by lower values, but as inverse numbers have been used for CO<sub>2</sub> emission per GDP for the purpose of this scoring, the large values here show the better situation.

**Table 3-18: Comparison (CO<sub>2</sub> 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<sub>2</sub> = carbon dioxide.

*Source*: Authors.

## *CO<sub>2</sub> emission/population*

### **1) BAU scenario**

#### **a. 2020/2000s-2**

CO<sub>2</sub> 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 capita (see Table 3-22). For countries with a high annual growth rate for GDP per capita, CO<sub>2</sub> emission/population tends to worsen.

b. 2035/2020

CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> = carbon dioxide.

*Source*: Authors.

Table 3-20 presents a comparison with the OECD Average (average for 1971-2009: 2.91). With CO<sub>2</sub> emission per population, the better situation is shown by lower values, but as inverse numbers have been used for CO<sub>2</sub> emission per population for the purpose of this scoring, the large values here show the better situation.

**Table 3-20: Comparison (CO<sub>2</sub> 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<sub>2</sub> = 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<sub>2</sub> 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				APS			
		2020	2035	2020/2000s-2	2035/2020	2020	2035	2020/2000s-2	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.