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Energy Security Risks in ASEAN: Modern Perspectives and Emerging Challenges

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Preface

Several ASEAN Member States (AMS) have made strong commitments to address climate change by setting ambitious greenhouse gas (GHG) emissions reduction targets, including carbon neutrality pledges. One of the greatest challenges facing these countries is how to balance sustained economic growth with effective climate change mitigation.

Many of the conventional thermal power plants in the region have only recently begun operations, and they will continue to play a critical role in ensuring a stable electricity supply in the short to medium term. Even as ASEAN expands the share of renewable energy in its energy mix, the security of fossil fuel supply remains a vital component of national energy strategies.

In recent years, energy security considerations have evolved under new global pressures. Soaring fossil fuel prices, heightened geopolitical risks, and increasing climate finance constraints on fossil fuel projects have all added new dimensions to the energy security debate. Against this backdrop, this study analyses the energy security risks of ASEAN Member States, with a focus on fossil fuels, while incorporating these emerging perspectives.

This report is structured into four chapters. Chapter 1 outlines the background and objectives of the research. Chapter 2 defines energy security and presents the analytical framework used in the study. Energy security is assessed across five key dimensions – energy efficiency, energy self-sufficiency, energy supply diversity (flexibility), carbon dioxide (CO_2) emissions, and geopolitical risk – using several indicators collectively referred to as Energy Security Indexes (ESI). These include the total primary energy supply (TPES) self-sufficiency rate, TPES diversity, generation diversity, TPES-to-GDP ratio, CO_2-to-GDP ratio, low-carbon indicator, fossil fuel indicator, import diversity, volatility risk indicator, Middle East indicator, and Russia indicator. Each indicator is compared with the Organisation for Economic Co-operation and Development (OECD) averages for reference.

Chapter 3 analyses changes in these ESIs over time, alongside trends in macroeconomic conditions, energy supply and demand, energy import patterns, and shifts in national energy policies. Finally, Chapter 4 presents the study's conclusions and policy recommendations derived from the analysis.

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List of Abbreviations and Acronyms

ASEAN	Association of Southeast Asian Nations
CCS	carbon capture and storage
CO_2	carbon dioxide
EGAT	Electricity Generating Authority of Thailand
ERIA	Economic Research Institute for ASEAN and East Asia
ESI	energy security index
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IEEJ	The Institute of Energy Economics, Japan
Lao PDR	Lao People's Democratic Republic
LNG	liquefied natural gas
MW	megawatt
OECD	Organisation for Economic Co-operation and Development
PDP	Power Source Development Plan
PEP	Philippine Energy Plan
SMEs	small and medium-sized enterprises
TPES	total primary energy supply
WITS	World Integrated Trade Solution

Executive Summary

This study analyses the energy security risks of ASEAN Member States, with a particular focus on fossil fuels, updating the findings of a previous study conducted in 2012. Ensuring energy security remains a critical international issue, yet its definition continues to evolve in response to global shifts in energy dynamics. Beyond ensuring sufficient and affordable energy supply, there is now a growing emphasis on environmental sustainability – particularly on achieving carbon neutrality and addressing climate change.

The study evaluates energy security across five main dimensions: energy efficiency, energy self-sufficiency, energy supply diversity (flexibility), carbon dioxide (CO_2) emissions, and geopolitical risk. Using these dimensions, an Energy Security Index (ESI) was developed to assess the status of each ASEAN Member State. These parameters were selected to reflect recent challenges, including the global supply disruptions caused by the Russian Federation's invasion of Ukraine and the heightened urgency of climate action worldwide.

The analysis reveals that progress in improving ESIs has varied across countries, reflecting their differing energy contexts. Over the past 2 decades, ASEAN countries have achieved notable diversification in their total primary energy supply and power generation. However, this diversification has often been accompanied by increased reliance on fossil fuels – particularly coal – to sustain rapid economic growth. For many emerging economies, fossil fuels remain indispensable in balancing the dual goals of economic development and long-term decarbonisation. Therefore, the process and pathway toward decarbonisation must be tailored to each country's specific circumstances.

From the perspective of energy security – particularly supply stability and price resilience – thermal power generation continues to play a crucial role. Equally important are efforts to diversify fossil fuel import facilities, expand import and export options, and strengthen regional stockpiling systems to enhance collective resilience.

While the potential for renewable energy varies across ASEAN, the development of regional power grid interconnections offers significant promise for improving supply stability. The greater use of renewables and, where acceptable, nuclear power, will contribute to both energy self-sufficiency and diversification. However, differences in renewable energy potential and public acceptance of nuclear power must be carefully considered. Strengthening and expanding the regional power network, along

with promoting distributed and multiplex energy systems, will be key to achieving these goals.

As renewable energy penetration increases, managing supply–demand fluctuations will become more complex. To address this, ASEAN Member States must accelerate the adoption of energy storage systems, demand response mechanisms, and virtual power plants, which can enhance flexibility and grid stability.

Achieving decarbonisation also requires comprehensive action across all sectors. In the industrial sector, which accounts for a significant share of CO_2 emissions – particularly amongst local small and medium-sized enterprises (SMEs) – reducing carbon intensity is essential. Supporting SMEs in strengthening their capacity for energy efficiency and emissions reduction is therefore a critical component of climate finance and sustainable industrial development.

Chapter 1
Background of the Study

The Paris Agreement (an international treaty on climate change that came into force in 2016) aims to reach the global peak of greenhouse gas (GHG) emissions as soon as possible and 'achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century'. Considering the Paris Agreement, many countries including Member States of the Association of Southeast Asian Nations (ASEAN) have announced highly ambitious medium- to long-term GHG emissions reduction targets. One of the biggest challenges for ASEAN Member States is how to balance economic growth and climate change action. ASEAN is expected to continue to grow steadily in the coming decades due to an increase in the working population and rising productivity. ASEAN Member States are currently highly dependent on fossil fuels, and many of the conventional thermal power plants have just started operations. They will play a critical role in ensuring a stable supply of electricity in the short- and medium-term. In this context, energy security of fossil fuels is, and will continue to be, important for ASEAN's energy policy, whilst efforts to expand renewable energy are expected to be significant. At the same time, however, financial pressure from developed countries or multilateral development banks has increased.

Russia's invasion of Ukraine has brought about a major change in the global energy landscape. Restrictions on energy trade with Russia due to economic sanctions, and Russia's retaliatory measures to reduce or suspend energy exports, have caused fossil fuel prices (oil, gas, LNG, coal) to soar and competition for supply sources to intensify globally, making stable energy supply and security an urgent priority for the energy sector. The stable supply and security of energy has been positioned as an urgent and important issue in the energy sector.

In 2012, the Economic Research Institute for ASEAN and East Asia (ERIA) conducted a study to develop an energy security index (ERIA, 2012). This time, whilst building on the previous studies, this study aims to assess energy security of fossil fuels of ASEAN Member States in the past 20 years and provides policy recommendations based on the current new circumstances.

Chapter 2

Assessment of Energy Security

2.1. Definition of Energy Security and Assessment Method

Ensuring energy security has been positioned as an important issue internationally, but its definition is expanding and changing day by day in response to changes in the global energy situation. In addition to the sufficiency and affordability of the physical supply of energy, recently there has been a strong demand for environmental considerations, especially for the realisation of carbon neutrality and climate change countermeasures.

This study focuses on five major aspects of energy security: energy efficiency, energy self-sufficiency, energy supply diversity (flexibility), CO_2 emissions, and geopolitical risks. Multiple indicators (energy security indexes [ESI]) are used to measure energy security in relative terms, and the status of each country is examined.

This study covers nine ASEAN Member States[1] and three reference countries.[2] In organising the status of energy security in each country, for each indicator, we utilise statistical data for the past 20 years, i.e. 2000–2019. The score of each country's indicator is compared relative to the OECD average score of 5. However, even if the relative score is more than double that of the OECD, the maximum value is 10.

2.2. Data Source

In this section, changes in the ESI 2000–2019 are calculated. The following data sources are used in the calculation: IEA Energy Balance Table, IEA statistics including 'Oil Information,' 'Coal Information,' and 'CO_2 Emissions from Fuel Combustion, Cedigaz 2022, data from the World Bank's 'World Integrated Trade Solution', General Administration of Customs of the People's Republic of China, and the Government of India, Ministry of Commerce and Industry, Department of Commerce.

[1] Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.
[2] China, India, and Japan.

2.3. Selection of Energy Security Indexes

The selected ESIs in this study are: total primary energy supply/gross domestic product (TPES/GDP), TPES self-sufficiency, volatility risk indicator, TPES diversity, power generation diversity, CO_2 emissions/GDP, low-carbon indicator, fossil fuel indicator, import diversity, Middle East indicator, and Russia indicator.

The TPES/GDP ratio is used to determine whether energy is being used efficiently and whether demand is being managed. TPES self-sufficiency and volatility risk indicators are used to confirm the degree of utilisation of domestic resources and whether energy price stability is high (how much of the energy is dependent on international market prices). To check whether diversity (substitutability) of energy supply is achieved without relying on a single energy source, TPES diversity and power generation diversity are used. CO_2 emissions/GDP, fossil fuel indicator, and low-carbon indicator were used to confirm the amount of CO_2 emissions associated with energy supply and whether the energy composition is environmentally friendly. Finally, to determine the extent to which energy imports are exposed to geopolitical risks, we need to consider how diversified the import sources are, and how much the import volume from the Middle East and Russia is relative to the total import volume. Therefore, import diversity, the Middle East indicator, and the Russia indicator were used. Table 2.1 provides an overview of each indicator and what can be understood from the indicators.

Table 2.1. Definition of Energy Security and Assessment Method

Definition of Energy Security (Components)	Energy Security Index (ESI)	Details
- Management of demand	- TPES/GDP ratio	- Energy efficiency
- Development of domestic resources - Energy price stability	- TPES self-sufficiency - Volatility risk indicator	- Ratio of energy self-sufficiency - Ratio of net imports fossil fuel in TPES
- Energy supply diversity (Substitutability)	- TPES diversity - Power generation diversity	- Diversification of energy sources in TPES - Diversification of energy sources in power generation
- Environmental sustainability	- CO_2 emissions/GDP - Fossil fuel indicator - Low-carbon indicator	- CO_2 intensity - Ratio of fossil fuel in TPES - Ratio of renewable

Definition of Energy Security (Components)	Energy Security Index (ESI)	Details
		energy in TPES
- Geopolitical risk of import sources	- Import diversity - Middle East indicator - Russia indicator	- Diversification of import sources of fossil fuels - Dependence of fossil fuel imports on the Middle East - Dependence of fossil fuel imports on Russia

GDP = gross domestic product, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

2.3.1. TPES/GDP

TPES/GDP is an indicator that constitutes demand management in the definition of energy security. It shows the primary energy supply required to generate one unit of GDP and how the economy is growing, whilst reducing energy consumption. Table 2.2 shows the results of TPES/GDP of each Member State in absolute value, and table 2.3 provides relative score to compare each Member State. All of the indicators have been evaluated relative to the OECD average of 5 (the upper limit is 10). Higher values indicate that energy is being used efficiently.

$$TPES/GDP = \frac{TPES}{GDP\ (billion\ USD\ 2015\ prices\ and\ exchange\ rates)}$$

$$Relative\ score = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.2. Results of TPES/GDP
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0.51	0.37	0.34	0.34
Indonesia	0.39	0.33	0.28	0.23
Lao PDR	0.31	0.29	0.25	0.32
Malaysia	0.33	0.33	0.31	0.27
Myanmar	0.69	0.43	0.32	0.31
Philippines	0.53	0.45	0.42	0.36
Singapore	0.16	0.11	0.09	0.10
Thailand	0.34	0.33	0.34	0.32
Viet Nam	0.32	0.31	0.31	0.28
China	0.51	0.37	0.34	0.34
India	0.53	0.45	0.42	0.36
Japan	0.13	0.12	0.11	0.09
OECD	0.12			

GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.1 Comparison of TPES/GDP
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	1	2	2	2
Indonesia	2	2	2	3
Lao PDR	2	2	3	2
Malaysia	2	2	2	2
Myanmar	1	1	2	2
Philippines	1	1	1	2
Singapore	4	6	7	6
Thailand	2	2	2	2
Viet Nam	2	2	2	2
China	1	2	2	2
India	1	1	1	2
Japan	5	5	6	7
OECD	5	5	5	5

GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

2.3.2. TPES Self-sufficiency

TPES self-sufficiency is an indicator that represents the development of domestic resources in the definition of energy security. TPES self-sufficiency refers to the ability of a country to fulfil its own energy needs. It is calculated as production over the TPES. Table 2.4 shows the results of the indicator in absolute value, and Table 2.5 provides in relative score for comparison. Higher values indicate greater energy self-sufficiency and a higher energy security status.

$$\text{TPES self sufficiency} = \frac{Production}{TPES}$$

$$Relative\ score = \frac{Index\ country\ A}{Index\ OECD} \cdot 5$$

Table 2.4. Results of TPES Self-sufficiency
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0.78	0.72	0.62	0.52
Indonesia	1.52	1.71	2.05	1.95
Lao PDR	0.98	0.88	1.07	1.17
Malaysia	1.55	1.35	1.12	1.09
Myanmar	1.28	1.51	1.50	1.32
Philippines	0.51	0.59	0.59	0.52
Singapore	0.02	0.02	0.02	0.02
Thailand	0.56	0.58	0.59	0.55
Viet Nam	1.38	1.35	1.11	0.79
China	0.98	0.91	0.86	0.80
India	0.78	0.74	0.67	0.63
Japan	0.19	0.19	0.10	0.10
OECD	0.76			

OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.5. Comparison of TPES Self-sufficiency
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	5	5	4	3
Indonesia	10	10	10	10
Lao PDR	6	6	7	8
Malaysia	10	9	7	7
Myanmar	8	10	10	9
Philippines	3	4	4	3
Singapore	0	0	0	0
Thailand	4	4	4	4
Viet Nam	9	9	7	5
China	6	6	6	5
India	5	5	4	4
Japan	1	1	1	1
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

2.3.3. Volatility Risk Indicator

This is an indicator that represents energy price stability in the definition of energy security. It shows the ratio of net imports of coal, petroleum products, and natural gas to primary energy supply. If fossil fuel prices rise, domestic energy prices could be significantly affected. Table 2.6 shows the results of the indicator in absolute value, and Table 2.7 provides in relative score for comparison. Higher values indicate a low level of exposure to global market thus risk of price volatility. If the value is low, it can be said that the risk of price volatility is high.

$$\text{Volatility risk indicator} = \frac{Import\ -\ Export\ (Coal, oil, natural\ gas)\ *}{TPES}$$

$$Relative\ score\ = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

* If (exports > imports), then net import = 0. In other words, low-carbon indicator = 0

Table 2.6. Results of Volatility Risk Indicator
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0.22	0.28	0.36	0.47
Indonesia	0.00	0.00	0.00	0.00
Lao PDR	0.17	0.19	0.22	0.19
Malaysia	0.00	0.00	0.00	0.00
Myanmar	0.00	0.00	0.00	0.00
Philippines	0.51	0.43	0.43	0.50
Singapore	2.01	2.55	2.88	2.62
Thailand	0.47	0.46	0.43	0.49
Viet Nam	0.00	0.00	0.00	0.23
China	0.03	0.08	0.16	0.20
India	0.22	0.27	0.33	0.38
Japan	0.83	0.83	0.92	0.93
OECD	0.27			

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.7. Comparison of Volatility Risk Indicator
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	6	5	4	3
Indonesia	10	10	10	10
Lao PDR	8	7	6	7
Malaysia	10	10	10	10
Myanmar	10	10	10	10
Philippines	3	3	3	3
Singapore	1	1	0	1
Thailand	3	3	3	3
Viet Nam	10	10	10	6
China	10	10	9	7
India	6	5	4	4
Japan	2	2	1	1
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.4. TPES Diversity

This is an indicator of energy supply diversity (substitutability) in the definition of energy security. Higher values indicate that supply is available in a variety of energy sources and that the state of energy security is good. Table 2.8 shows the results of the indicator in absolute value, and Table 2.9 provides in relative score for comparison. The Herfindahl-Hirschman index (HHI) has been used here as a good measure of degree of diversity. The HHI is defined as the sum of the squares of the individual market shares of each firm in the market. An HHI of 1 would mean that there is only one firm in the market, a monopoly structure. The HHI approaches 0 as competition increases. It is also known as the oligopoly index.

$$TPES\ Diversity\ =\ HHI\ =\ \sum_{i=1}^{n} C_i\ ^2$$

$$C_i\ =\ Share\ of\ TPES\ components$$

$$n\ =\ Energy\ that\ makes\ up\ TPES$$

$$Relative\ score\ =\ \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.8. Results of TPES Diversity
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	6,608	5,903	4,797	3,607
Indonesia	2,646	2,455	2,350	2,294
Lao PDR	6,563	5,401	6,173	6,175
Malaysia	4,104	3,901	3,505	3,315
Myanmar	5,501	5,113	4,959	3,559
Philippines	2,689	2,289	2,220	2,359
Singapore	7,453	6,006	5,420	5,581
Thailand	3,083	2,906	2,847	2,846
Viet Nam	3,054	2,511	2,342	2,824
China	4,410	5,172	5,228	4,456
India	2,874	2,896	3,074	3,106
Japan	3,132	2,887	3,032	2,941
OECD	2,512			

OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.9. Comparison of TPES Diversity
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	2	2	3	3
Indonesia	5	5	5	5
Lao PDR	2	2	2	2
Malaysia	3	3	4	4
Myanmar	2	2	3	4
Philippines	5	5	6	5
Singapore	2	2	2	2
Thailand	4	4	4	4
Viet Nam	4	5	5	4
China	3	2	2	3
India	4	4	4	4
Japan	4	4	4	4
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

2.3.5. Power Generation Diversity

This is an indicator that represents the diversity of energy supply (substitutability) in the definition of energy security. It shows the diversity of power generation, and the higher the value, the more electricity can be generated without relying on a single resource. The trend of secondary energy supply (especially electricity) is important for energy security because it affects the ability of the energy system to respond quickly to sudden changes in the supply-demand balance, which is a key aspect of short-term energy security. In this sense, it is important to understand the diversity of power generation. Table 2.10 shows the results of the indicator in absolute value, and Tabe 2.11 provides in relative score for comparison. Higher values indicate that generation is available from a variety of energy sources and that the state of energy security is good.

$$Power\ generation\ diversity\ =\ HHI\ =\ \sum_{i=1}^{n} C_i\ ^2$$

$$C_i\ =\ Share\ of\ power\ generation\ supply\ components$$

$$n\ =\ Power\ generation\ supply\ source\ that\ makes\ up\ power\ supply$$

$$Relative\ score\ =\ \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.10. Results of Power Generation Diversity (absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	9,270	8,932	3,789	4,407
Indonesia	2,701	2,936	3,215	3,893
Lao PDR	10,000	10,000	9,997	5,619
Malaysia	5,248	4,851	4,005	3,766
Myanmar	4,018	4,552	5,455	4,580
Philippines	2,242	2,316	2,671	3,285
Singapore	4,778	6,522	7,446	9,035
Thailand	5,437	5,444	5,435	4,884
Viet Nam	3,408	3,372	3,430	3,403
China	6,377	6,576	6,056	4,989
India	5,070	4,862	5,313	5,779
Japan	2,187	2,210	2,585	2,824
OECD	2,263			

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.11. Comparison of Power Generation Diversity (relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	1	1	3	3
Indonesia	4	4	4	3
Lao PDR	1	1	1	2
Malaysia	2	2	3	3
Myanmar	3	2	2	2
Philippines	5	5	4	3
Singapore	2	2	2	1
Thailand	2	2	2	2
Viet Nam	3	3	3	3
China	2	2	2	2
India	2	2	2	2
Japan	5	5	4	4
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.6. CO_2 Emissions/GDP

This is an indicator that represents environmental sustainability in the definition of energy security. It shows the amount of CO_2 emissions required to produce one unit of GDP and how much economic growth is achieved, whilst suppressing emissions. Table 2.12 shows the results of the indicator in absolute value, and Table 2.13 provides in relative score for comparison. Higher values indicate that economic growth and CO_2 emissions are balanced. A high value can be an objective indicator of efforts to reduce carbon intensity.

$$CO2\ Emissions/GDP\ = \frac{CO2\ emissions\ (kt\ of\ CO2)}{GDP\ (billion\ USD\ 2015\ prices\ and\ exchange\ rates)}$$

$$Relative\ score\ = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.12. Results of CO_2 Emissions/GDP (absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	320	316	360	489
Indonesia	677	625	585	524
Lao PDR	179	208	250	910
Malaysia	801	831	775	665
Myanmar	473	262	240	391
Philippines	434	345	322	342
Singapore	274	187	160	138
Thailand	1,409	1,210	1,045	900
Viet Nam	1,622	1,389	1,166	895
China	1,117	1,117	972	743
India	1,129	1,034	1,018	882
Japan	288	271	279	245
OECD	282			

GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022a) and IEA (2022d).

Table 2.13. Comparison of CO_2 Emissions/GDP
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	4	4	4	3
Indonesia	2	2	2	3
Lao PDR	8	7	6	2
Malaysia	2	2	2	2
Myanmar	3	5	6	4
Philippines	3	4	4	4
Singapore	5	8	9	10
Thailand	1	1	1	2
Viet Nam	1	1	1	2
China	1	1	1	2
India	1	1	1	2
Japan	5	5	5	6
OECD	5	5	5	5

GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.7. Low-carbon Indicator

This is the second indicator that represents environmental sustainability in the definition of energy security. It shows the share of renewables and nuclear power in primary energy supply. Table 2.14 shows the results of the indicator in absolute value, and Table 2.15 provides in relative score for comparison. Higher values indicate that the greater the introduction of renewable energy and nuclear power. If this value is high, it can objectively indicate domestic efforts to develop renewable energy.

$$\text{Low} - \text{carbon indicator} = \frac{Renewable\ energy\ sources *}{TPES}$$

$*$ Renewable energy sources
$=$ nuclear, hydro, geothermal, solar, wind, other, combustible renewable energy

$$Relative\ score = \frac{Index\ country\ A}{Index\ OECD} \cdot 5$$

Table 2.14. Results of Low-carbon Indicator
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0.78	0.72	0.62	0.52
Indonesia	0.37	0.35	0.30	0.26
Lao PDR	0.93	0.82	0.96	0.61
Malaysia	0.03	0.02	0.02	0.03
Myanmar	0.73	0.71	0.72	0.55
Philippines	0.45	0.44	0.42	0.36
Singapore	0.02	0.02	0.03	0.02
Thailand	0.18	0.19	0.19	0.20
Viet Nam	0.48	0.36	0.31	0.20
China	0.17	0.11	0.09	0.11
India	0.32	0.28	0.25	0.24
Japan	0.18	0.18	0.10	0.09
OECD	0.19			

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022).

Table 2.15. Comparison of Low-carbon Indicator
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	10	10	10	10
Indonesia	10	9	8	7
Lao PDR	10	10	10	10
Malaysia	1	1	1	1
Myanmar	10	10	10	10
Philippines	10	10	10	9
Singapore	0	0	1	1
Thailand	5	5	5	5
Viet Nam	10	10	8	5
China	4	3	2	3
India	9	8	7	6
Japan	5	5	3	2
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.8. Fossil Fuel Indicator

This is the third indicator that represents environmental sustainability in the definition of energy security. It shows the share of fossil fuels in primary energy supply. We understand that it is difficult to simply compare the ratio of fossil fuel use with the OECD average because of different circumstances in developing economies where needs for fossil energy is higher to supply sufficient amount of energy at affordable price. However, we refer to it to objectively see what the share of fossil fuels to primary energy supply is. Table 2.16 shows the results of the indicator in absolute value, and Table 2.17 provides in relative score for comparison. Higher values indicate that the share of fossil fuels in primary energy supply is low. If this value is low, it can be said that the climate finance risk (decarbonisation pressure from abroad) is high.

$$\text{Fossil fuel indicator} = HHI = \sum_{i=1}^{n} C_i{}^2$$

$C_i = Share\ of\ fossil\ fuel\ dependence\ in\ TPES *$

$n = Fossil\ fuel\ energy\ sources\ that\ makes\ up\ TPES$

$Fossil\ fuel = crude\ oil, coal, natural\ gas$

$$Relative\ score = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.16. Results of Fossil Fuel Indicator (absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	464	767	1,077	1,307
Indonesia	1,676	1,663	1,807	1,953
Lao PDR	311	445	650	3,197
Malaysia	4,098	3,898	3,503	3,309
Myanmar	301	362	321	958
Philippines	1,746	1,384	1,402	1,776
Singapore	7,451	6,003	5,413	5,577
Thailand	2,770	2,578	2,497	2,469
Viet Nam	1,152	1,473	1,719	2,620
China	4,206	5,110	5,200	4,423
India	2,009	2,237	2,602	2,675
Japan	2,908	2,670	3,001	2,919
OECD	2,375			

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022d).

Table 2.17. Comparison of Fossil Fuel Indicator
(relative score)

	2000-2004	2005-2009	2010-2014	2015-2019
Cambodia	10	10	10	9
Indonesia	7	7	7	6
Lao PDR	10	10	10	4
Malaysia	3	3	3	4
Myanmar	10	10	10	10
Philippines	7	9	8	7
Singapore	2	2	2	2
Thailand	4	5	5	5
Viet Nam	10	8	7	5
China	3	2	2	3
India	6	5	5	4
Japan	4	4	4	4
OECD	5	5	5	5

OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.9. Import Diversity

This is an indicator that represents the geopolitical risk of import sources in the definition of energy security. It shows that import sources of fossil fuels (coal, crude oil, gas) are diversified. When import partners are diversified, the stability of supply can be maintained even when supply disruption occurs at one of source countries due to an unforeseen event. Table 2.18 shows the results of the indicator in absolute value, and Table 2.19 provides in relative score for comparison. Higher values indicate that import partner countries are diversified.

$$\text{Import diversity} = HHI = \sum_{i=1}^{n} C_i{}^2$$

$C_i = Share\ of\ import\ partners\ in\ total\ fossil\ fuel\ imports$

$n = Fossil\ fuel\ import\ that\ makes\ up\ total\ fossil\ fuel\ supply$

$Fossil\ fuel = crude\ oil, coal, natural\ gas$

$MAX = 30{,}000$

$$Relative\ score = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.18. Results of Import Diversity
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	19,824	12,732	14,490	14,554
Indonesia	4,478	6,398	8,750	6,984
Lao PDR	NA	NA	16,246	12,083
Malaysia	6,845	7,034	7,857	9,044
Myanmar	16,972	NA	6,530	8,630
Philippines	7,547	11,057	12,343	10,580
Singapore	5,087	8,213	16,203	14,036
Thailand	6,343	6,986	11,469	11,830
Viet Nam	15,952	14,522	7,345	9,149
China	7,410	12,720	9,214	9,801
India	8,019	11,506	11,284	7,876
Japan	7,729	7,868	8,350	9,216
OECD	3,030			

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022), World Integrated Trade Solution, General Administration of Customs of the People's Republic of China, Government of India, Ministry of Commerce and Industry, Department of Commerce.

Table 2.19. Comparison of Import Diversity
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	1	1	1	1
Indonesia	3	2	2	2
Lao PDR	NA	NA	1	1
Malaysia	2	2	2	2
Myanmar	1	NA	2	2
Philippines	2	1	1	1
Singapore	3	2	1	1
Thailand	2	2	1	1
Viet Nam	1	1	2	2
China	2	1	2	2
India	2	1	1	2
Japan	2	2	2	2
OECD	5	5	5	5

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.10. Middle East Indicator

This is the second indicator that represents the geopolitical risk of import sources in the definition of energy security. It shows how dependent a country is on the Middle East as a source of fossil fuel (crude oil and natural gas). Most of the fuel imported from the Middle East passes through chokepoints (narrow straits used as global sea lanes). The risk of physical supply disruptions due to maritime transport has been shown to be high. Table 2.20 shows the results of the indicator in absolute value, and Table 2.21 provides in relative score for comparison. Higher scores indicate less dependence on the Middle East as an import partner.

$$\text{Middle East indicator} = HHI = \sum_{i=1}^{n} C_i{}^2$$

$C_i = Share\ of\ imports\ from\ the\ Middle\ East\ in\ total\ fossil\ fuel\ imports$

$n = Fossil\ fuel\ energy\ sources\ that\ makes\ up\ TPES$

$Fossil\ fuel = crude\ oil, natural\ gas$

$MAX = 20{,}000$

$$Relative\ score = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.20. Results of Middle East Indicator (absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0	0	0	0
Indonesia	3,495	3,476	3,398	6,169
Lao PDR	NA	NA	0	13
Malaysia	6,274	6,685	7,746	5,483
Myanmar	0	NA	0	0
Philippines	9,285	8,775	7,435	8,434
Singapore	7,665	8,016	8,855	7,584
Thailand	8,337	7,935	13,321	12,095
Viet Nam	0	0	0	7,977
China	5,028	5,130	8,621	6,445
India	10,000	15,448	14,940	12,137
Japan	10,954	11,288	11,179	10,830
OECD	6,245			

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022), World Integrated Trade Solution, General Administration of Customs of the People's Republic of China, Government of India, Ministry of Commerce and Industry, Department of Commerce.

Table 2.21. Comparison of Middle East Indicator
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	10	10	10	10
Indonesia	9	9	9	5
Lao PDR	NA	NA	10	10
Malaysia	5	5	4	6
Myanmar	10	NA	10	10
Philippines	3	4	4	4
Singapore	4	4	4	4
Thailand	4	4	2	3
Viet Nam	10	10	10	4
China	6	6	4	5
India	3	2	2	3
Japan	3	3	3	3
OECD	5	5	5	5

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

2.3.11. Russia Indicator

This is the third indicator that represents the geopolitical risk of import sources in the definition of energy security. It shows how dependent a country is on Russia as a source of fossil fuel. This is an indication of the high geopolitical risk of disruption of fossil fuel supplies from Russia. Table 2.22 shows the results of the indicator in absolute value, and Table 2.23 provides in relative score for comparison. Higher values indicate less dependence on Russia as an import partner.

$$\text{Russia indicator} = HHI = \sum_{i=1}^{n} C_i{}^2$$

$C_i = Share\ of\ imports\ from\ the\ Russia\ in\ total\ fossil\ fuel\ imports$

$n = Fossil\ fuel\ energy\ sources\ that\ makes\ up\ TPES$

$Fossil\ fuel = crude\ oil, coal, natural\ gas$

$MAX = 30{,}000$

$$Relative\ score = \frac{1}{\frac{Index\ country\ A}{Index\ OECD}} \cdot 5$$

Table 2.22. Results of Russia Indicator
(absolute value)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	0	0	0	43
Indonesia	196	0	311	1,773
Lao PDR	NA	NA	0	0
Malaysia	0	1	776	1,599
Myanmar	0	NA	179	923
Philippines	40	67	1,417	510
Singapore	3	48	210	331
Thailand	4	141	941	741
Viet Nam	1,207	130	754	1,858
China	5,622	5,197	5,943	5,900
India	0	7,289	6,556	6,381
Japan	617	1,047	2,573	2,762
OECD	5,423			

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022), World Integrated Trade Solution, General Administration of Customs of the People's Republic of China, Government of India, Ministry of Commerce and Industry, Department of Commerce.

Table 2.23. Comparison of Russia Indicator
(relative score)

	2000–2004	2005–2009	2010–2014	2015–2019
Cambodia	10	10	10	10
Indonesia	10	10	10	10
Lao PDR	NA	NA	10	10
Malaysia	10	10	10	10
Myanmar	10	NA	10	10
Philippines	10	10	10	10
Singapore	10	10	10	10
Thailand	10	10	10	10
Viet Nam	10	10	10	10
China	5	5	5	5
India	10	4	4	4
Japan	10	10	10	10
OECD	5	5	5	5

NA = not available, OECD = Organisation for Economic Co-operation and Development.
Note: Most recent data available for each country.
Source: Authors.

Chapter 3
Country Analysis

3.1. Methodology

Total primary energy supply (TPES) self-sufficiency, TPES diversity, power generation diversity, TPES/GDP, CO_2/GDP low-carbon indicator, fossil fuel indicator, import diversity, volatility risk indicator, Middle East indicator, and Russia indicator were selected and compared to the OECD average (average for 2000–2019). The results were then plotted on a radar graph. The radar graphs were taken from a starting point of 2000 and examined as to how they have changed in 5-year intervals.

3.2. Country Analysis

This section describes the major characteristics of the energy security index (ESI) in each country. A higher score indicates better conditions. As the OECD average is taken to be 5, if the circle in the radar graph expands beyond 5, it means that the scores exceed the OECD average.

3.2.1. Cambodia

3.2.1.1. Macroeconomics, energy supply and demand, energy import trends

Primary energy consumption per unit of GDP declined significantly until the mid-2000s, and decoupling of economic growth and energy consumption progressed, but improvements in energy efficiency have stagnated since then (Figure 3.2). Most of the total primary energy supply is made up of biomass and oil, but coal began to be used mainly for power generation around 2013, and its use has gradually expanded since 2013 in line with the growth in energy demand (Figure 3.4). Cambodia has almost no fossil fuel resources and is dependent on imports from ASEAN Member States. Until around 2011, the power generation sector was dominated by oil, but since 2012, the use of hydropower and coal has expanded (Figure 3.5).

Figure 3.1. Absolute Values of GDP, TPES, CO_2 in Cambodia

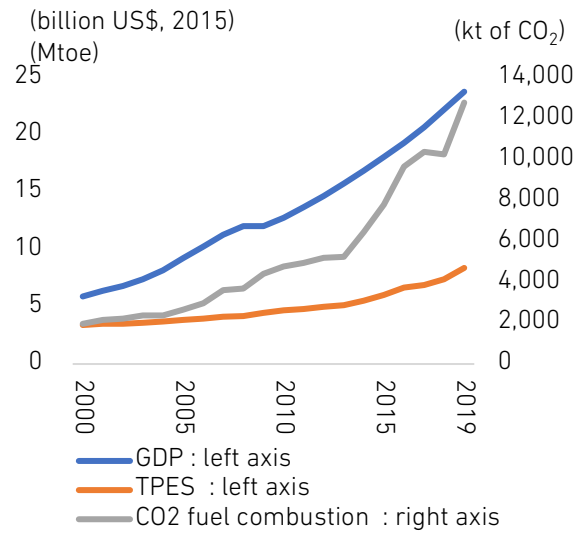


Figure 3.2. TPES/GDP, CO_2 Emissions/GDP in Cambodia

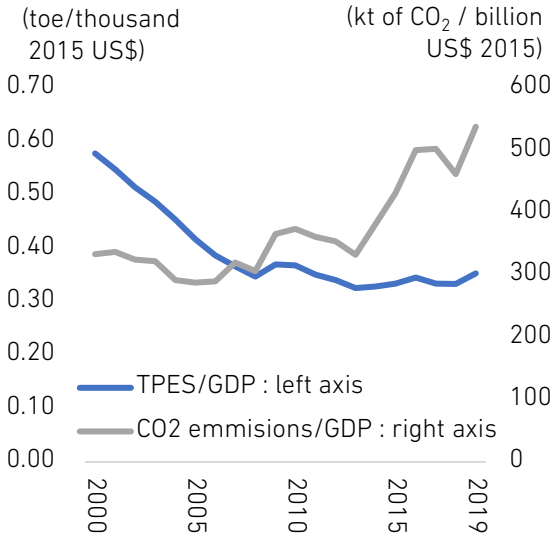


Figure 3.3. Low-carbon Indicator in Cambodia

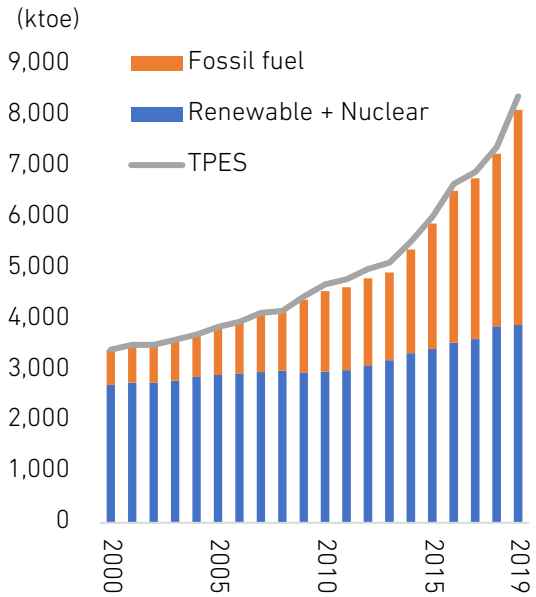


Figure 3.4. TPES Diversity in Cambodia

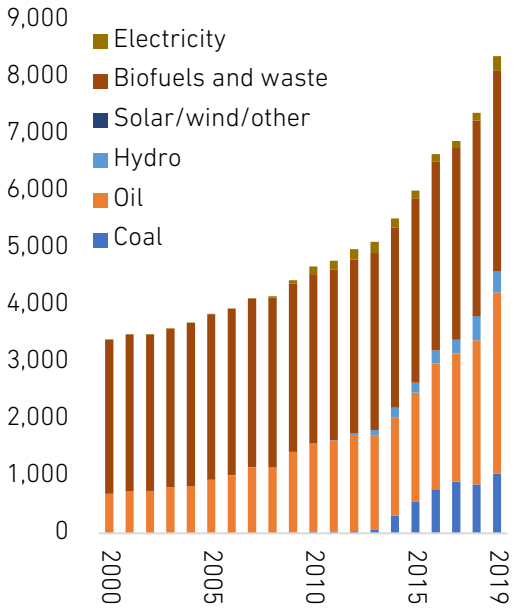


Figure 3.5. Power Generation Diversity in Cambodia

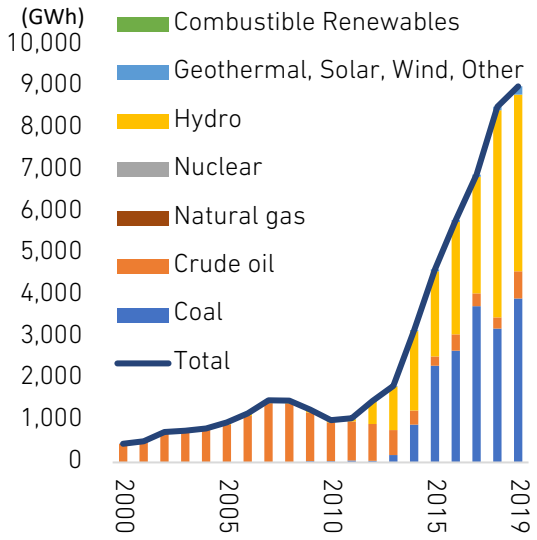


Figure 3.6. Import Diversity (Crude Oil) in Cambodia

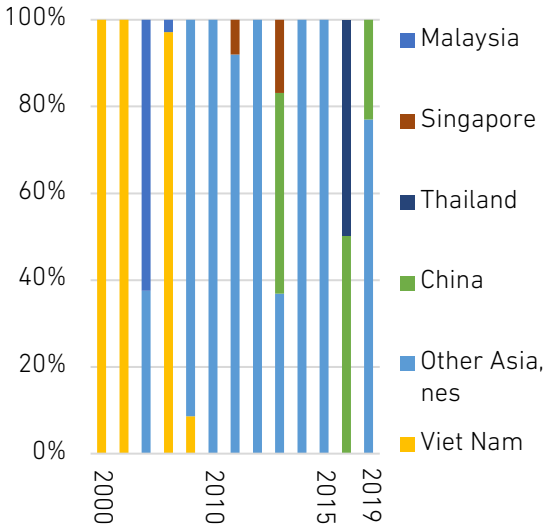
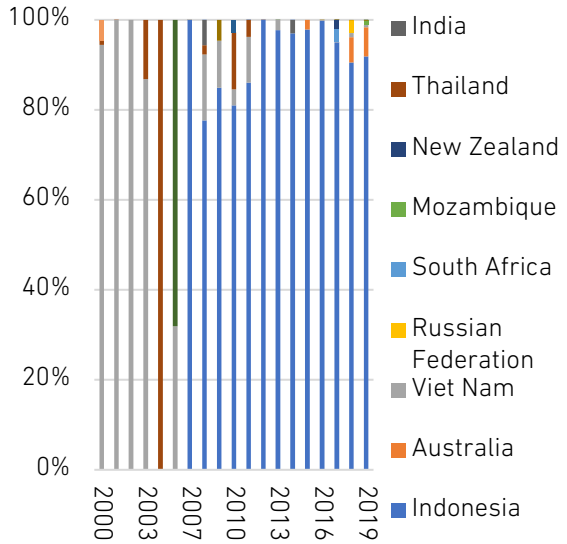


Figure 3.7. Import Diversity (Coal) in Cambodia



No data available (2000–2019) on Import Diversity (LNG) in Cambodia

GDP = gross domestic product, GWh = gigawatt-hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.1.2. Energy policy overview

In Cambodia, petroleum development is encouraged under the Petroleum Regulations of 1991. In 2001, the Law on the Management and Use of Mineral Resources (Mining Law) was enacted to promote domestic and foreign investment in coal exploration and development. In 2013, the Third Rectangular Strategy was formulated, which aims to expand power source development. The National Policy, Strategy and Action Plan on Energy Efficiency was formulated in 2013. In May 2023, the government announced its National Energy Efficiency Policy 2022–2030. This policy establishes a target of reducing energy consumption for heat and electricity by at least 19% by 2030. In 2019, the Electricity of Cambodia Corporation announced its policy to increase the share of solar power generation in total electricity generation to 15% by 2020. In 2019, the government outlined its National Strategic Development Plan 2019–2023, in which it aims to enhance its energy sources, boost energy efficiency, and advocate for energy conservation. These measures are intended to ensure that all consumers receive reliable and high-quality electricity at competitive rates. In November 2021, the government planned to no longer allow the development of new coal-fired power plants. The government decided to use natural gas as a decentralised transition fuel in December 2021. As for renewables, in November 2021, the government planned to operate seven solar power plants with a total output of 495 megawatts (MW) by 2023; and in April 2022, it planned to expand solar power generation to over 7 gigawatts (GW) by 2040. The installed capacity of solar power is 482 MW as of 2023.

3.2.1.3. ESI overview

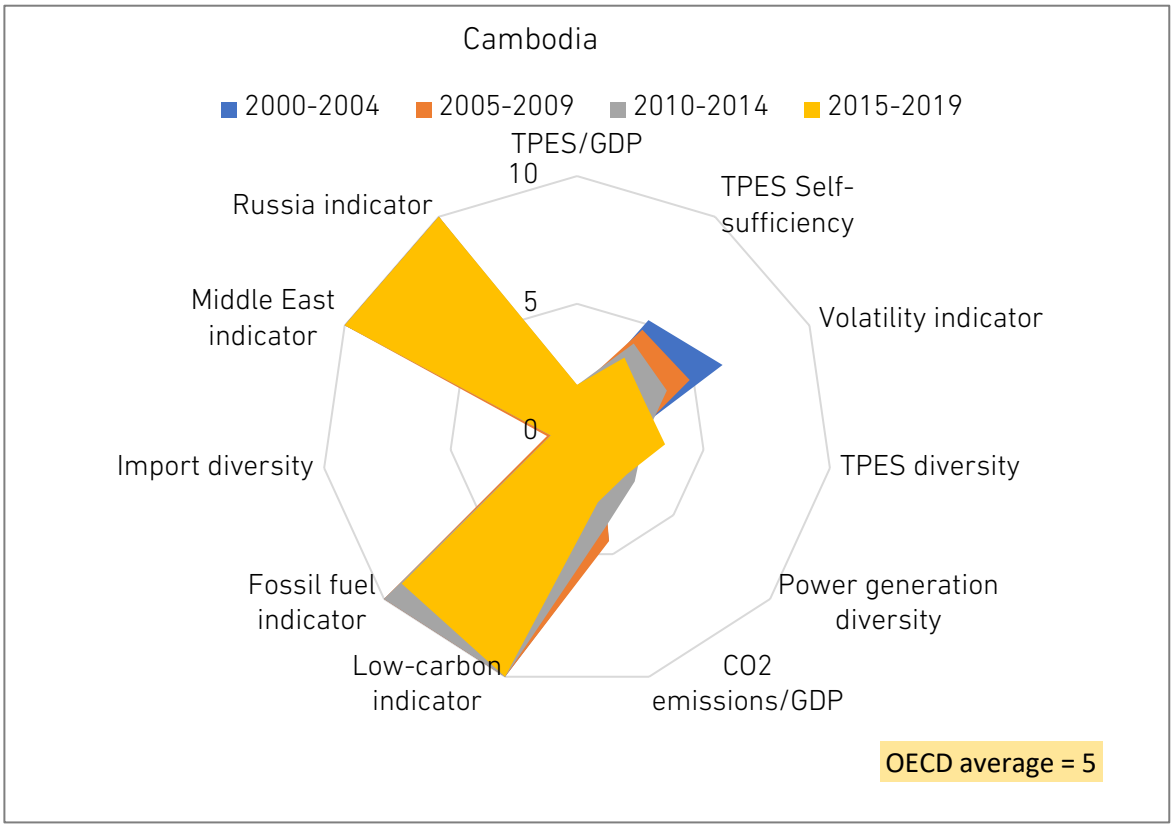
Cambodia is characterised with improved power generation diversity, but worse CO_2 emissions/GDP (Table 3.1, Figure 3.8). Possible causes are because of the expansion of power source development along with economic growth, the use of coal mainly for power generation started around 2009, and its use has gradually expanded since 2013 in line with the growth of energy demand. Furthermore, the use of petroleum can be attributed to the growing demand for petroleum, especially for automobiles. Fossil fuel resources are almost non-existent in Cambodia, and the country relies on imports from ASEAN Member States for coal and petroleum products, but this has improved in recent years due to import diversification.

Table 3.1. Major ESIs in Cambodia in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	1	2	2	2
TPES self-sufficiency	5	5	4	3
Volatility risk indicator	6	5	4	3
TPES diversity	2	2	3	3
Power generation diversity	1	1	3	3
CO_2 emissions/GDP	4	4	4	3
Low-carbon indicator	10	10	10	10
Fossil fuel indicator	10	10	10	9
Import diversity	1	1	1	1
Middle East indicator	10	10	10	10
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.8. Major ESIs in Cambodia in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.2. Indonesia

3.2.2.1. Macroeconomics, energy supply and demand, energy import trends

TPES/GDP and CO_2/GDP indicators are on a downwards trend (Figure 3.10). Against the background of the shift to the service industry, continuous energy conservation measures are required in each sector. In terms of TPES, although the policy is to reduce the ratio of oil and coal and promote renewable energy, fossil fuels are being used to meet the recent increase in demand (Figure 3.12). The National Energy Policy (Kebijakan Energi Nasional, KEN) formulated in October 2014 aims to shift to cleaner energy, and the ratio of renewable energy in the power generation mix is on the rise (Figure 3.13). Saudi Arabia's share of crude oil imports, which had been on a downwards trend in recent years, has increased sharply, and imports from Brunei Darussalam have decreased (Figure 3.14). As for coal, imports from Viet Nam have decreased, and imports from Australia and Russia cover the most (Figure 3.15).

Figure 3.9. Absolute Values of GDP, TPES, CO_2 in Indonesia

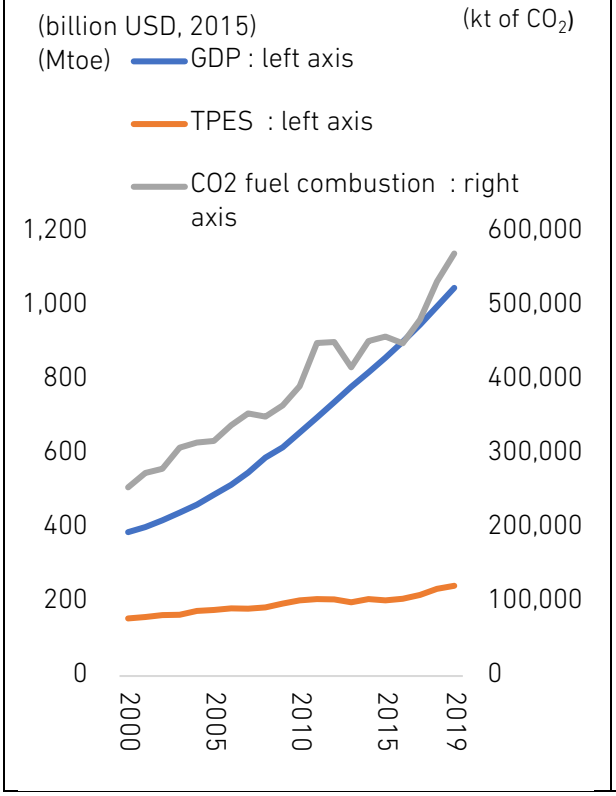


Figure 3.10. TPES/GDP, CO_2 Emissions/GDP in Indonesia

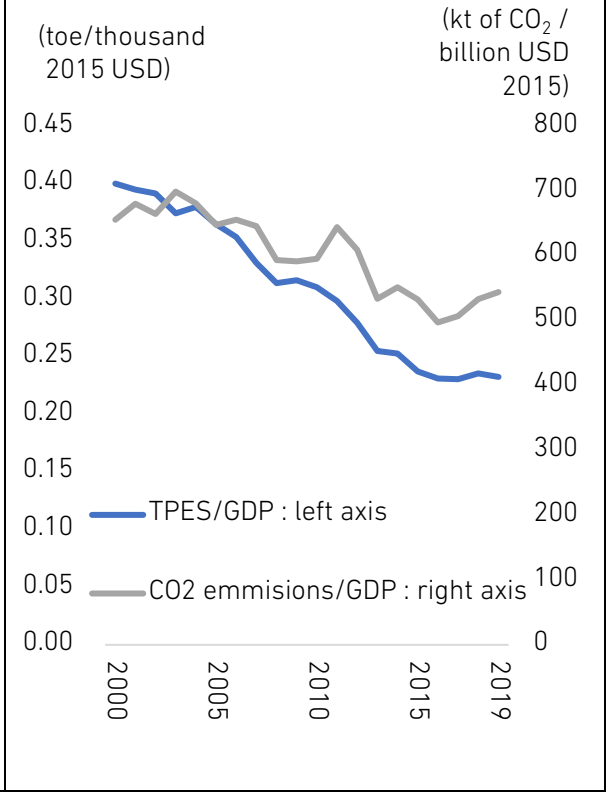


Figure 3.11. Low-carbon Indicator in Indonesia

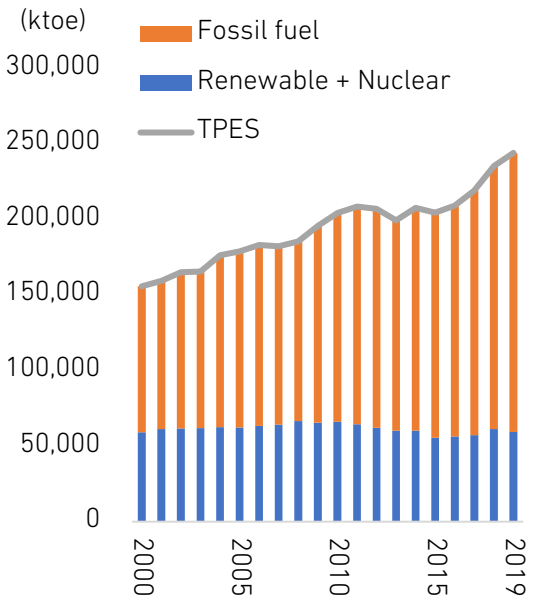


Figure 3.12. TPES Diversity in Indonesia

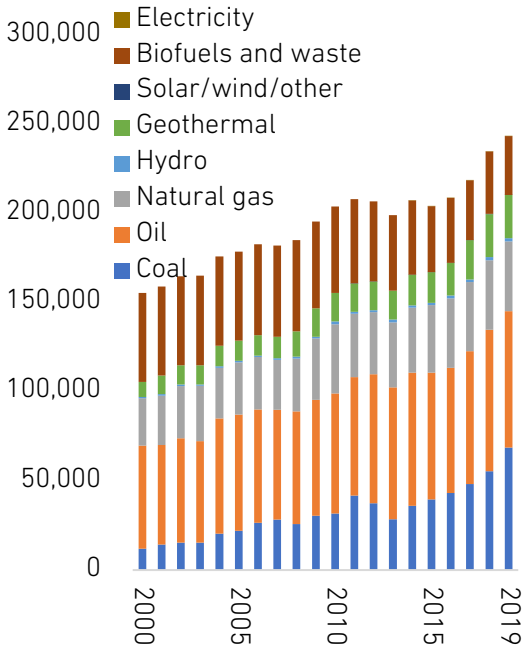


Figure 3.13. Power Generation Diversity in Indonesia

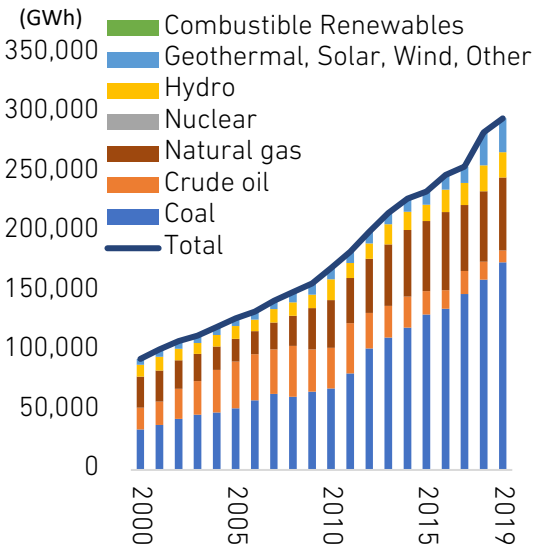


Figure 3.14. Import Diversity (crude oil) in Indonesia

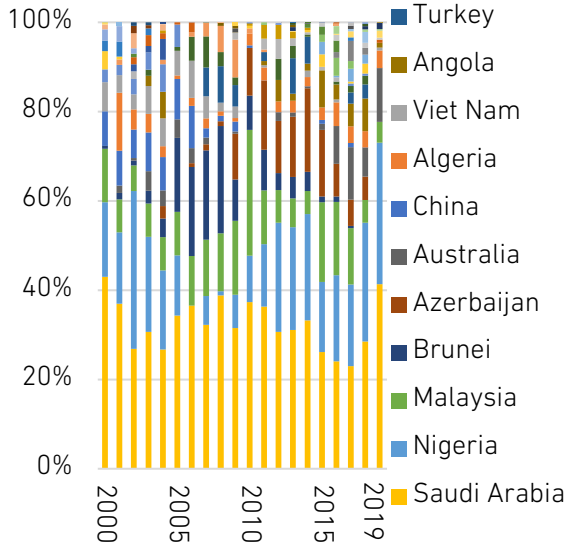


Figure 3.15. Import Diversity (coal) in Indonesia

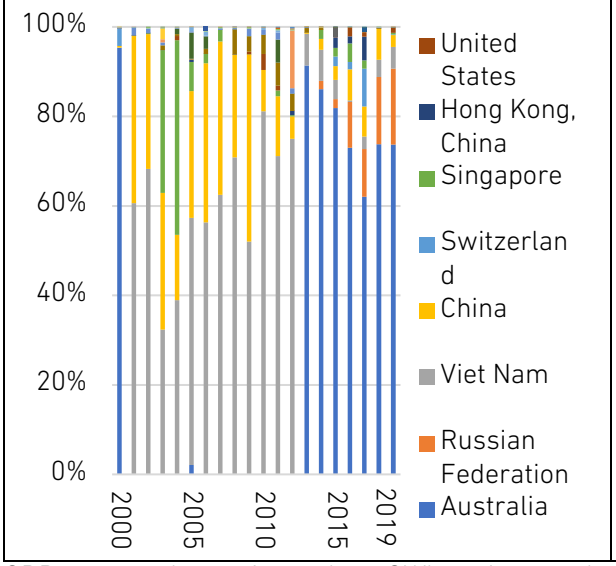
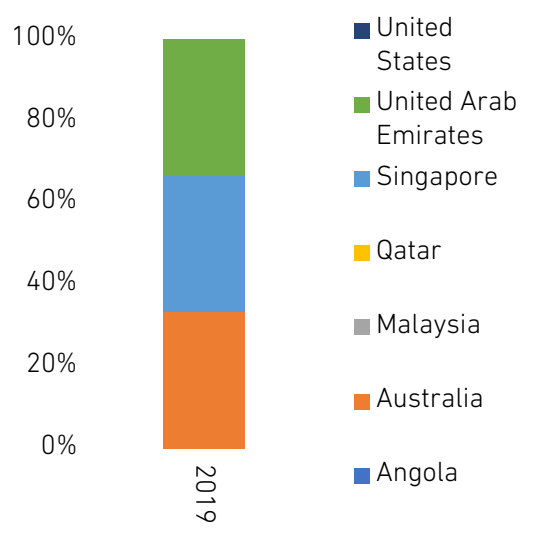


Figure 3.16. Import Diversity (LNG) in Indonesia



GDP = gross domestic product, GWh = gigawatt-hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.2.2. Energy policy overview

In 2007, Indonesia enacted the Law on Energy (Energy Law), which emphasises promoting resource development and domestic supply. The National Energy Policy (KEN), formulated in October 2014, covers the period from 2014 to 2050 and aims to meet growing energy demand in an environmentally responsible manner.

Table 3.2. Energy Mix Indicated by Kebijakan Energi Nasional

	2020	2025	2030	2035	2050
Coal	30%	30%	30%	29%	25%
Gas	23%	22%	23%	23%	24%
Oil	29%	24%	22%	21%	20%
Renewables	19%	24%	25%	27%	31%

Source: Kebijakan Energi Nasional [National Energy Policy].

Indonesia had been expected to require LNG imports starting in 2025 due to increasing domestic demand and the decline of domestic gas fields. However, with the commencement of production at new domestic gas projects, the country has not imported natural gas as of 2024. In January 2021, a target was set to reduce gasoline imports from 381,000 barrels in 2020 to zero in 2030. PERTAMINA will manage the strategic petroleum reserve. In 2021, the government intended not to build new coal-fired power plants. Rencana Umum Perencanaan Tenaga Listrik [General Plan for

Electric Power Planning] (RUPTL) 2021–2030 plans to add 40.6 GW of generation capacity over 10 years, with 51.6%, or 20.9 GW, coming from renewable energy sources.

3.2.2.3. ESI overview

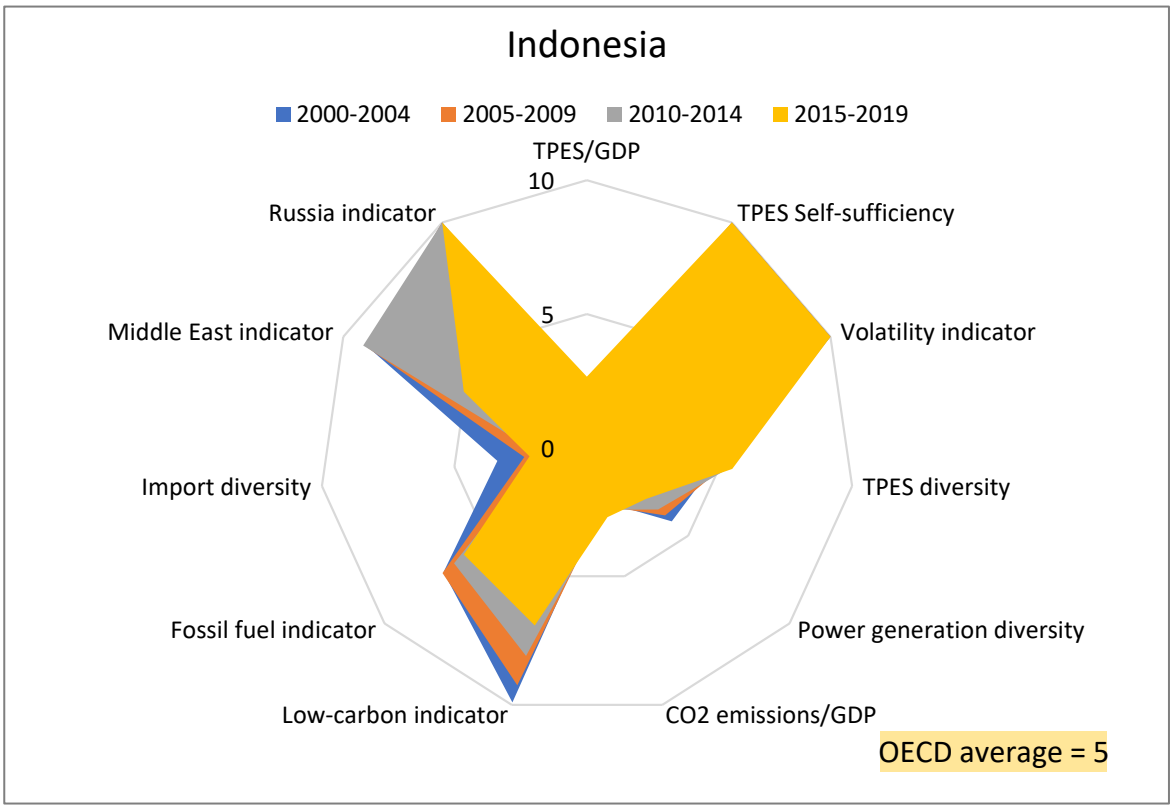
Indonesia is characterised by maintaining a high TPES self-sufficiency even as energy demand increases with economic growth. TPES/GDP is gradually improving, and the country has achieved efficient energy consumption. TPES diversity is improving, but power generation diversity is deteriorating (Table 3.3).

Table 3.3. Major ESIs in Indonesia in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	2	2	2	3
TPES self-sufficiency	10	10	10	10
Volatility risk indicator	10	10	10	10
TPES diversity	5	5	5	5
Power generation diversity	4	4	4	3
CO_2 emissions/GDP	2	2	2	3
Low-carbon indicator	10	9	8	7
Fossil fuel indicator	7	7	7	6
Import diversity	3	2	2	2
Middle East indicator	9	9	9	5
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.17. Major ESIs in Indonesia in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.3. Lao PDR

3.2.3.1. Macroeconomics, energy supply and demand, energy import trends

In Lao PDR, biomass energy such as firewood has been used. The increase in energy demand is mainly covered by the expanded use of coal, and the composition of primary energy supply is about 60% coal and other renewable energy (Figure 3.21). Coal is distributed throughout Lao PDR, and most of the coal resources are used for domestic industries and power generation. In the power generation sector, hydropower was responsible for electricity supply until the Hongsa coal-fired power plant started operation in 2015. Since 2015, the use of coal has expanded rapidly (Figure 3.22). Although Lao PDR still has ample potential for hydropower development, it is expected that the use of coal-fired power generation will expand in order to cover the rapid growth in power demand in the future. Most of its crude oil is imported from Thailand, and some is imported from Viet Nam, Indonesia, and Australia (Figure 3.23).

Figure 3.18. Absolute Values of GDP, TPES, CO_2 in Lao PDR

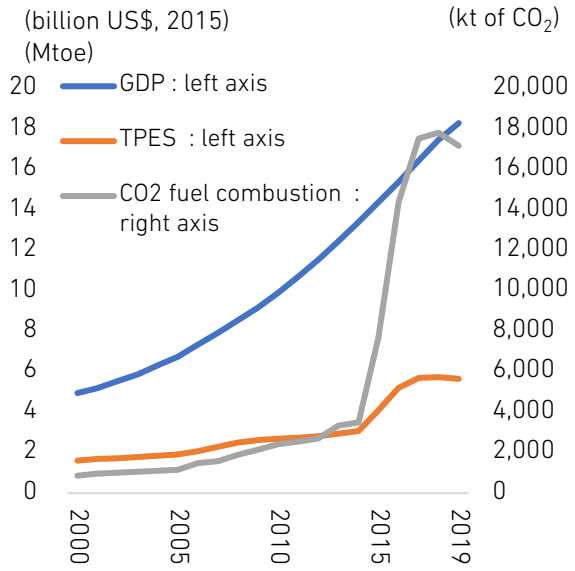


Figure 3.19. TPES/GDP, CO_2 Emissions/GDP in Lao PDR

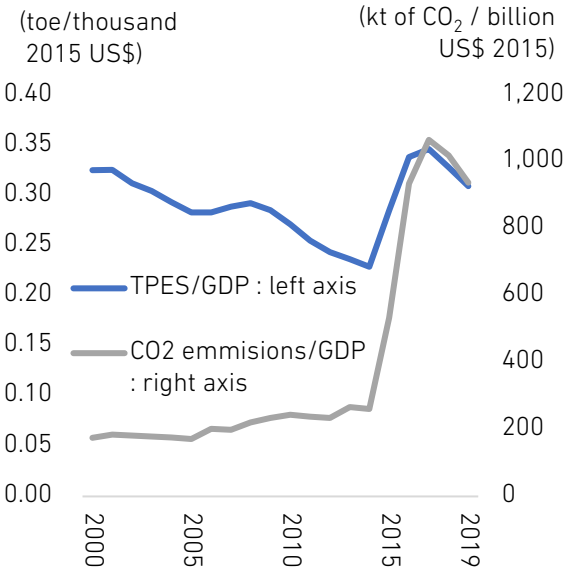


Figure 3.20. Low-carbon Indicator in Lao PDR

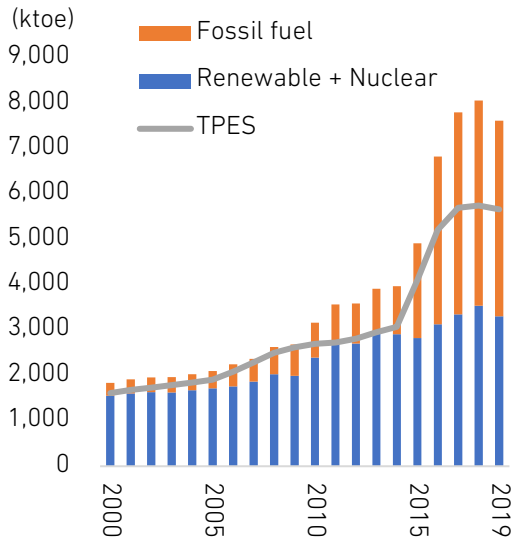


Figure 3.21. Low-carbon Indicator in Lao PDR

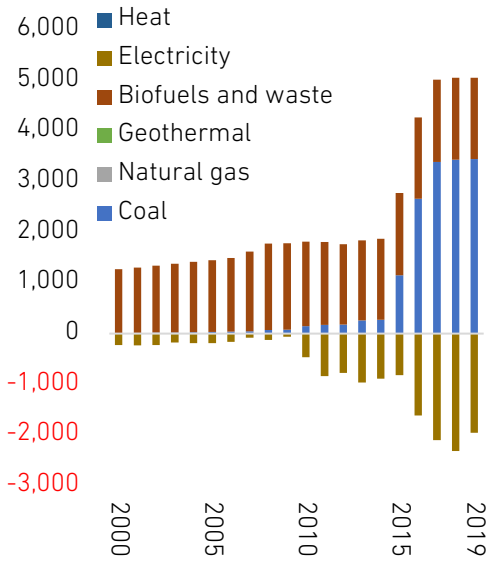


Figure 3.22. Power Generation Diversity in Lao PDR

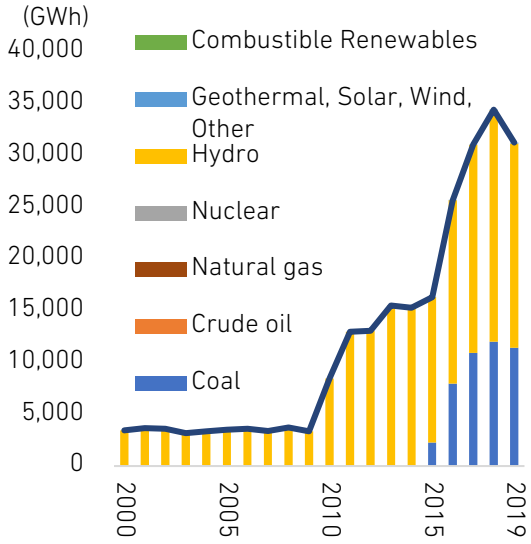


Figure 3.23. Import Diversity (crude oil) in Lao PDR

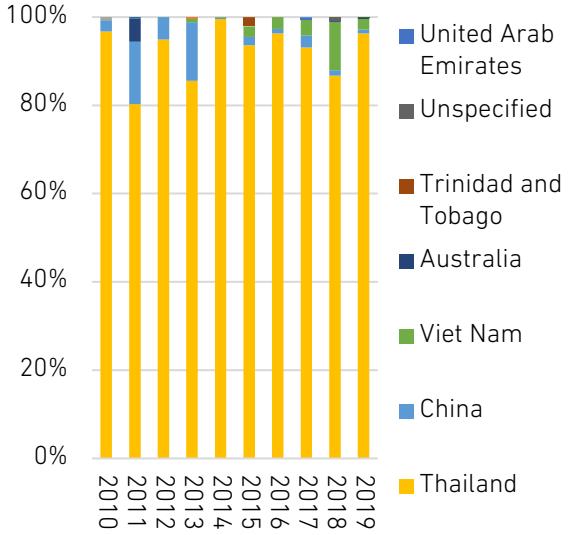
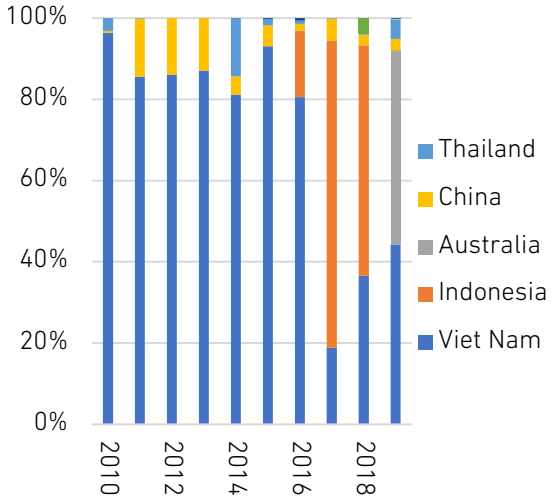


Figure 3.24. Import Diversity (coal) in Lao PDR



No data available (2000–2019) on Import Diversity (LNG) in Lao PDR

GDP = gross domestic product, GWh = gigawatt-hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.3.2. Energy policy overview

The target is 30% share of renewable energy in total energy consumption by 2025. In 2011, the Electricity Law (1997) was amended to regulate electricity generation and distribution in Lao PDR, setting standards for the management, production, distribution, transmission, and import and/or export of electricity. In 2016, 'Vision 2030' positioned the power sector as an important sector of the economy and sets strategic goals for the power sector. In 2015–2016 the Hongsa coal-fired power plant (three units) started operation. Solar power and biofuel diesel power generation are also planned. Lao PDR

conducts shale gas exploration in its coal mines and is investigating the possibility of shale gas deposits. Coal is positioned as an important energy resource to replace hydropower. The Mining Law (amended in December 2008 and enforced in December 2009) is a law on the feasibility study, survey, exploration, prospecting, and processing of mineral resources. The private stockpiling obligation is set at 21 days for companies importing oil and 10 days for distributers. The Decree on Oil Business No. 331 established the target for private stockpiling obligation as 60 days by 2040. In December 2020, Lao PDR's first oil refinery started operations.

3.2.3.3. ESI overview

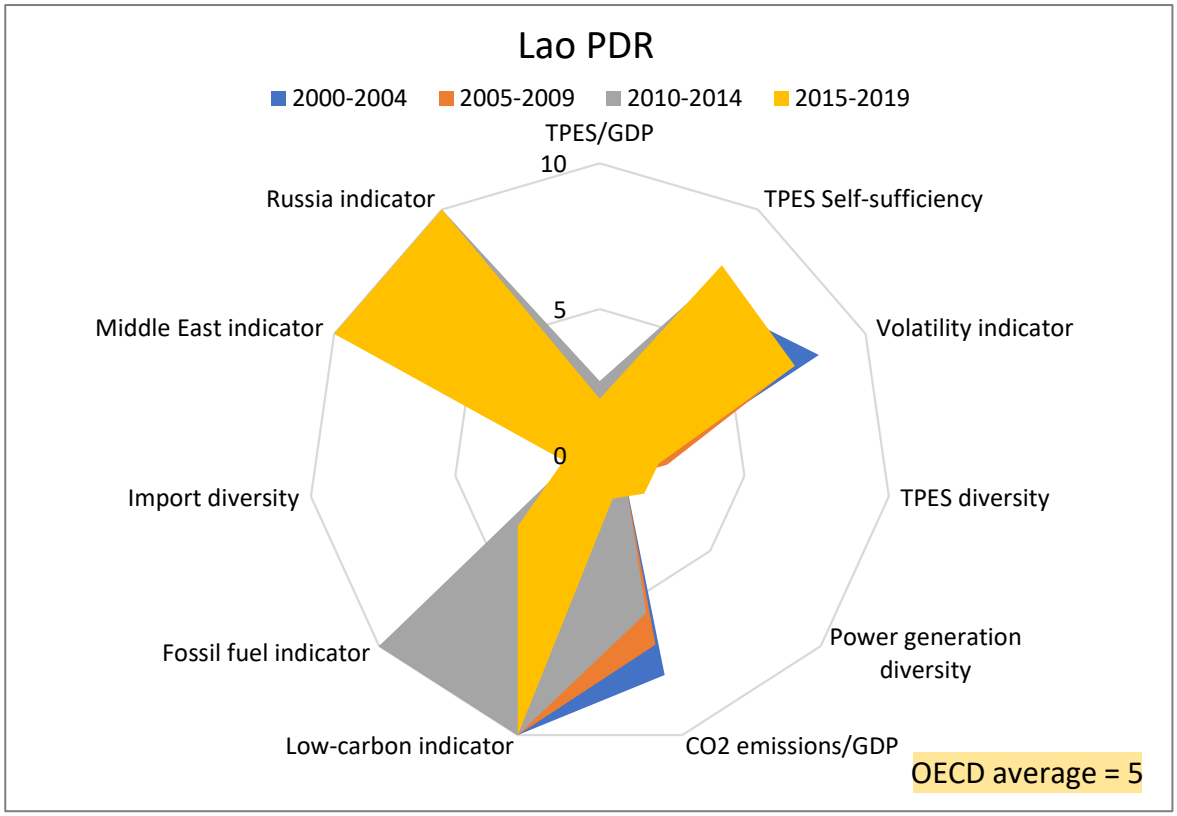
Lao PDR has improved TPES self-sufficiency. It also has abundant hydropower and has a high low-carbon indicator. However, it is characterised by a large increase in CO_2 emissions and a high rate of increase in energy consumption relative to economic growth. The fossil fuel indicator shows a worsening trend due to an increase in coal's share of primary energy supply (Table 3.4, Figure 3.25). The large increase in CO_2 emissions is mainly due to a lignite-fired power plant built by the Electricity Generating Authority of Thailand (EGAT). It should be noted that the construction and operation of the lignite-fired power plant by Thailand's EGAT may increase CO_2 emissions in Lao PDR, but has contributed to a stable power supply. Fossil fuel import data for Lao PDR are available from 2010. The relative evaluation has deteriorated as most of the imports are dependent on Thailand and China.

Table 3.4. Major ESIs in Lao PDR in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	2	2	3	2
TPES self-sufficiency	6	6	7	8
Volatility risk indicator	8	7	6	7
TPES diversity	2	2	2	2
Power generation diversity	1	1	1	2
CO_2 emissions/GDP	8	7	6	2
Low-carbon indicator	10	10	10	10
Fossil fuel indicator	10	10	10	4
Import diversity	NA	NA	1	1
Middle East indicator	NA	NA	10	10
Russia indicator	NA	NA	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, NA = not available, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.25. Major ESIs in Lao PDR in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.4. Malaysia

3.2.4.1. Macroeconomics, energy supply and demand, energy import trends

The absolute amount of TPES and CO_2 is on the rise (Figure 3.26), but TPES/GDP and CO_2 emissions/GDP are on the decline, realising compatibility with economic growth (Figure 3.27). On the other hand, with abundant domestic fossil fuel resources, fossil fuels account for most of the domestic energy supply. The ratio of renewable energy in the power generation mix has been increasing since around 2010 due to the influence of energy policies (Figure 3.30).

About 50% of crude oil imports come from the Middle East, such as Saudi Arabia and the United Arab Emirates, and the import ratio from Venezuela is relatively large (Figure 3.31). Most coal is imported from comes from Indonesia and Australia, and the amount of Russian coal has also increased in recent years (Figure 3.32). LNG was imported from the Middle East and other countries until around 2016, but in recent years, most has come from Australia and Brunei Darussalam (Figure 3.33).

Figure 3.26. Absolute Values of GDP, TPES, CO_2 in Malaysia

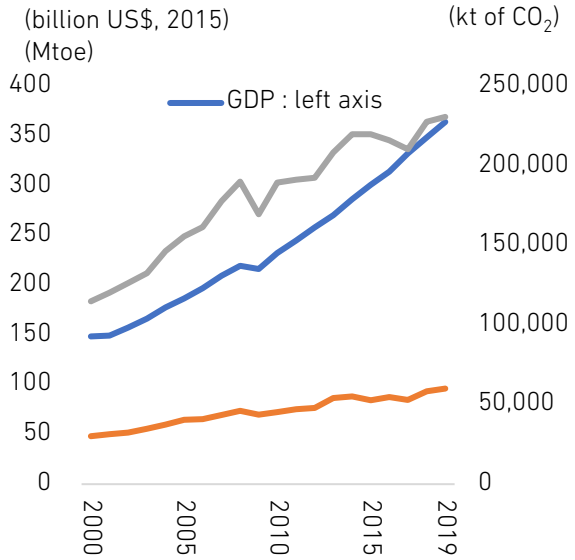


Figure 3.27. TPES/GDP, CO_2 Emissions/GDP in Malaysia

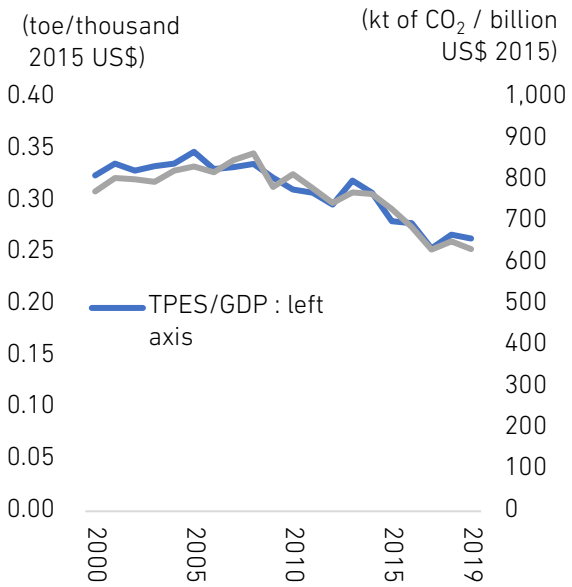


Figure 3.28. Low-carbon Indicator in Malaysia

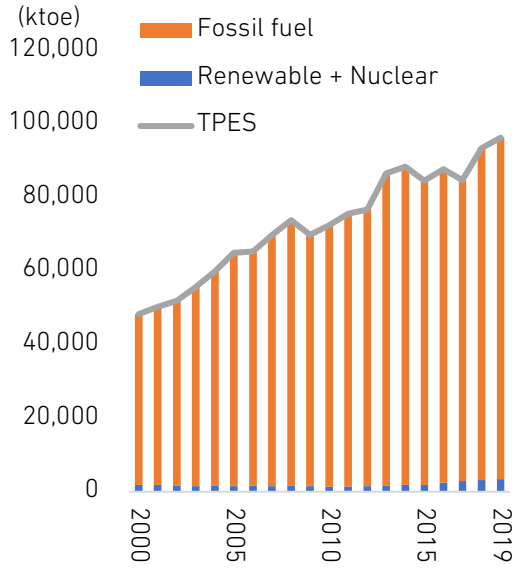


Figure 3.29. TPES Diversity in Malaysia

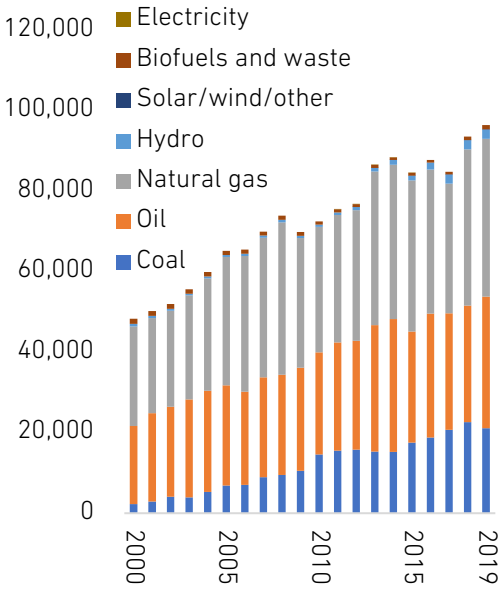


Figure 3.30. Power Generation Diversity in Malaysia

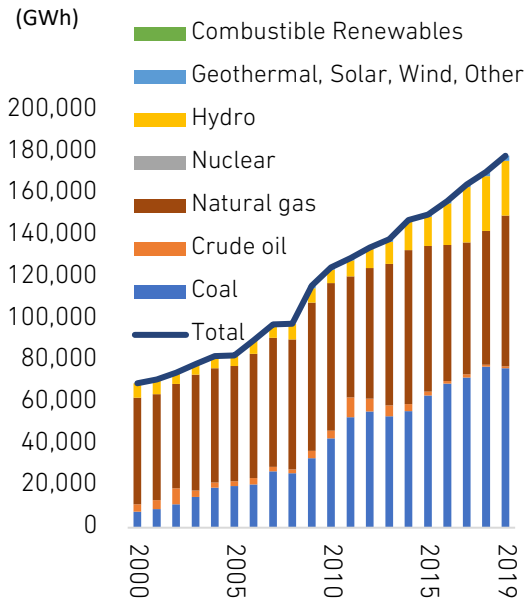


Figure 3.31. Import Diversity (crude oil) in Malaysia

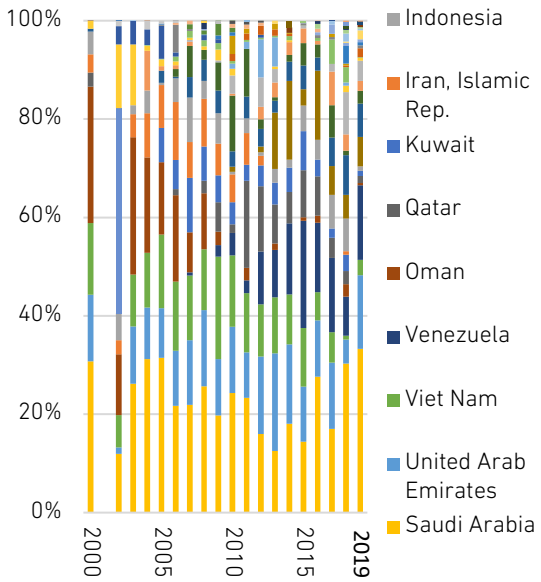


Figure 3.32. Import Diversity (coal) in Malaysia

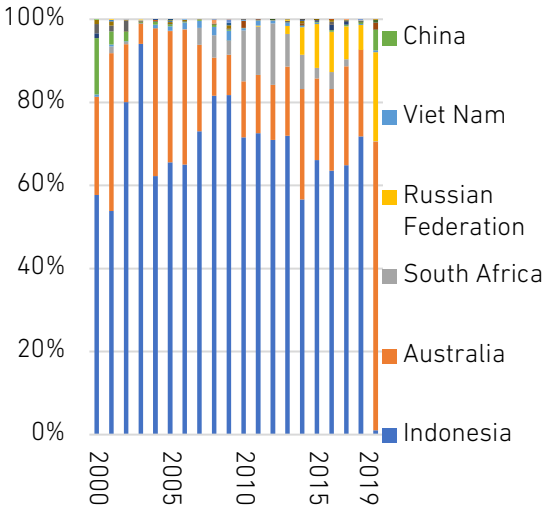
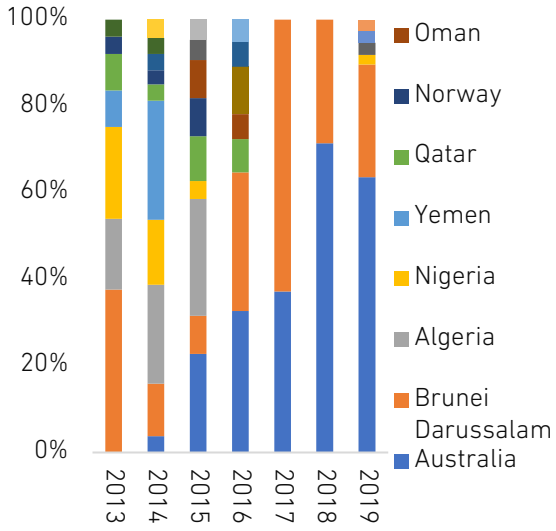


Figure 3.33. Import Diversity (LNG) in Malaysia



GDP = gross domestic product, GWh = gigawatt-hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.4.2. Energy policy overview

In 2001, the Five-Fuel Diversification Policy was developed, which introduced an energy mix classification consisting of five main sources: natural gas, coal, oil, hydro, and renewable energy. A target of 20% renewable energy was set for 2018. The National Petroleum Policy was established to regulate the oil and gas industry. The use of oil and gas resources was positioned to serve national needs as a top priority. Coal was promoted as an alternative power source in order to reduce domestic

consumption of natural gas and to increase exports. The government froze construction of new coal-fired power plants to reduce GHG emissions. The country aims to reduce GHG emissions per unit of GDP by 45% from 2005 levels by 2030.

In 2022, the National Energy Policy 2022–2040 was announced. The policy targets total installed capacity of renewable energy to increase from 7,597 MW (2018) to 18,431 MW (2040), coal share of installed capacity from 31.4% (2018) to 18.6% (2040), and renewable energy share of total primary energy supply from 7.2% (2018) to 17.0% (2040).

3.2.4.3. ESI overview

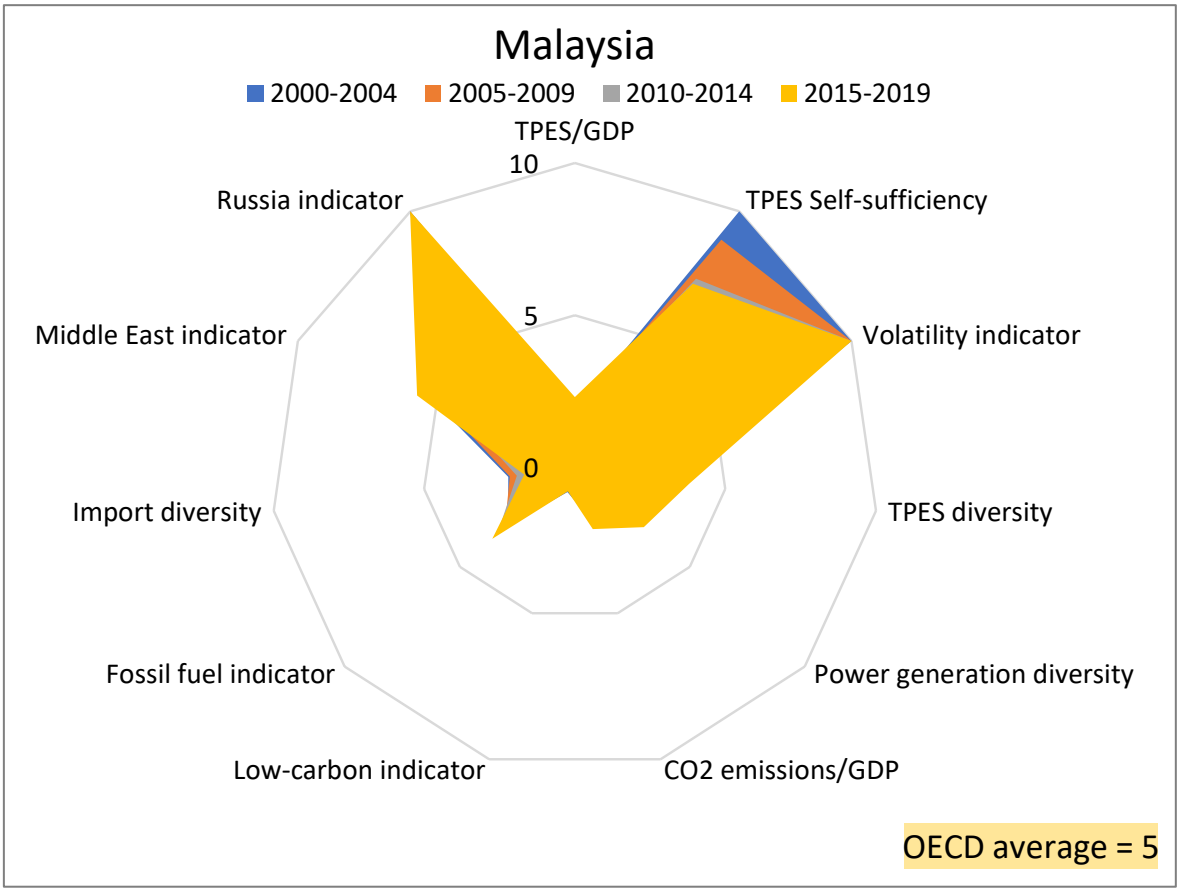
Malaysia is characterised by high TPES self-sufficiency due to domestic production of crude oil and natural gas. Also, the country is unique in its improving dependence on the Middle East and improving trend in TPES and power generation diversity. TPES self-sufficiency is deteriorating, however, above the OECD average (Table 3.5, Figure 3.34).

Table 3.5. Major ESIs in Malaysia in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	2	2	2	2
TPES Self-sufficiency	10	9	7	7
Volatility risk indicator	10	10	10	10
TPES diversity	3	3	4	4
Power generation diversity	2	2	3	3
CO_2 emissions/GDP	2	2	2	2
Low-carbon indicator	1	1	1	1
Fossil fuel indicator	3	3	3	4
Import diversity	2	2	2	2
Middle East indicator	5	5	4	6
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.34. Major ESIs in Malaysia in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.5. Myanmar

3.2.5.1. Macroeconomics, energy supply and demand, energy import trends

Myanmar's energy demand has increased rapidly, especially since 2010, along with its economic development (Figure 3.35). Biomass accounts for just under 50% of the primary energy supply, but this share has been declining since 2010, and the growing energy demand has been met by petroleum and resource-rich natural gas (Figure 3.38). As for power generation, the country utilises abundant hydropower resources: hydropower accounts for about 50% of the generated power. However, in recent years, hydroelectric power development has stagnated due to concerns about adverse social and environmental impacts, and the prospects for development are unclear (Figure 3.39).

In recent years, the development of gas-fired power plants has also been promoted, but since natural gas is a valuable means of earning foreign currency, as of 2016, about 80% of domestic production was exported to Thailand and China, so it is not necessary

to use resources domestically. In addition, the production of natural gas is on a downwards trend, and the recovery of production is one of the challenges.

Figure 3.35. Absolute values of GDP, TPES, CO_2 in Myanmar

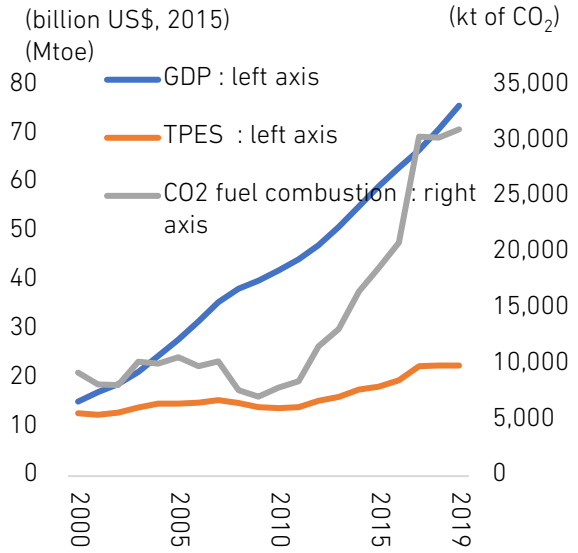


Figure 3.36. TPES/GDP, CO_2 Emissions/GDP in Myanmar

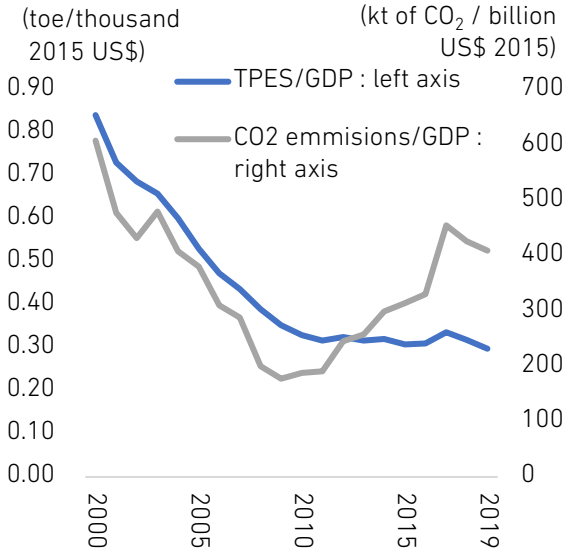


Figure 3.37. Low-carbon Indicator in Myanmar

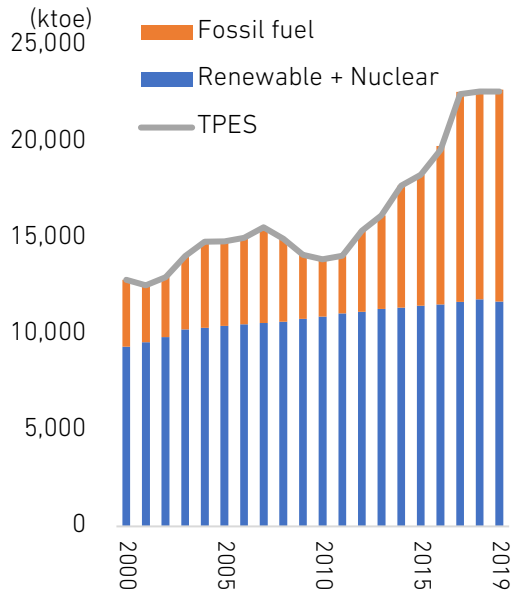


Figure 3.38. TPES Diversity in Myanmar

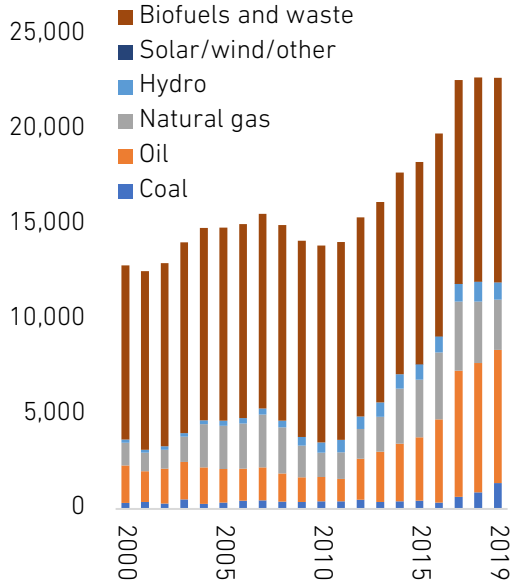


Figure 3.39. Power Generation Diversity in Myanmar

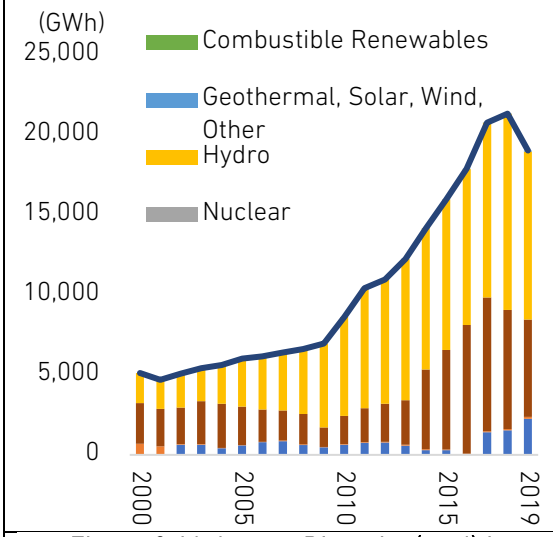


Figure 3.40. Import Diversity (crude oil) in Myanmar

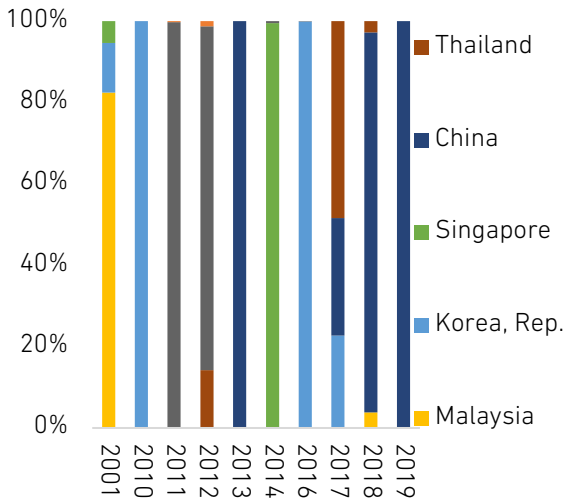
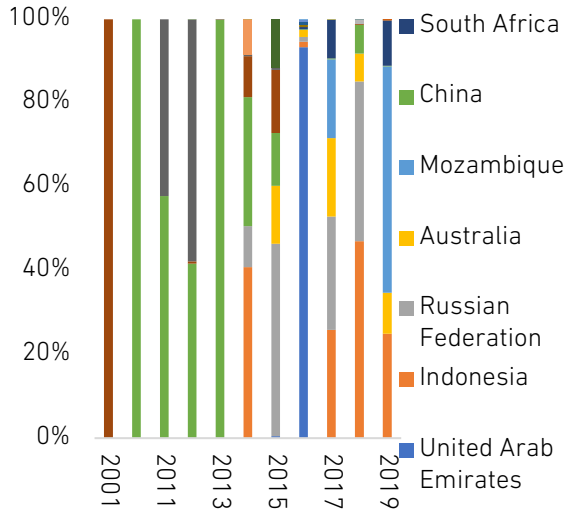


Figure 3.41. Import Diversity (coal) in Myanmar



No data available (2000–2019) on Import Diversity (LNG) in Myanmar

GDP = gross domestic product, GWh = gigawatt-hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.5.2. Energy policy overview

Demand for energy is expected to continue to grow in Myanmar. Oil and gas development is being promoted by the Foreign Investment Law, which allows foreign investment to participate. In 2014 the National Energy Policy was established. The policy addresses the utilisation of renewable energy, improvement of energy efficiency, promotion of energy conservation, exploration and development of energy resources, and realisation of stable energy prices. It also sets targets for the expansion of the power sector, including an electrification rate of 75% by 2025 and 100% by 2030.

The energy mix for 2030 is set as 38% hydro, 20% natural gas, 33% coal, and 9% renewable energy. A plan has been announced to increase power generation from renewable energy sources to 9% by 2030. At the same time, Myanmar announced plans to expand solar and hydropower generation. According to the 2016 Myanmar Energy Master Plan, Myanmar plans to increase the share of renewable energy in total power generation capacity to 9% by 2030, excluding small hydropower. Except for large hydropower, renewable energy will be deployed for rural electrification. In 2022, the goal was to increase renewable energy generation from 1% to 9 by 2030.

3.2.5.3. ESI overview

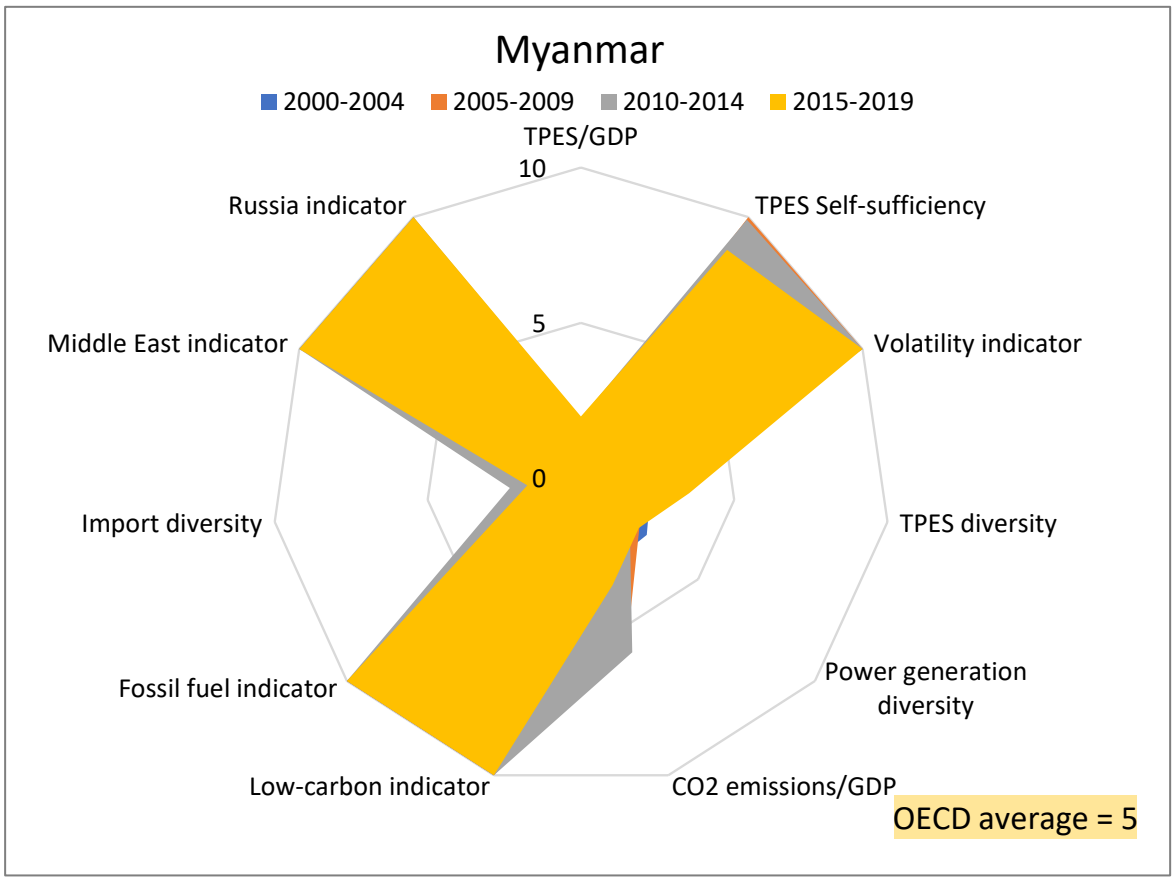
Myanmar is characterised by high TPES self-sufficiency and low-carbon indicator, specifically due to the use of abundant hydropower. Since 2015, CO_2 emissions have increased relative to economic growth because of the increased use of coal to meet the rapidly growing energy demand. TPES/GDP and TPES diversity is gradually improving (Table 3.6). Fossil fuel import data for Myanmar are available from 2001 and 2010 onwards.

Table 3.6. Major ESIs in Myanmar in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	1	1	2	2
TPES self-sufficiency	8	10	10	9
Volatility risk indicator	10	10	10	10
TPES diversity	2	2	3	4
Power generation diversity	3	2	2	2
CO_2 emissions/GDP	3	5	6	4
Low-carbon indicator	10	10	10	10
Fossil fuel indicator	10	10	10	10
Import diversity	1	NA	2	2
Middle East indicator	10	NA	10	10
Russia indicator	10	NA	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, NA = not available, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.42. Major ESIs in Myanmar in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.6. Philippines

3.2.6.1. Macroeconomics, energy supply and demand, energy import trends

TPES/GDP has been on a downwards trend since 2000. This can be attributed to the growth in GDP since 2010 centred on the service industry, which consumes little energy (Figure 3.44). Since around 2010, the Philippines has been stabilising its politics, and since then the real GDP growth rate has continued at 6%–7%, and energy demand has also increased sharply (Figure 3.43). The Philippines is rich in domestic resources such as geothermal power, hydroelectric power, coal, and natural gas. On the other hand, with the increase in energy consumption, the import volume of oil and coal is increasing, and the development of domestic energy resources has become an important policy. The increase in energy demand from around 2010 has been met by using coal (Figure 3.46). The proportion of renewable energy is also on the rise, indicating a policy of expanding solar power generation (Figure 3.47). After experiencing natural disasters, the importance of resilience, the securing of alternative power sources, and the introduction of renewable energy have increased in the

Philippines. It relies heavily on the Middle East for crude oil imports and relies mostly on Indonesia for coal (Figure 3.48, Figure 3.49).

Figure 3.43. Absolute Values of GDP, TPES, CO_2 in the Philippines

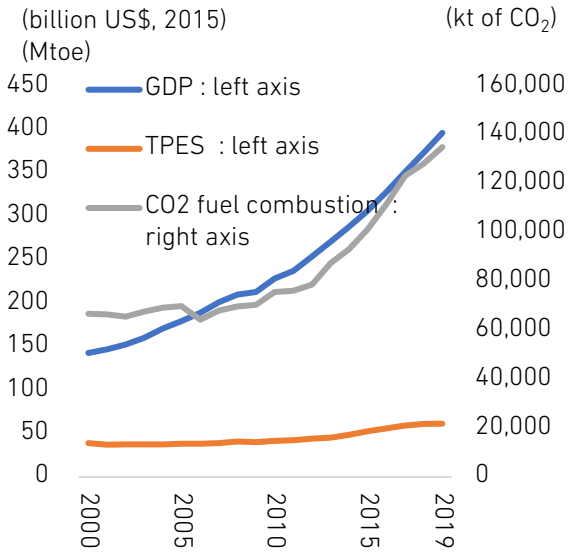


Figure 3.44. TPES/GDP, CO_2 Emissions/GDP in the Philippines

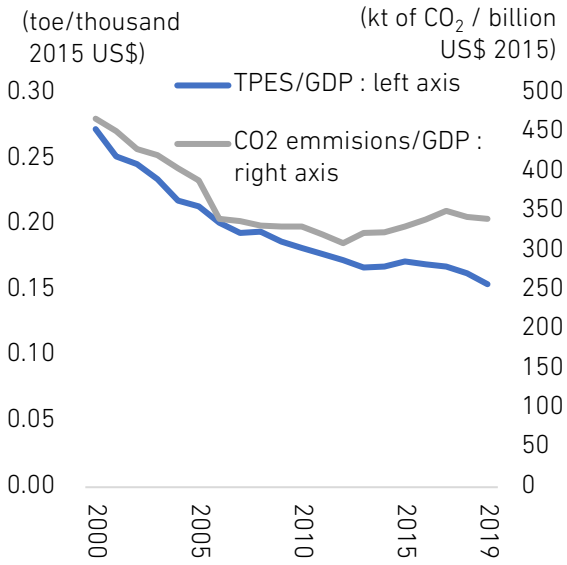


Figure 3.45. Low-carbon Indicator in the Philippines

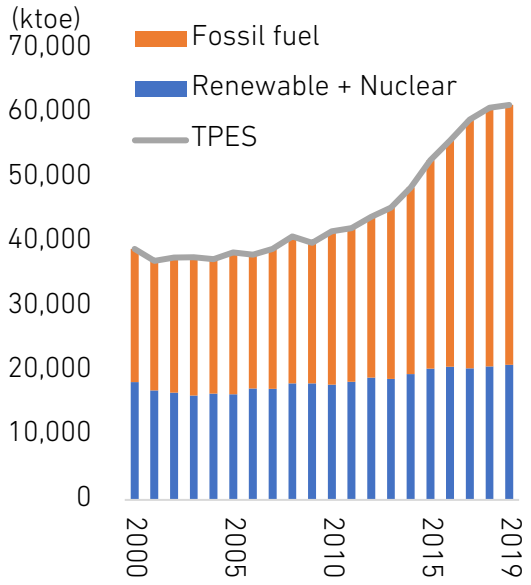


Figure 3.46. TPES Diversity in the Philippines

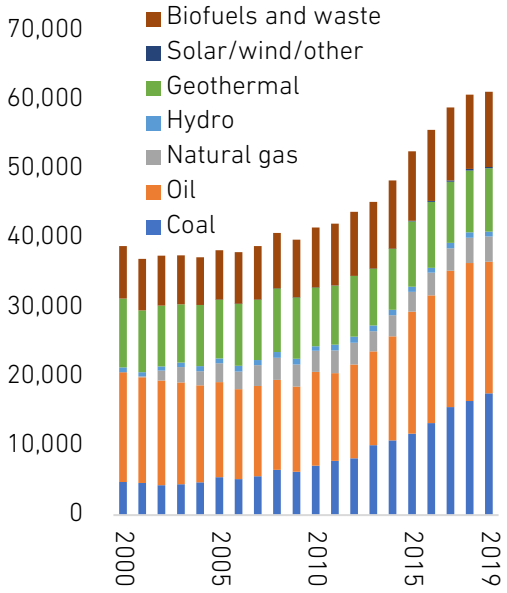


Figure 3.47. Power Generation Diversity in Philippines

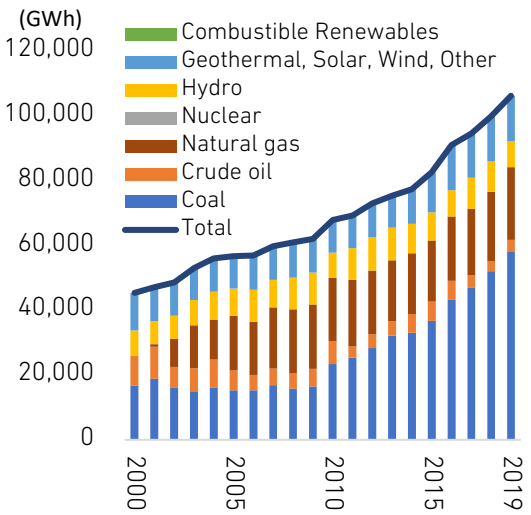


Figure 3.48. Import Diversity (crude oil) in Philippines

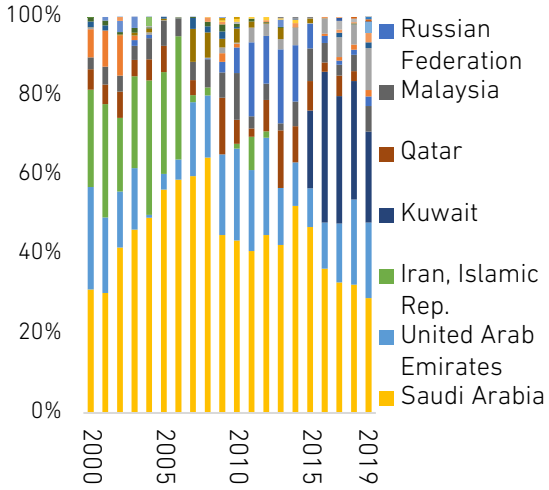
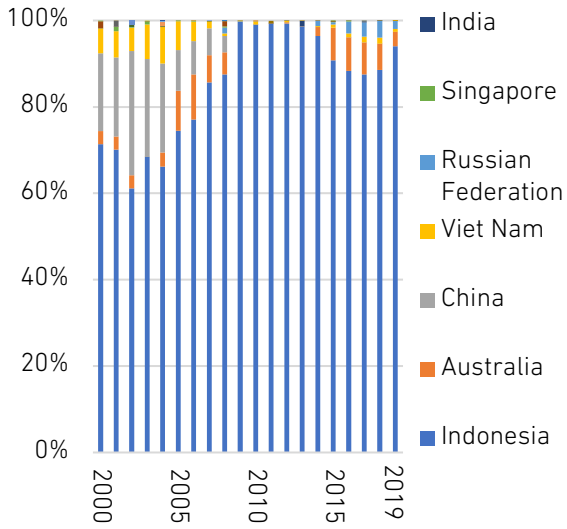


Figure 3.49. Import Diversity (coal) in the Philippines



No data available (2000–2019) on Import Diversity (LNG) in the Philippines

GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.6.2. Energy policy overview

In 2004, the National Energy Efficiency and Conservation Program was established to set the principles of energy conservation policy. It has significantly improved energy efficiency (per unit of GDP). In 2016, the government announced its intention not to rule out the construction of new coal-fired power plants for the purpose of providing affordable electricity, whilst at the same time initiating work to review its energy supply system, including reducing coal-fired power generation. In 2012, it announced targets for the introduction of renewable energy through feed-in tariffs and its

purchase price. In 2012, it announced targets for the introduction of renewable energy through feed-in tariffs and set targets for the introduction of renewable energy up to 2030. In 2017, to curb CO_2 emissions, the Renewable Portfolio Standards (requiring electricity retailers to procure a portion of their energy from renewable sources) and the Green Energy Option (requiring consumers to procure energy from renewable sources) were enacted.

The Philippine Energy Plan (PEP2020–2040) calls for a shift to a resilient energy system. The government amended the Enforcement Bylaws of the Renewable Energy Law to remove restrictions on foreign investment. In December 2020, the Department of Energy issued an advisory on the moratorium of endorsements for greenfield coal-fired power projects in line with improving the sustainability of the Philippines' electric power industry.

3.2.6.3. ESI overview

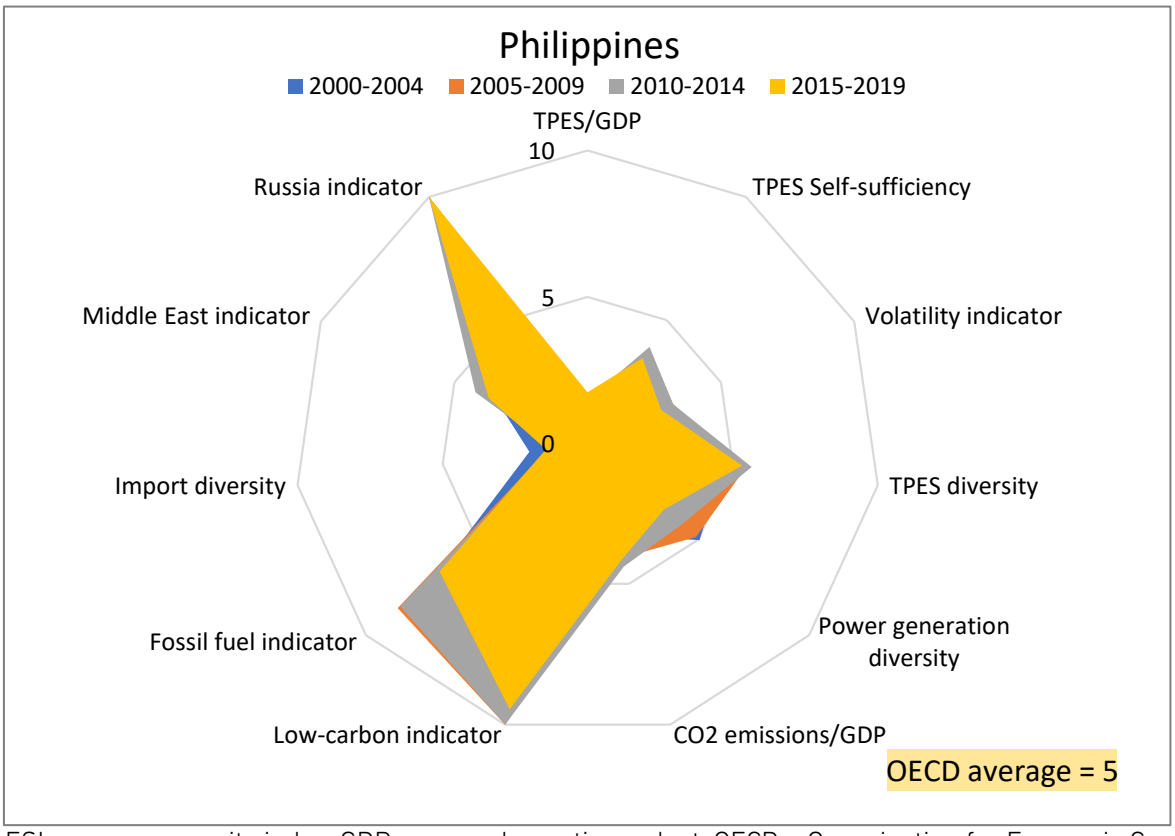
The Philippines is rich in domestic resources such as geothermal power, hydropower, coal, and natural gas. On the other hand, imports of fossil fuels have been increasing and the expansion of coal-fired power generation in electricity is remarkable, characterised by a worsening trend in power generation diversity. The low-carbon indicator and fossil fuel indicator are relatively high compared to the OECD. TPES/GDP has gradually improved in recent years (Table 3.7. Figure 3.50).

Table 3.7. Major ESIs in the Philippines in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	1	1	1	2
TPES self-sufficiency	3	4	4	3
Volatility risk indicator	3	3	3	3
TPES diversity	5	5	6	5
Power generation diversity	5	5	4	3
CO_2 emissions/GDP	3	4	4	4
Low-carbon indicator	10	10	10	9
Fossil fuel indicator	7	9	8	7
Import diversity	2	1	1	1
Middle East indicator	3	4	4	4
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.50. Major ESIs in the Philippines in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.7. Singapore

3.2.7.1. Macroeconomics, energy supply and demand, energy import trends

CO_2 emissions/GDP and TPES/GDP are on a downwards trend (Figure 3.52). Although most of the TPES depends on crude oil and gas, the absolute amount of CO_2 emissions has not increased significantly compared to economic growth (Figure 3.51). In terms of power generation composition, most of it depends on gas, but the ratio of renewable energy has been gradually increasing in recent years (Figure 3.55). More than 60% of crude oil imports come from the Middle East (Figure 3.56). Coal is from Viet Nam, 50% of LNG is from Australia, and the rest comes from Qatar and Indonesia (Figure 3.57. Figure 3.58).

Figure 3.51. Absolute Values of GDP, TPES, CO_2 in Singapore

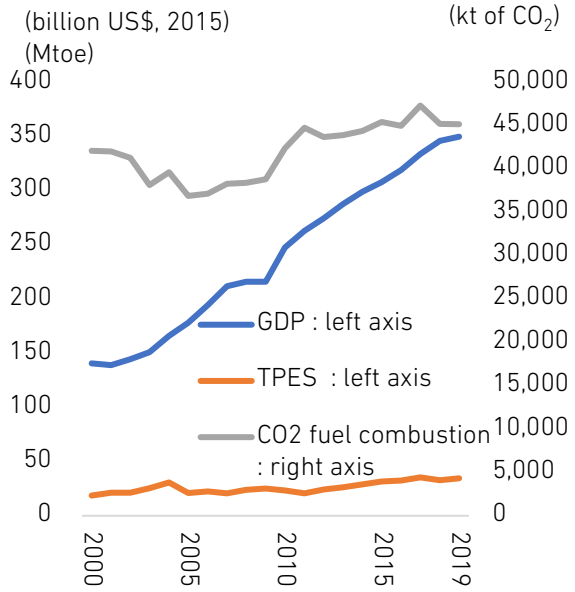


Figure 3.52. TPES/GDP, CO_2 Emissions/GDP in Singapore

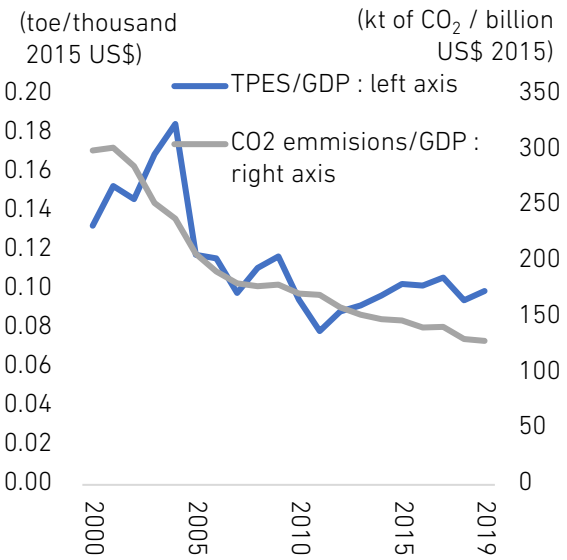


Figure 3.53. Low-carbon Indicator in Singapore

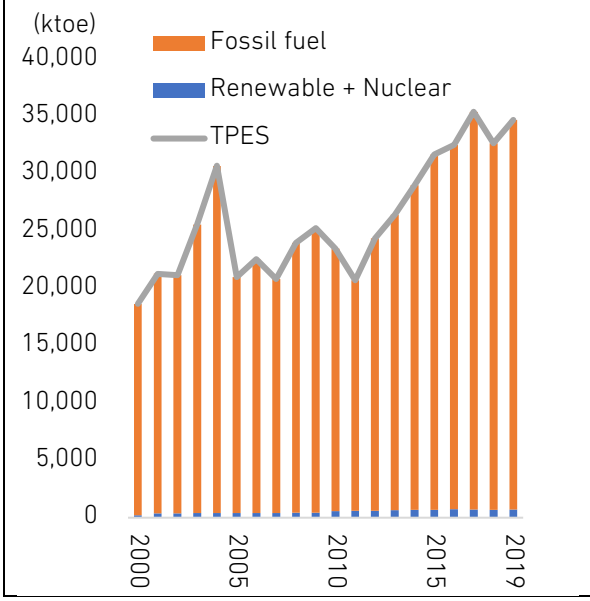


Figure 3.54. TPES Diversity in Singapore

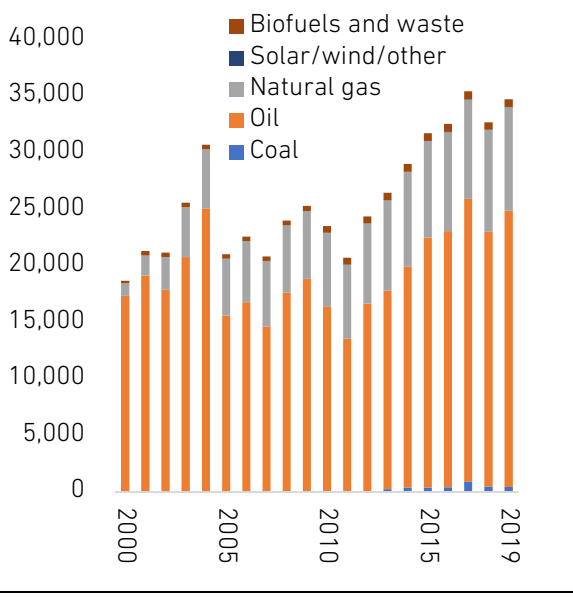


Figure 3.55. Power Generation Diversity in Singapore

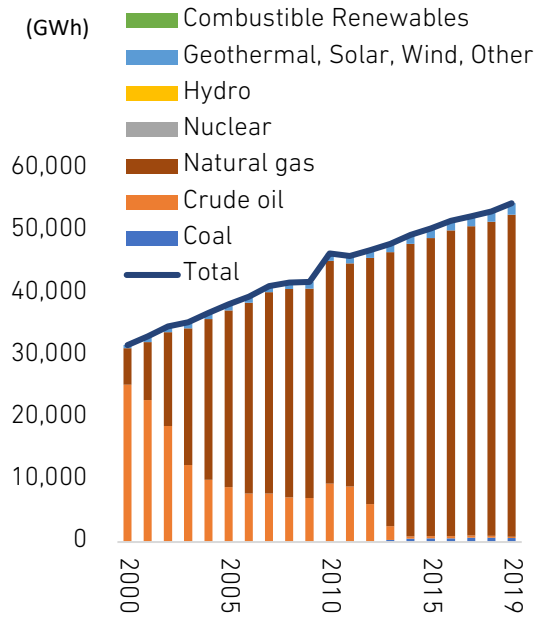


Figure 3.56. Import Diversity (Crude oil) in Singapore

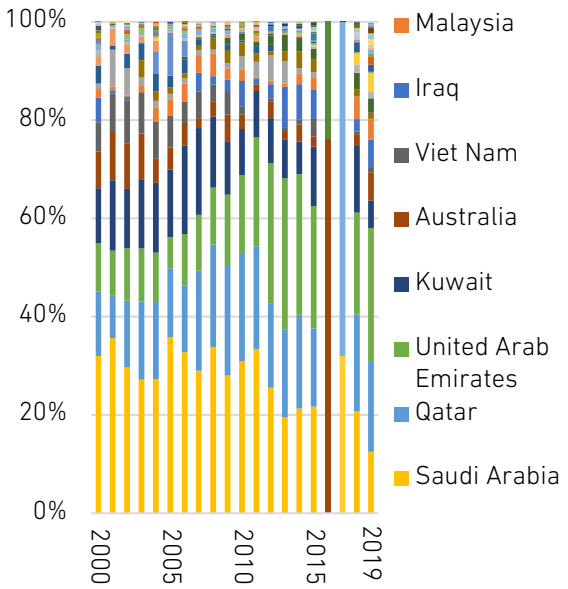


Figure 3.57. Import Diversity (coal) in Singapore

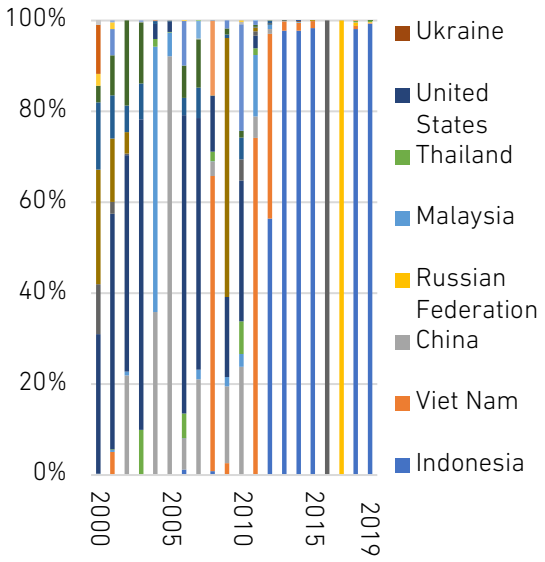
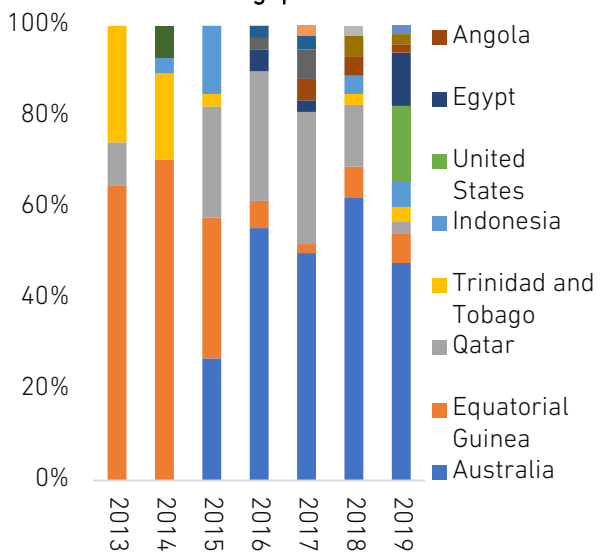


Figure 3.58. Import Diversity (LNG) in Singapore



GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.7.2. Energy policy overview

In May 2013, Singapore began importing LNG to diversify supply sources and ensure a stable supply. In 2007, the government announced the national energy strategy 'Energy for Growth' with the aim of (1) promoting market competition, (2) diversifying energy supply, (3) improving energy efficiency, (4) investing in energy research and development, (5) strengthening international cooperation, and (6) government

response. In addition to strengthening its position as Asia's No. 1 petroleum hub, the country aims to expand the scope of energy trading to include LNG, biofuels, and CO_2 emissions credits, and to strengthen clean and renewable energy, including solar, biofuels, and fuel cells. In 2009, the Sustainable Development Blueprint was released, setting numerical targets to reduce energy consumption per unit of GDP. It also includes improvements in waste recycling rates and reductions in water consumption. To support this plan, the Energy Conservation Act was enacted in 2012, and the law has been continuously improved since then. In 2021, Singapore released the Singapore Green Plan 2030, an environmental action plan.

3.2.7.3. ESI overview

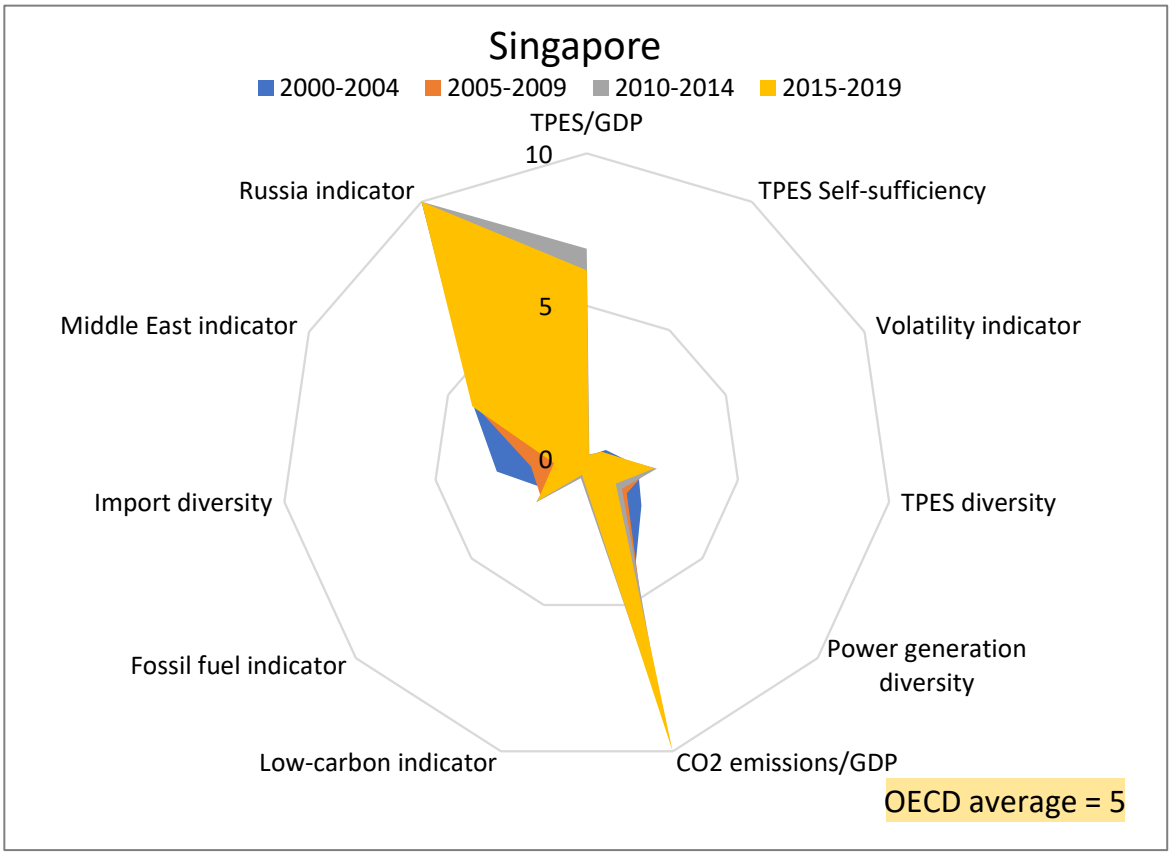
Singapore is highly dependent on imports and has low TPES self-sufficiency, volatility risk indicator, and low-carbon indicator. On the other hand, CO_2 emissions/GDP is high. TPES/GDP are slightly improving (Table 3.8, Figure 3.59).

Table 3.8. Major ESIs in Singapore in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	4	6	7	6
TPES self-sufficiency	0	0	0	0
Volatility risk indicator	1	1	0	1
TPES diversity	2	2	2	2
Power generation diversity	2	2	2	1
CO_2 emissions/GDP	5	8	9	10
Low-carbon indicator	0	0	1	1
Fossil fuel indicator	2	2	2	2
Import diversity	3	2	1	1
Middle East indicator	4	4	4	4
Russia indicator	10	10	10	10

ESI = Energy Security Index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.59. Major ESIs in Singapore in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.8. Thailand

3.2.8.1. Macroeconomics, energy supply and demand, energy import trends

In recent years, Thailand has experienced various phases of economic slowdown, such as the global financial crisis in 2008–2009 and the 2011 floods. A military coup occurred in May 2014, and the leader of the coup remained in power until the general election in March 2019. Against the backdrop of political instability, the economy has been sluggish (Figure 3.60). CO_2 emissions/GDP are on a downwards trend, but TPES/GDP had been increasing from 2005 to 2015 (Figure 3.61). The share of renewable energy in the power generation mix is on the rise (Figure 3.64). Dependence on the Middle East as a source of crude oil imports is on the decline (Figure 3.65). Most coal is imported from Indonesia and Australia. Qatar, Malaysia, and Australia account for about 80% of LNG (Figure 3.66, Figure 3.67).

Figure 3.60. Absolute Values of GDP, TPES, CO_2 in Thailand

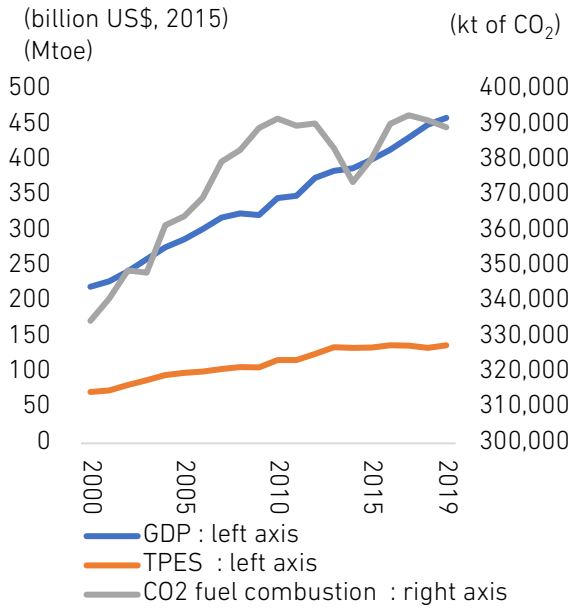


Figure 3.61. TPES/GDP, CO_2 Emissions/GDP in Thailand

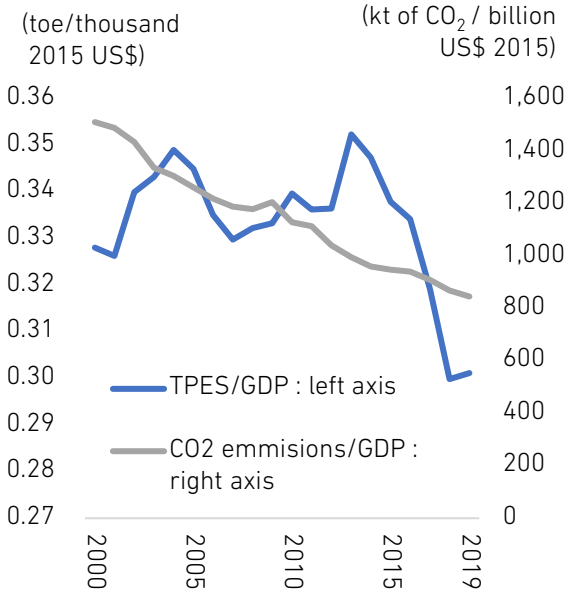


Figure 3.62. Low-carbon Indicator in Thailand

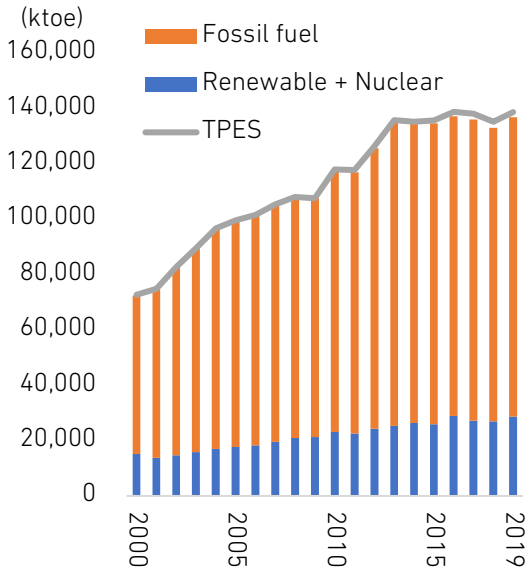


Figure 3.63. TPES Diversity in Thailand

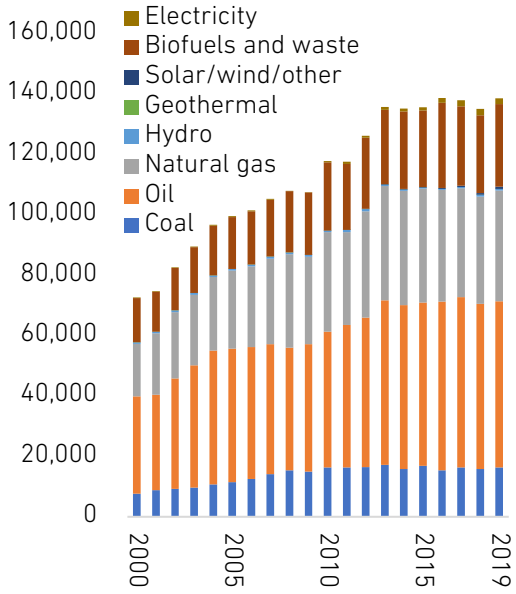


Figure 3.64. Power Generation Diversity in Thailand

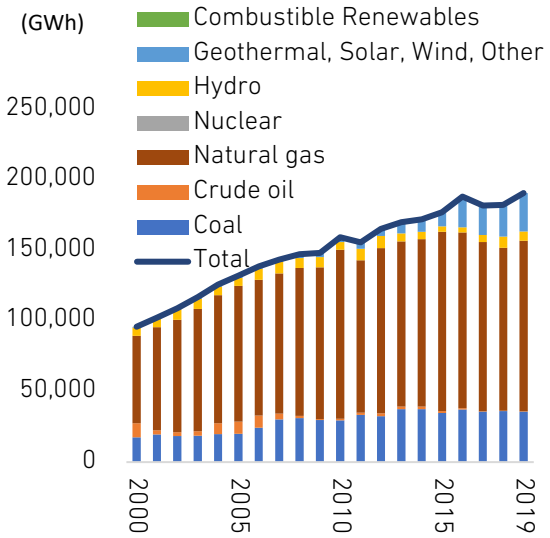


Figure 3.65. Import Diversity (crude oil) in Thailand

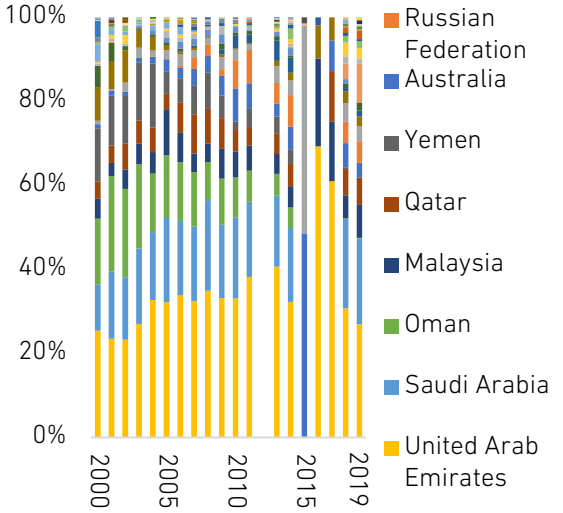


Figure 3.66. Import Diversity (Coal) in Thailand

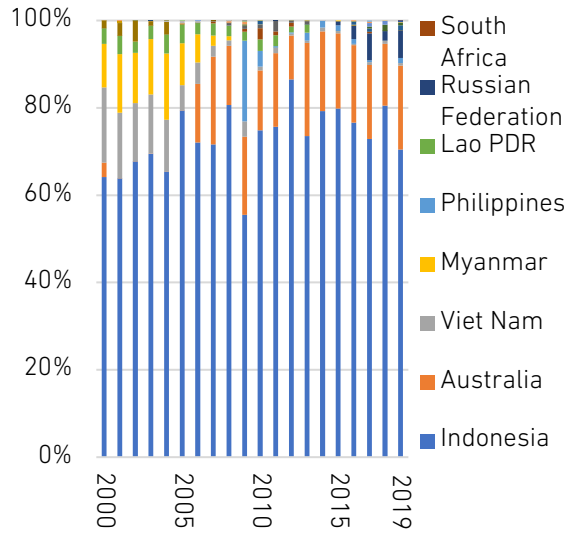
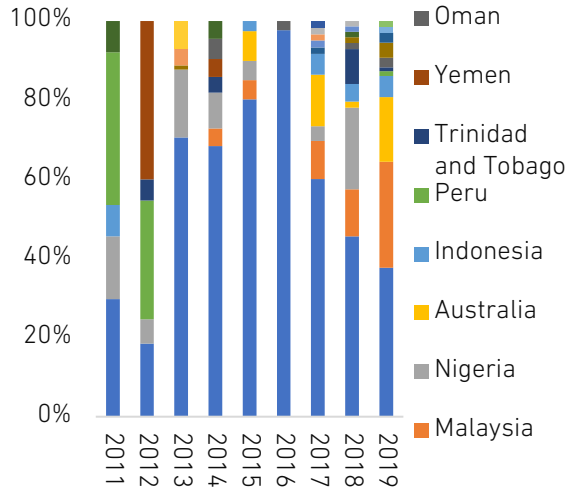


Figure 3.67. Import Diversity (LNG) in Thailand



GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.8.2. Energy policy overview

The Thailand Integrated Energy Blueprint was released in 2015, consisting of five plans: the Energy Efficiency Plan, the Power Development Plan (PDP), the Alternative Energy Development Plan, the Gas Plan, and the Oil Plan.

Oil: Increased investment in domestic exploration and development to expand production, and development of oil storage systems and pipelines to reduce transportation costs.

Gas: Thailand is working to secure gas in domestic and international fields. In 2018, the government announced that it was reviewing its long-term goals for power source development, including moving up the date for achieving a renewable energy source composition ratio to 2030. The government approved the Power Source Development Plan (PDP2018) in 2019 and published PDP2018 Rev1 in 2020; in 2037, the share of fuels for power generation will be 53% natural gas, 11% coal, 11% hydro, 19% renewables, and 0% nuclear energy. PDP2018 Rev1 also incorporated 6% of energy efficiency improvement. The Energy Conservation Promotion Act (B.E. 2035) was enacted in 1992, and the policy has been revised since then to emphasise energy conservation. The Energy Efficiency Plan 2018–2037, approved by the Cabinet in October 2020, establishes a target of reducing energy intensity by 30% by 2037 compared to 2010 levels. In 2021, the government projected that commercial operation of nuclear power plants would begin in 2049. In addition, the capacity of nuclear power plants will be increased to 35 GW by 2060.

3.2.8.3. ESI overview

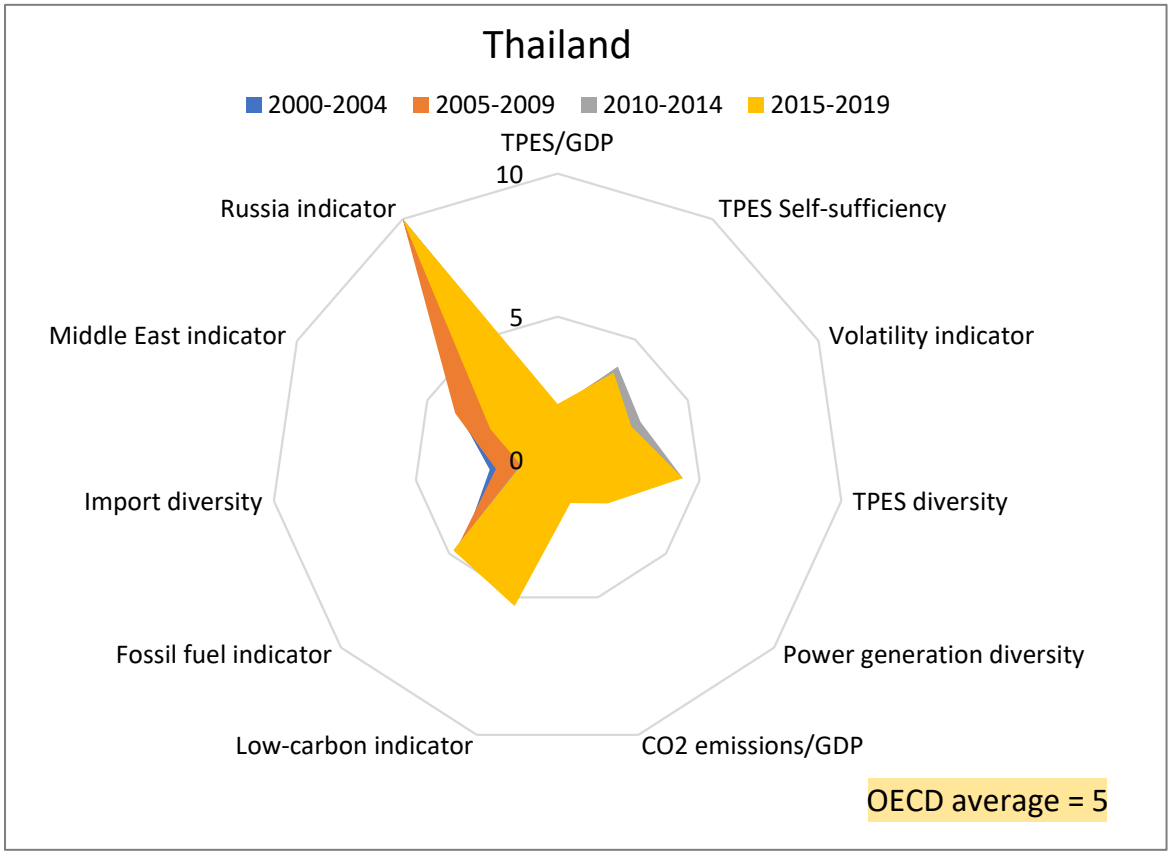
Thailand's import diversity tends to be lower than the OECD average, indicating a high dependence on some countries. On the other hand, CO_2 emissions/GDP are slightly improving. Thailand has relatively high TPES self-sufficiency, TPES diversity, and low-carbon indicator are close to the OECD average. It is characterised by an improving CO_2/GDP trend. In line with increasing energy demand, supplies from the Middle East and Russia are also on the rise. Note that CO_2 emissions from electricity imports from Lao PDR are not considered in Thailand (Table 3.9, Figure 3.68).

Table 3.9. Major ESIs in Thailand in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	2	2	2	2
TPES self-sufficiency	4	4	4	4
Volatility risk indicator	3	3	3	3
TPES diversity	4	4	4	4
Power generation diversity	2	2	2	2
CO_2 emissions/GDP	1	1	1	2
Low-carbon indicator	5	5	5	5
Fossil fuel indicator	4	5	5	5
Import diversity	2	2	1	1
Middle East indicator	4	4	2	3
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.68. Major ESIs in Thailand in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.9. Viet Nam

3.2.9.1. Macroeconomics, energy supply and demand, energy import trends

Viet Nam has experienced remarkable economic growth in recent years, with the real GDP growth rate of about 5%–8% since 2000, and a three-fold increase in primary energy supply (Figure 3.69). In response to the rapid increase in demand, fossil fuels, mainly coal, are used, and coal and oil account for 70% of the primary energy supply (Figure 3.72).

Viet Nam has hydropower resources throughout the country, coal resources in the north, and petroleum and natural gas resources in the south. Crude oil is exported to neighbouring countries such as China and Thailand, which have a large energy demand. However, imports of coal and petroleum are increasing along with the increase in domestic energy demand. CO_2 emissions/GDP are decreasing and decoupling of economic growth and energy consumption has progressed (Figure 3.70), but improvements in energy efficiency have stagnated since then. Fossil fuels (especially coal) are used to meet the increasing demand for energy. Power generation

composition and TPES diversity are also remarkable (Figure 3.73). Most coal is imported from Indonesia and Australia, but the share from Russia has been increasing in recent years (Figure 3.75).

Figure 3.69. Absolute Values of GDP, TPES, CO_2 in Viet Nam

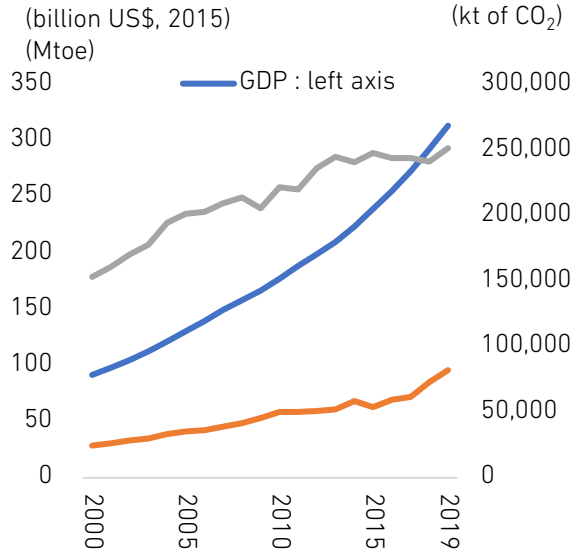


Figure 3.70. TPES/GDP, CO_2 Emissions/GDP in Viet Nam

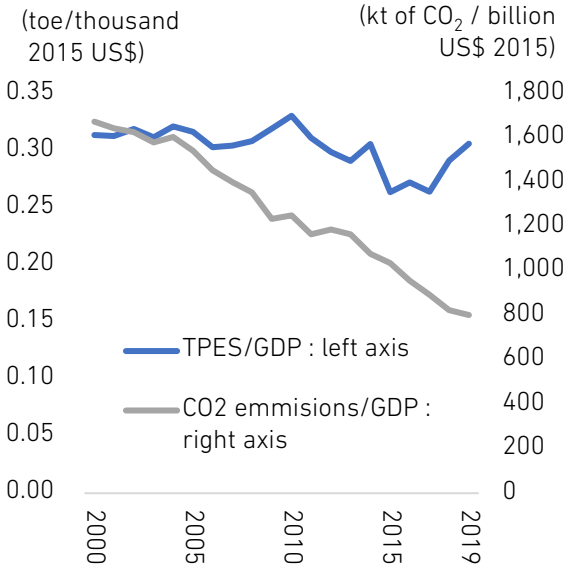


Figure 3.71, Low-carbon Indicator in Viet Nam

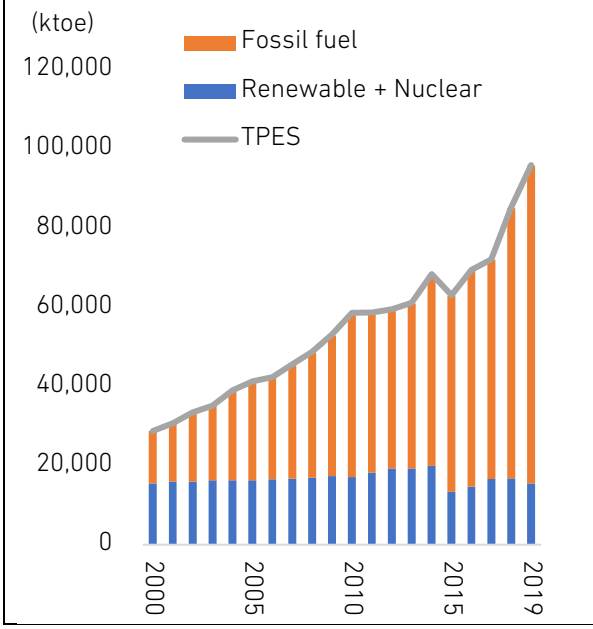


Figure 3.72. TPES Diversity in Viet Nam

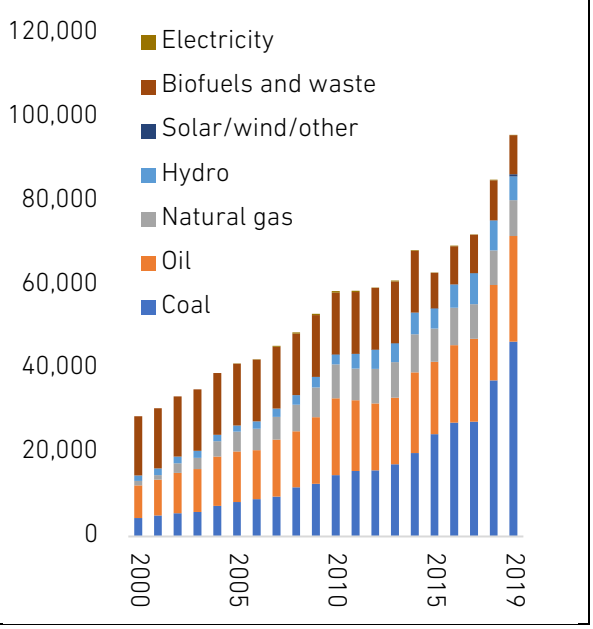


Figure 3.73. Power Generation Diversity in Viet Nam

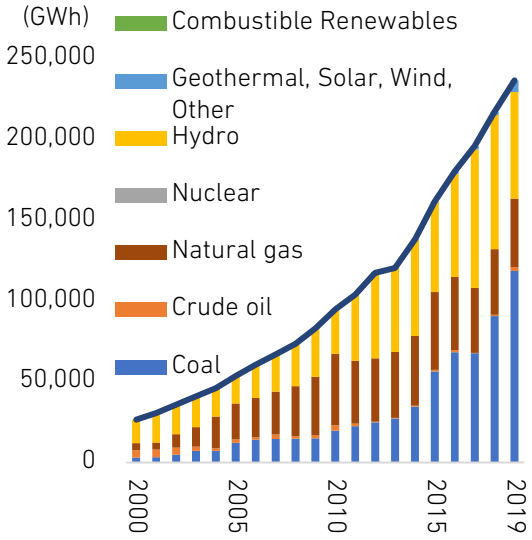


Figure 3.74. Import Diversity (Crude Oil) in Viet Nam

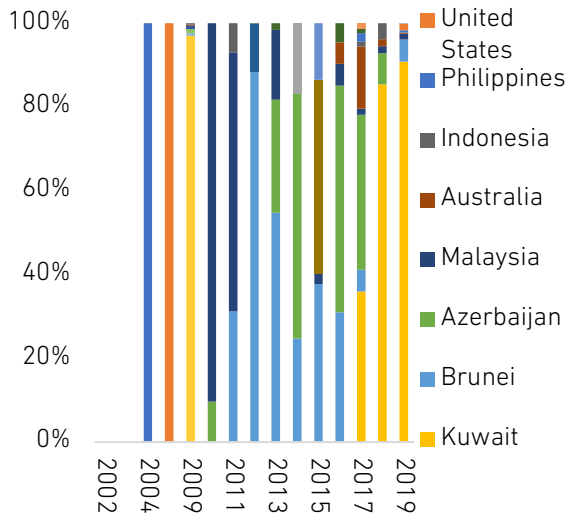
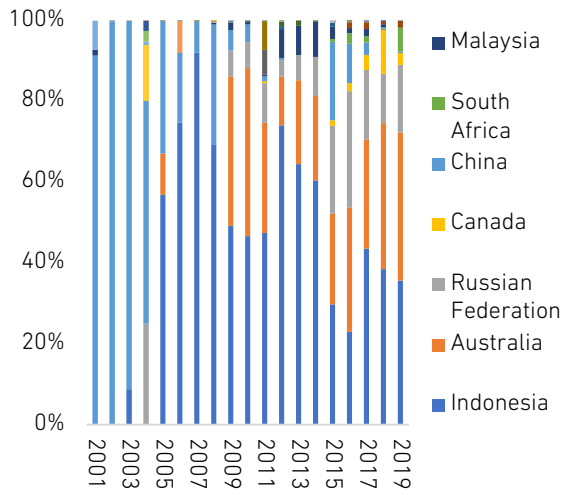


Figure 3.75. Import Diversity (Coal) in Viet Nam



No data available (2000–2019) on Import Diversity (LNG) in Viet Nam

GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.9.2. Energy policy overview

In 2007, the National Energy Development Strategy up to 2020, was adopted with the 2050 Vision. It emphasises diversification of energy resources and application of energy-saving technologies, as well as sustainable and rapid energy development. In 2015, Viet Nam set a target to increase the share of renewables in primary energy to 5% by 2020 and 11% by 2050. It states that it will use oil and gas economically, efficiently, and rationally, and will import what it needs for sustainable national development. In 2016, the Master Plan for Power Development for the 2011–2020 Period with the Vision to 2030 (Power Development Plan 7: Revised PDP7) was

adopted. It aims to promote the development of renewable energy sources and plans to operate nuclear power plants in preparation for the future depletion of primary energy sources in the country.

PDP8 was approved in May 2023. PDP8 mentions that total generation capacity will significantly increase to 150 GW by 2030 from 69 GW in 2020. Renewable energy will account for almost 50% of the energy mix by 2030, with 19.5% from hydropower, 18.5% from wind, and 8.5% from solar. Offshore wind capacity 6 GW of 2030 goal to 70 GW by 2050. Gas (both domestic and imported LNG) will account for 24.8% of the energy mix (37.33 GW) by 2030 as a complimentary transition fuel on the road towards net zero. Coal will account for 20% by 2030. Viet Nam remains committed to completely phasing out coal dependency by 2050. Under an agreement between the Viet Nam and Lao PDR governments, there is a current commitment to import 5,000 MW of capacity from Lao PDR by 2030, potentially increasing to 8,000 MW by 2050.

3.2.9.3. ESI overview

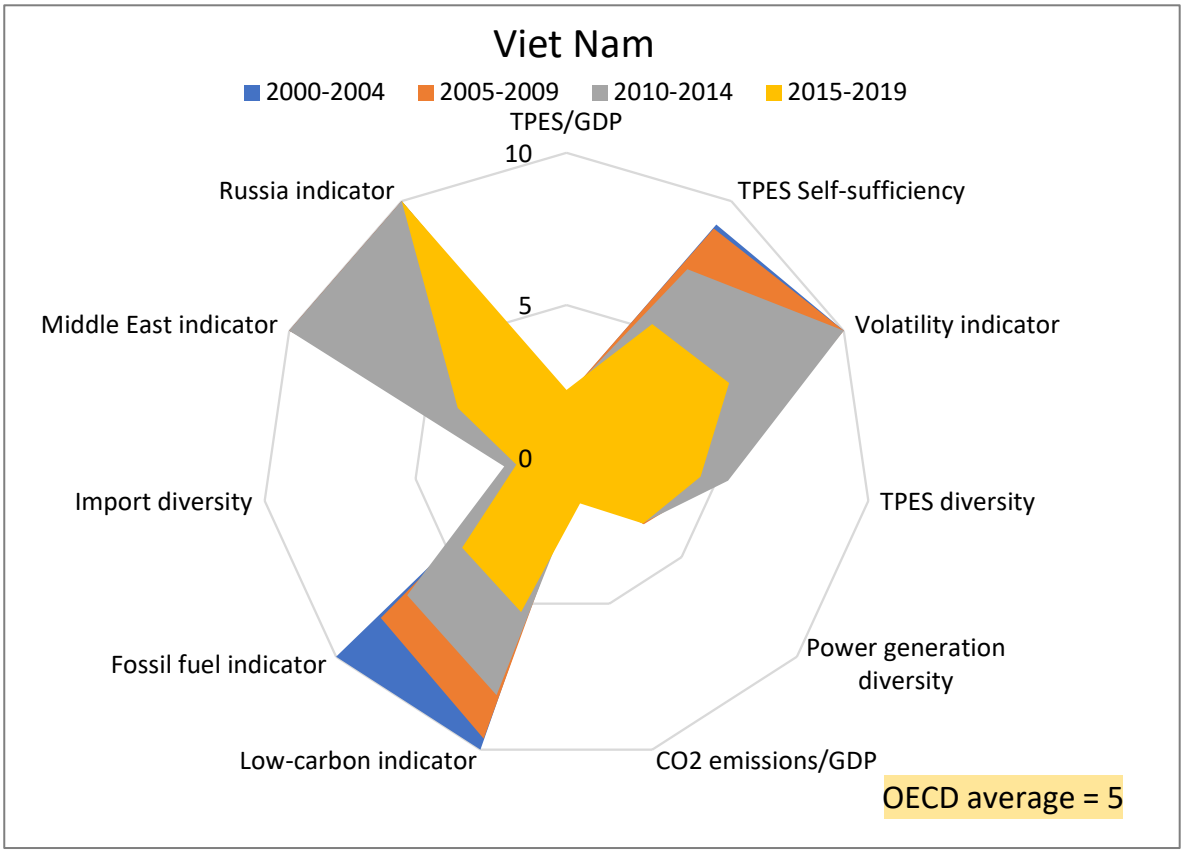
Viet Nam maintains a high level of TPES self-sufficiency due to its abundant domestic resources, however, TPES self-sufficiency has been on a downwards trend in recent years. At the same time, Viet Nam is characterised by improving trends in import diversity. On the other hand, the volatility risk indicator and low-carbon indicator are on a worsening trend due to the increasing imports of fossil fuels, mainly coal, in response to the rising energy demand associated with economic growth (Table 3.10, Figure 3.76).

Table 3.10. Major ESIs in Viet Nam in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	2	2	2	2
TPES self-sufficiency	9	9	7	5
Volatility risk indicator	10	10	10	6
TPES diversity	4	5	5	4
Power generation diversity	3	3	3	3
CO_2 emissions/GDP	1	1	1	2
Low-carbon indicator	10	10	8	5
Fossil fuel indicator	10	8	7	5
Import diversity	1	1	2	2
Middle East indicator	10	10	10	4
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.76. Major ESIs in Viet Nam in Comparison with OECD Average



ESI = Energy Security Index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.10. China

3.2.10.1. Macroeconomics, energy supply and demand, energy import trends

Although the absolute amount of CO_2 emissions is on the rise (Figure 3.77), TPES/GDP and CO_2 emissions/GDP are on the decline, and the decoupling of economic growth and energy consumption is progressing (Figure 3.78). Total primary energy gradually increased, and since 2003 growth has increased rapidly. Coal's share of energy supply has remained flat since around 2011, whilst the amount of oil, natural gas, and renewable energy is on the rise (Figure 3.80). It is also noted that the share of renewable energy generation in total power generation has increased sharply since 2010 (Figure 3.81). Russia and Saudi Arabia have increased their share of oil imports in recent years (Figure 3.82). As for coal, imports from Australia are declining, and the ratio of imports from Russia and Indonesia is increasing (Figure 3.83). On the other hand, LNG imports from Qatar are decreasing, whilst imports from Australia are increasing (Figure 3.84).

Figure 3.77. Absolute Values of GDP, TPES, CO_2 in China

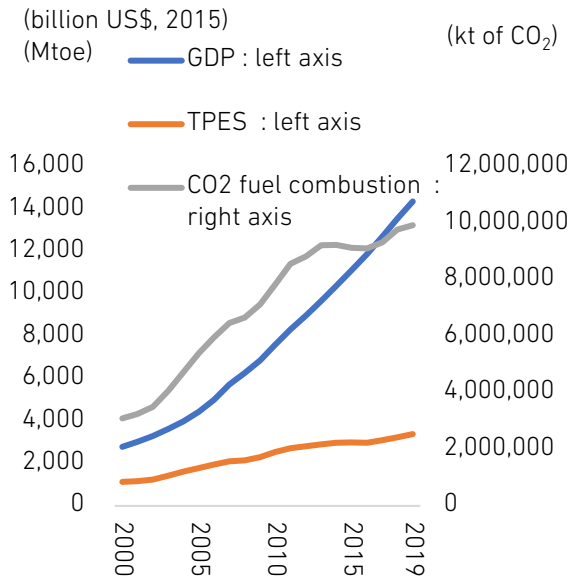


Figure 3.78. TPES/GDP, CO_2 Emissions/GDP in China

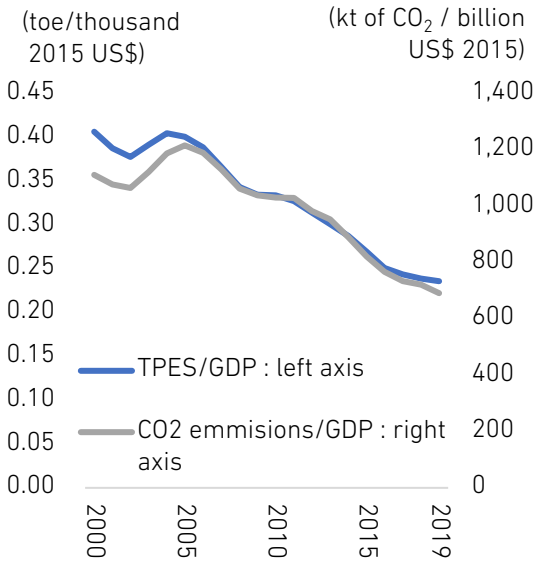


Figure 3.79. Low-carbon Indicator in China

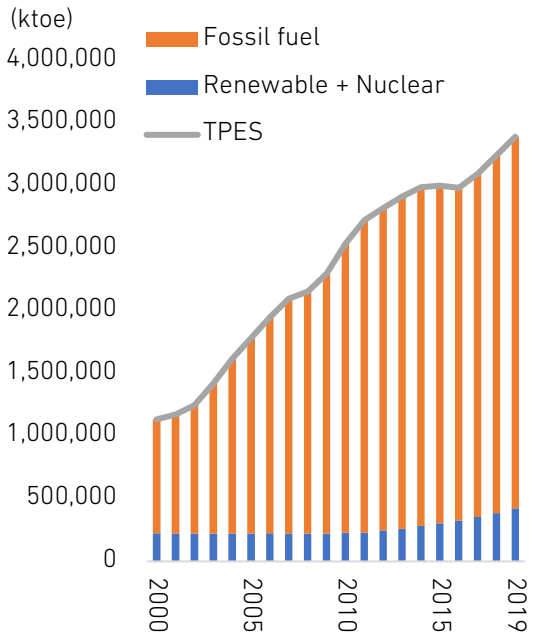


Figure 3.80. TPES Diversity in China

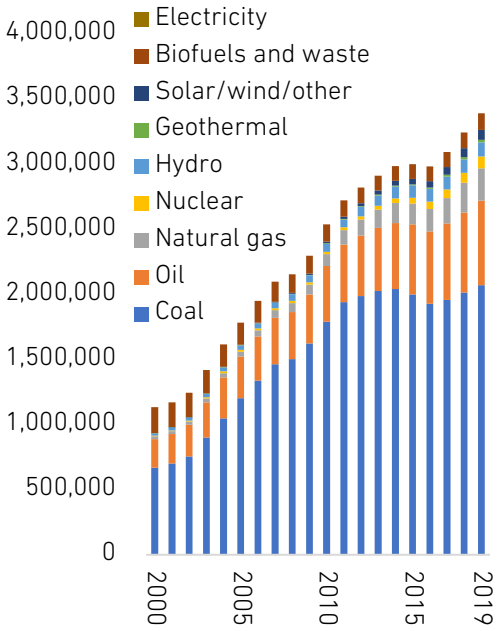


Figure 3.81. Power Generation Diversity in China

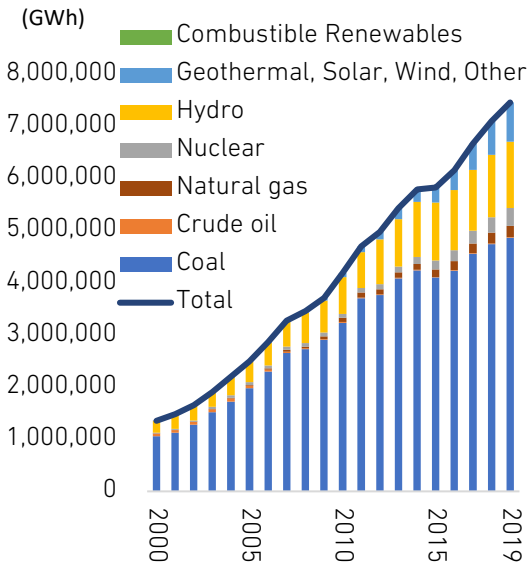


Figure 3.82. Import Diversity (Crude Oil) in China

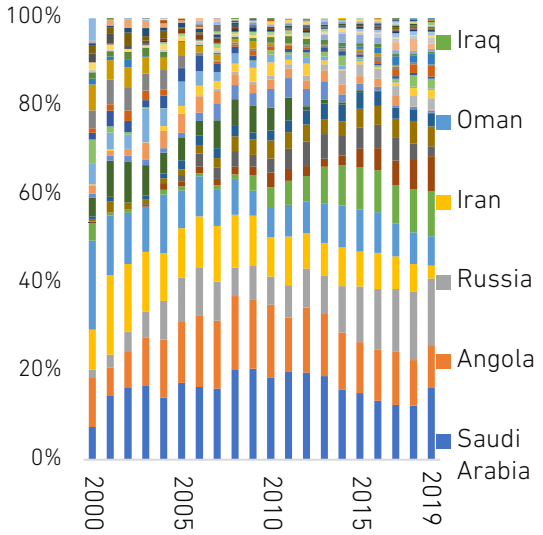


Figure 3.83. Import Diversity (coal) in China

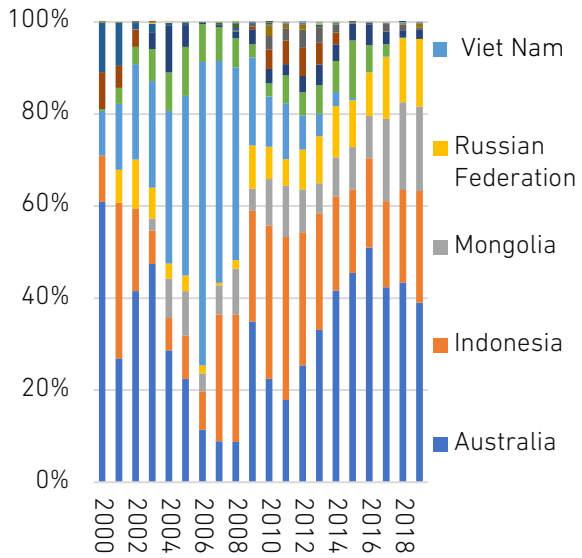
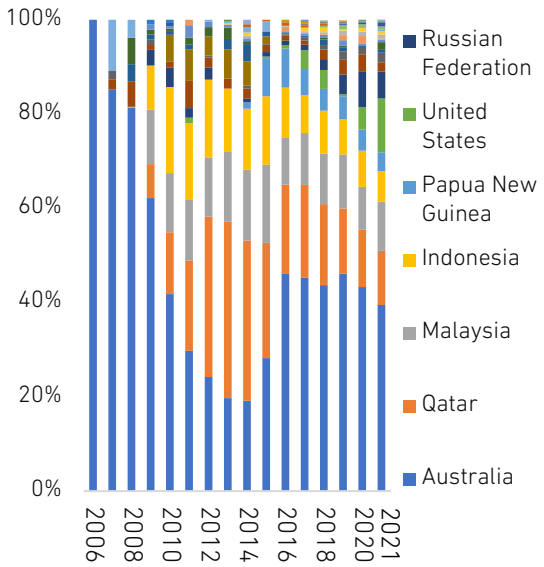


Figure 3.84. Import Diversity (LNG) in China



GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.10.2. Energy policy overview

China's energy consumption has been gradually increasing since the opening up and reform policy in 1978, with growth starting to accelerate in 2003. It has been a net importer of crude oil since the mid-1990s and a net importer of coal since 2009. Natural gas imports began in 2006. Non-hydro renewable energy generation, such as wind and solar, has increased rapidly since 2010, and the share of non-hydro renewable energy generation reached 10% in 2019.

In October 2021, the government announced an action plan to peak out CO_2 emissions by 2030. The policy aims to achieve this by switching to renewable energy, promoting energy conservation, and improving the efficiency of resource use as well as gradually reducing coal consumption and promoting the installation of renewable energy and nuclear power plants. It also announced an action plan to increase the ratio of non-fossil energy in energy consumption to over 80% by 2060.

3.2.10.3. ESI overview

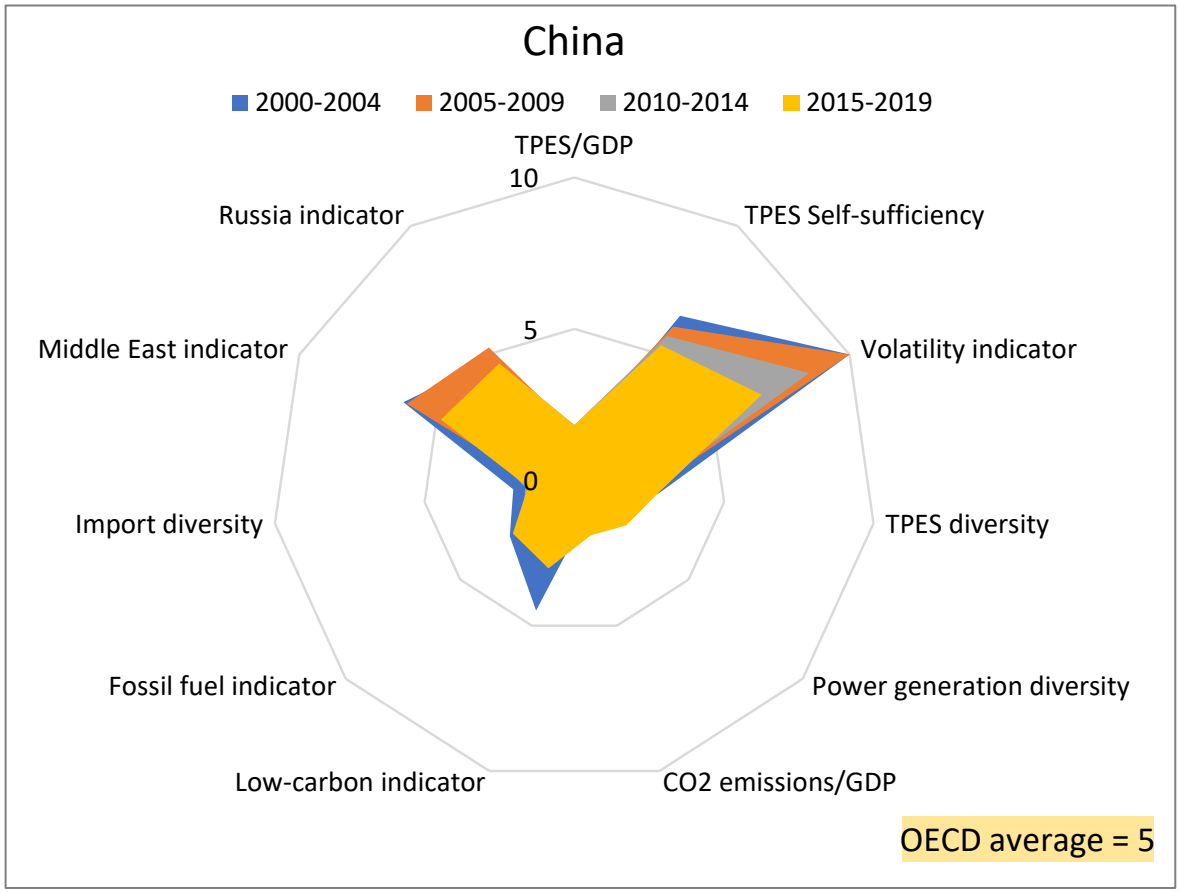
China is characterised by a deterioration in the volatility risk indicator and the Middle East indicator. Increased energy demand has led to increased imports of fossil fuels. TPES self-sufficiency is on a downwards trend. TPES diversity and power generation diversity have not changed much over the past 20 years (Table 3.11, Figure 3.85).

Table 3.11. Major ESIs in China in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	1	2	2	2
TPES self-sufficiency	6	6	6	5
Volatility risk indicator	10	10	9	7
TPES diversity	3	2	2	3
Power generation diversity	2	2	2	2
CO2 emissions/GDP	1	1	1	2
Low-carbon indicator	4	3	2	3
Fossil fuel indicator	3	2	2	3
Import diversity	2	1	2	2
Middle East indicator	6	6	4	5
Russia indicator	5	5	5	5

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.85. Major ESIs in China in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.11. India

3.2.11.1. Macroeconomics, energy supply and demand, energy import trends

India's economy has grown remarkably in recent years, with annual GDP growth rates exceeding 8% in some years since 2000 (Figure 3.86), and total primary energy supply has increased about 2.2 times and electricity supply about 2.9 times in about 20 years (Figure 3.89, Figure 3.90). In addition, the world's second largest population (about 1.37 billion people) is expected to overtake China to become the world's largest by about 2027, and it is expected that energy demand will continue to increase with economic and population growth, and that GHG emissions will increase accordingly. Domestic production cannot keep up with the rapid growth in domestic demand, and imports of fossil fuels are increasing. In particular, dependence on oil imports is around 80%, making it one of the most important policy issues in terms of energy security.

Figure 3.86. Absolute Values of GDP, TPES, CO_2 in India

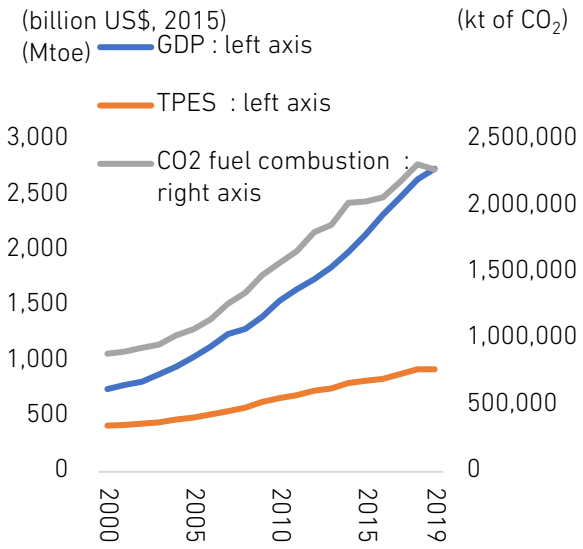


Figure 3.87. TPES/GDP, CO_2 Emissions/GDP in India

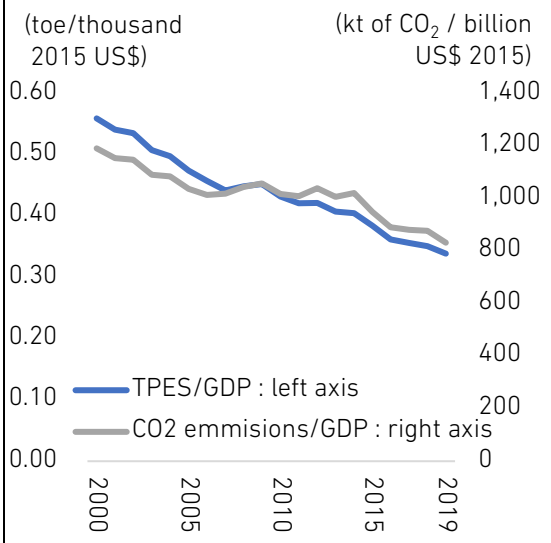


Figure 3.88. Low-carbon Indicator in India

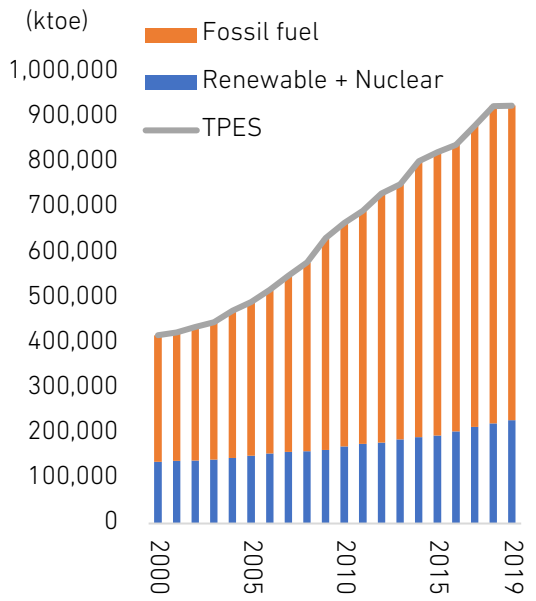


Figure 3.89. TPES Diversity in India

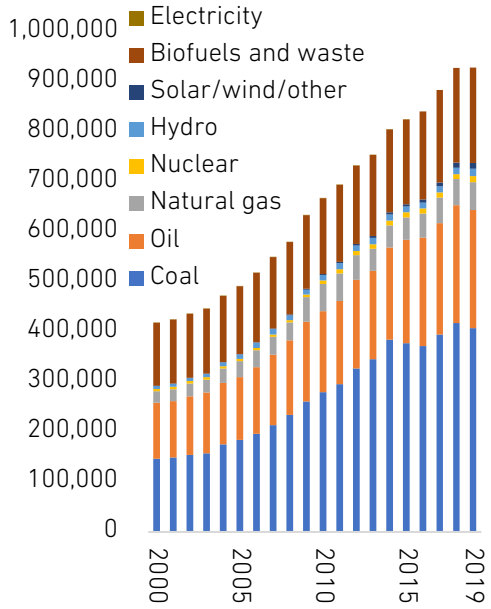


Figure 3.90. Power Generation Diversity in India

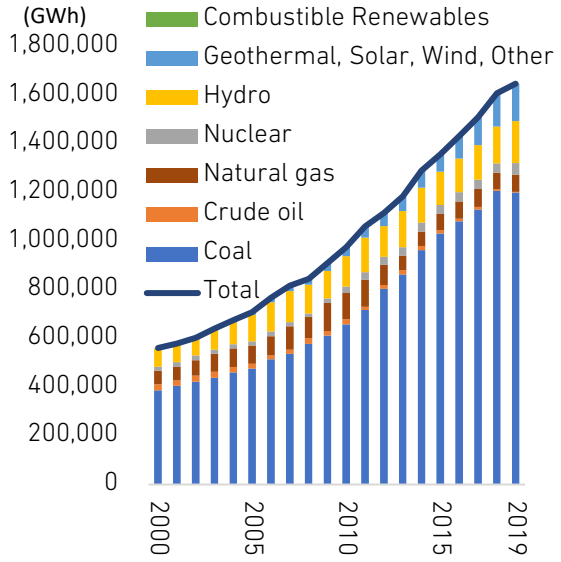


Figure 3.91. Power Generation Diversity in India

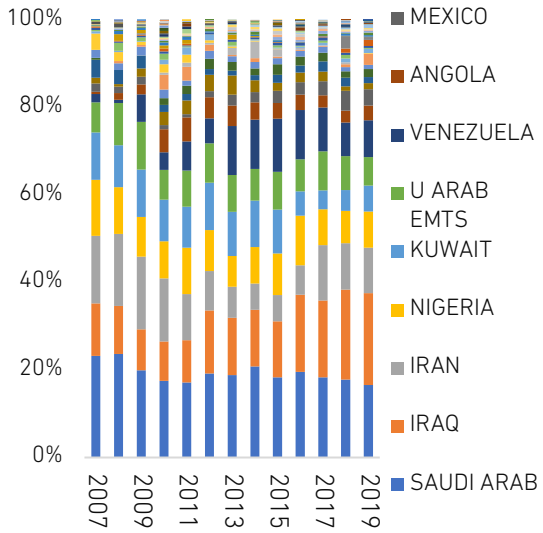


Figure 3.92. Import Diversity (coal) in India

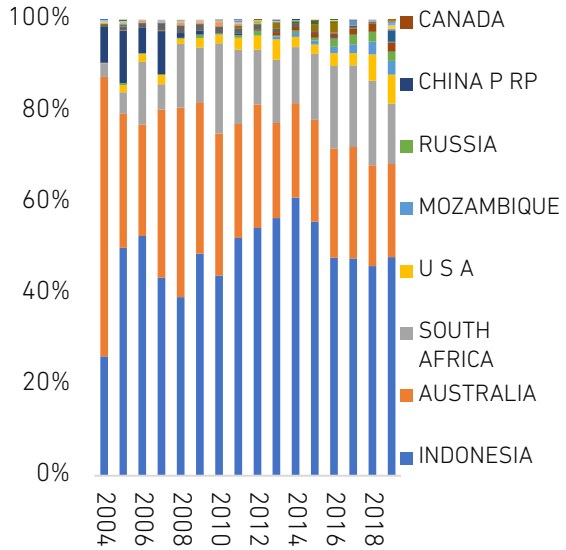
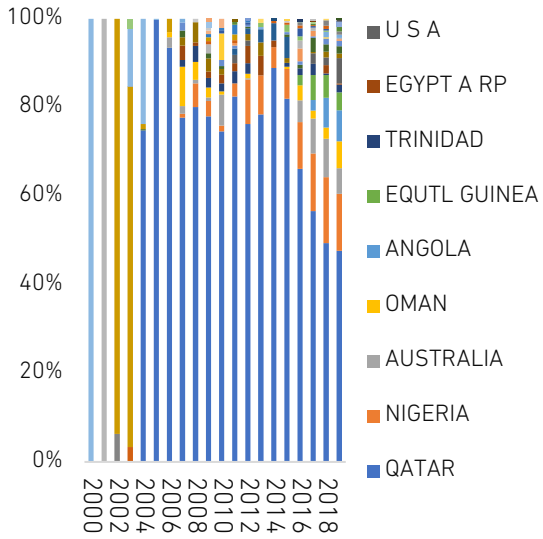


Figure 3.93. Import Diversity (LNG) in India



GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: IEA (2022), OECD – Coal imports by origin, IEA Coal Information Statistics (database), OECD – Oil imports by origin, IEA Oil Information Statistics (database), Cedigaz (2022), Government of India Ministry of Commerce and Industry Department of Commerce.

3.2.11.2. Energy policy overview

The Indian Policy Board (National Institute for Transforming India Aayog) formulated a 3-year action plan from 2017–2018 to 2019–2020, indicating the direction of future measures. The main measures are: the promotion of energy conservation, increased coal production and efficient distribution, increased power generation capacity and streamlined power transmission and distribution, increased oil and gas supply,

enhanced oil and gas refining and distribution, and introduction of renewable energy expansion.

From the perspective of strengthening energy security and combating climate change, the Indian government aims to expand renewable energy, mainly solar and wind power.

India's oil self-sufficiency rate is about 20%, and the goal is to reduce dependence on oil imports from the perspective of strengthening energy security and alleviating financial pressure caused by increased oil imports. The coal market is being opened to the private sector to increase domestic production of coal.

3.2.11.3. ESI overview

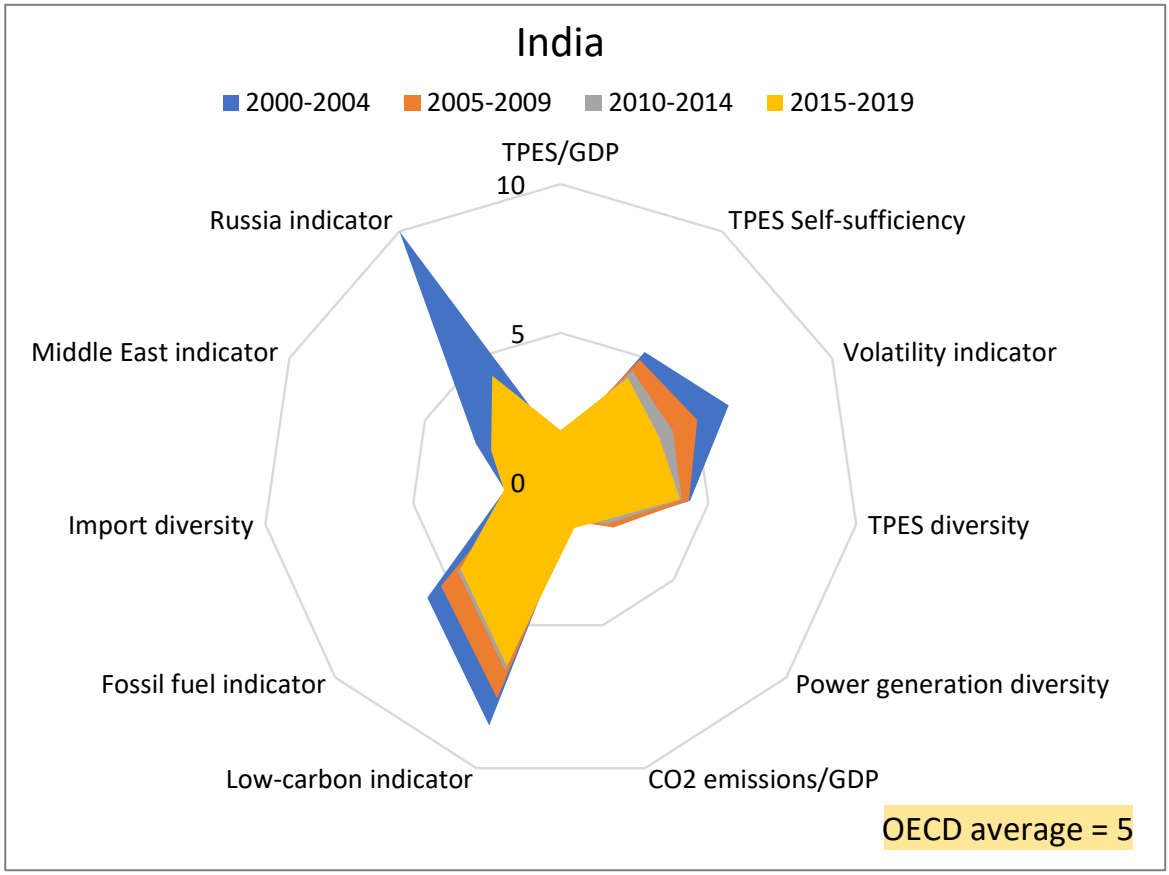
The ESI is generally deteriorating in India. Especially, the volatility risk indicator and the Russia indicator are deteriorating due to the increase in imports associated with higher energy demand. TEPS self-sufficiency and TPES diversity are declining. The low-carbon indicator is also deteriorating (Table 3.12, Figure 3.94).

Table 3.12. Major ESIs in India in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	1	1	1	2
TPES self-sufficiency	5	5	4	4
Volatility risk indicator	6	5	4	4
TPES diversity	4	4	4	4
Power generation diversity	2	2	2	2
CO_2 emissions/GDP	1	1	1	2
Low-carbon indicator	9	8	7	6
Fossil fuel indicator	6	5	5	4
Import diversity	2	1	1	2
Middle East indicator	3	2	2	3
Russia indicator	10	4	4	4

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.94. Major ESIs in India in Comparison with OECD Average



ESI = energy security index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

3.2.12. Japan

3.2.12.1. Macroeconomics, energy supply and demand, energy import trends

The absolute amount of CO_2 emissions temporarily increased due to the shutdown of nuclear power plants triggered by the tsunami and nuclear accident in 2011. However, in recent years, CO_2 emissions have also been on a downwards trend (Figure 3.95). Regarding the power generation mix, renewable energy is on the rise (Figure 3.99). Dependence on the Middle East for crude oil is extremely high, and Australia exports account for more than 60% of coal, followed by Indonesia and Russia. LNG sources are relatively diversified (Figure 3.100, Figure 3.101, Figure 3.102).

Figure 3.95. Absolute Values of GDP, TPES, CO_2 in Japan

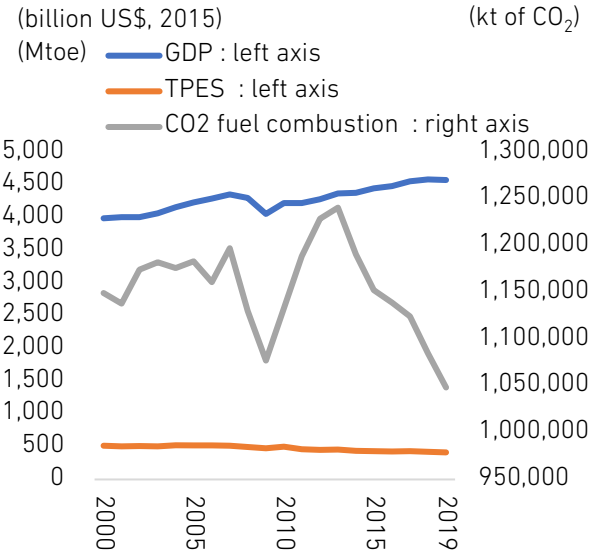


Figure 3.96. TPES/GDP, CO_2Emissions/GDP in Japan

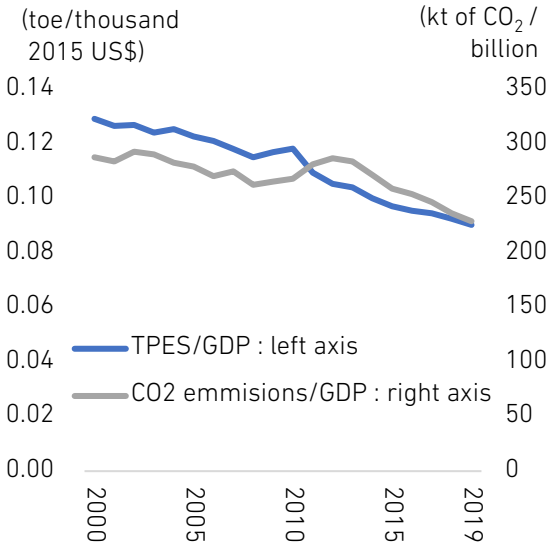


Figure 3.97. Low-carbon Indicator in Japan

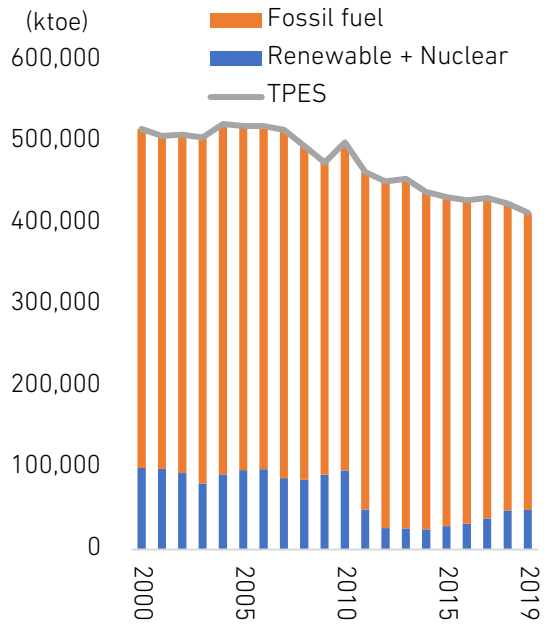


Figure 3.98. TPES Diversity in Japan

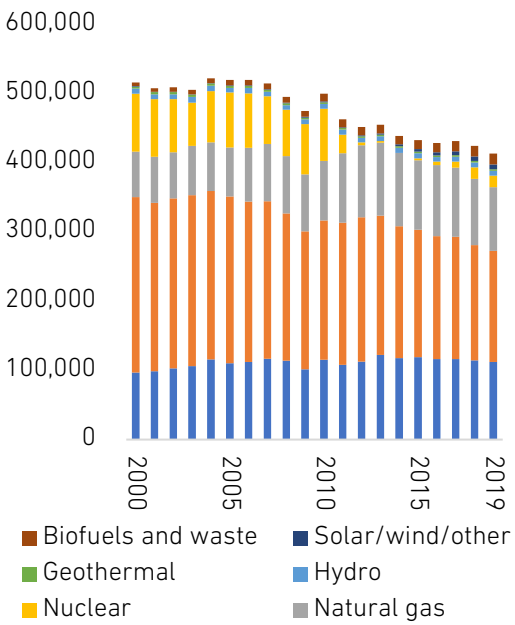


Figure 3.99. Power Generation Diversity in Japan

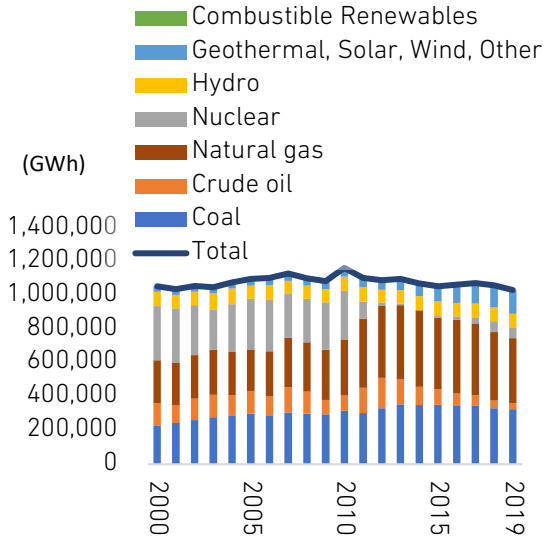


Figure 3.100. Import Diversity (crude oil) in Japan

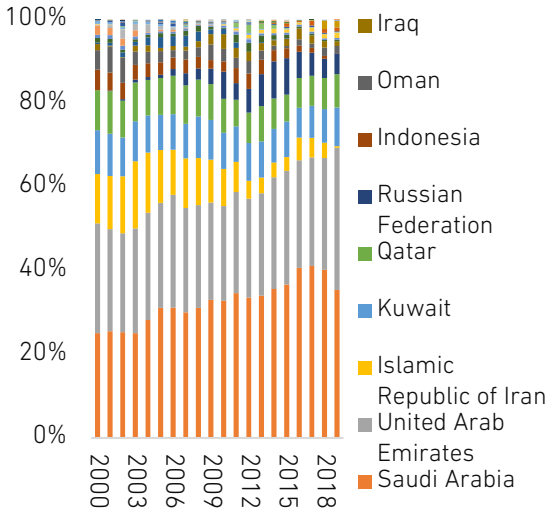


Figure 3.101. Import Diversity (coal) in Japan

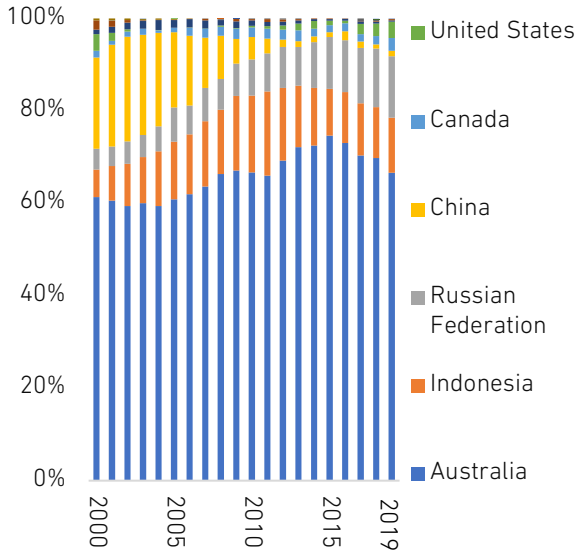
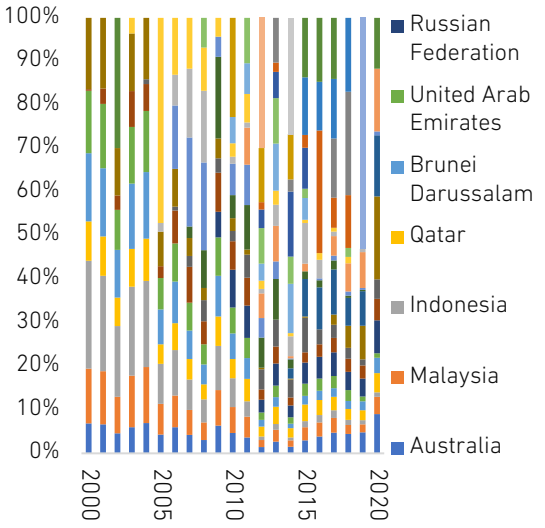


Figure 3.102. Import Diversity (LNG) in Japan



GDP = gross domestic product, GWh = gigawatt hour, LNG = liquefied natural gas, toe = tonne of oil equivalent, TPES = total primary energy supply, USD = United States dollar.
Note: Most recent data available for each country.
Source: Authors based on IEA (2022b), IEA (2022c), IEA (2022d), Cedigaz (2022).

3.2.12.2. Energy policy overview

In 2002, the Basic Act on Energy Policy was enacted. The basic policy is to ensure stable supply, environmental compatibility, and use of market principles. In March 2011, the Great East Japan Earthquake occurred, and the energy policy was reviewed. The Cabinet approved the 4th Strategic Energy Plan in 2014, the 5th Plan in 2018, the 6th Plan in 2021, and the 7th Plan in 2025. In the latest plan, the government encourages the maximum introduction of renewable energy, whilst promoting coexistence with local communities and minimising the public burden. The plan also mentioned that it

is important to minimise overall integration costs for society. With regard to nuclear power, the plan aims to sustainably utilise nuclear power at the necessary scale, with safety as the top priority. The government continues to promote the phase-out of inefficient coal-fired power generation by 2030, and efforts utilising ammonia and CCUS in the long term. Regarding LNG, LNG power plants are maintained and will be replaced with the objective of future decarbonisation through long-term decarbonised power generation auctions. The plan acknowledged that oil remains a vital energy source for daily life and economic activities due to its high energy density, well-developed stockpile system, portability, and ease of storage. These characteristics position oil as a reliable energy supply in times of crisis.

3.2.12.3. ESI overview

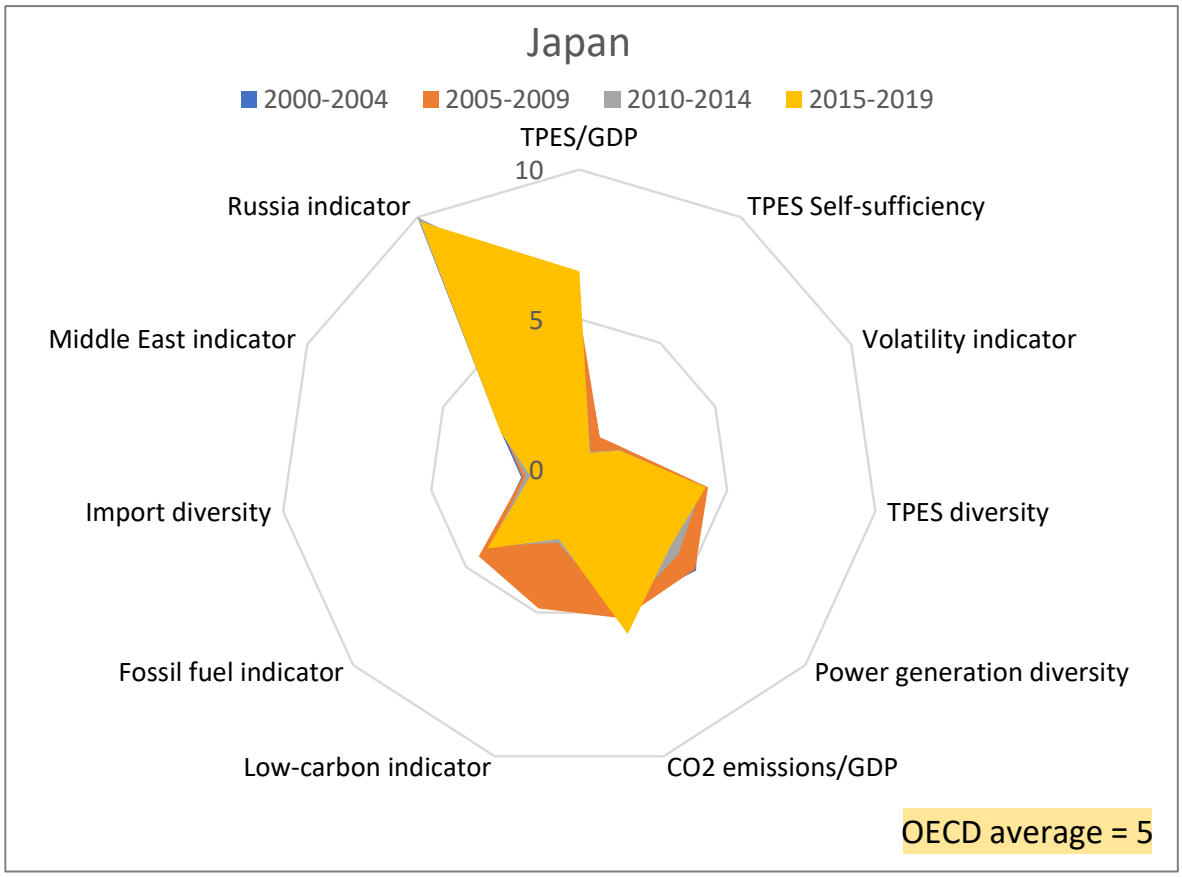
Japan is characterised by a high share of imported fossil fuels, which is greatly affected by fossil fuel price volatility. On the other hand, TPES/GDP have been improving in recent years. TPES diversity is almost unchanged, similar to the OECD average. Power generation diversity, CO_2 emissions/GDP, low-carbon indicator, fossil fuel indicator, and volatility risk indicator have been worsening. Import diversity and Middle East indicator have remained the same for over past 20 years but are below the OECD average (Table 3.13, Figure 3.103).

Table 3.13. Major ESIs in Japan in Comparison with OECD Average

Selected ESIs	2000–2004	2005–2009	2010–2014	2015–2019
TPES/GDP	5	5	6	7
TPES self-sufficiency	1	1	1	1
Volatility risk indicator	2	2	1	1
TPES diversity	4	4	4	4
Power generation diversity	5	5	4	4
CO_2 emissions/GDP	5	5	5	6
Low-carbon indicator	5	5	3	2
Fossil fuel indicator	4	4	4	4
Import Diversity	2	2	2	2
Middle East indicator	3	3	3	3
Russia indicator	10	10	10	10

ESI = energy security index, GDP = gross domestic product, LNG = liquefied natural gas, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Figure 3.103. Major ESIs in Japan in Comparison with OECD Average



GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, TPES = total primary energy supply.
Note: Most recent data available for each country.
Source: Authors.

Chapter 4
Conclusions and Policy Implications

In this study, we re-examined the method of assessing energy security based on the previous study conducted 10 years ago and found no major changes in terms of items and indicators to be evaluated. This can be said to indicate that the important points in assessing the energy security of the Association of Southeast Asian Nations (ASEAN) Member States have not changed from the past, even though there is an energy security supply crisis due to factors such as the Russian invasion of Ukraine and the strengthening of climate change measures.

Reflecting the energy situation in each country, improvements in the energy security index (ESI) have varied. Looking at the trends over the past 20 years, diversification (mainly TPES and power generation) has increased in each country. At the same time, however, diversification often comes from the expanded use of fossil fuels, such as coal-fired power, in the context of growing economies.

4.1. Importance of Low-carbon and Decarbonised Use of Fossil Fuels

Non-fossil energy (mainly renewable energy) is important from the viewpoint of decarbonisation, but the amount of electricity generated depends on the season and weather. Therefore, electricity derived from fossil energy that can provide a stable amount of power, is essential. Thermal power generation also plays a role as a regulating power source for renewable energy, so it is expected to continue to be one of the important power sources in the future. The use of fossil energy, which has the advantage of stability, will help to ensure energy security in the medium- to long-term, avoid power outages, and curb rising energy prices. In addition, decarbonisation of fossil fuels is important to achieve compatibility with climate change goals.

ASEAN Member States will inevitably continue to increase their energy demand in the future, and they will need to continue to provide a stable supply of large amounts of energy. Meanwhile, it is also important for ASEAN Member States to actively promote low-carbon and decarbonisation of energy sources to reduce global CO_2 emissions in the future. Therefore, fossil fuels are essential for many emerging countries to achieve both economic growth and decarbonisation. It is more important to identify the process of achieving decarbonisation by considering each country's specific circumstances.

4.2. Concrete Ways to Make the Energy System Resilient

Decarbonisation efforts utilising existing fossil fuel-fired power plants (replacement of existing coal- and gas-fired power plants to higher efficiency technologies, co-firing or 100% firing of hydrogen and ammonia) are an option, although the up-front cost is an issue. Cooperation with countries outside the ASEAN region for the commercialisation of carbon capture and storage (CCS) technology is also critical. If thermal power generation supports stable supply, from an energy security perspective (stability of supply and price), diversification of fossil fuel import facilities in each country, expansion of fossil fuel import/export, and stockpiles in the region are also important.

Whilst the potential for renewables varies from country to country, the international grid connection within the region will help improve the stable supply of electricity in ASEAN region as a whole. As set out in the APAEC Phase II: 2021–2025, accelerating the progress of ASEAN power grid projects and expanding multilateral electricity trading whilst incorporating variable renewables in the grid are vital milestones (ASEAN Centre for Energy, 2020). On the other hand, one of the challenges in expanding the introduction of renewable energy such as solar and wind power is how to deal with fluctuations in power generation due to natural conditions such as weather. In addition, supply shortages due to power supply problems caused by storms and floods, which are exacerbated by climate change, are also expected. In addition to multiplexing and dispersing energy sources and strengthening the power network that connects them, it is necessary to expand the introduction of energy storage systems that respond to fluctuations in supply and demand, and energy resource aggregation systems such as demand response and virtual power plants.

4.3. Issue of CO_2 Emissions Attribution

Some ASEAN Member States are currently using independent power producers to build fossil fuel power plants in other countries and to import electricity. The responsibility for controlling and reducing CO_2 emissions should originally belong to consuming countries, but at present, such emissions cannot be counted. Therefore, the issue of attribution of CO_2 emissions needs to be sorted out. It would be reasonable to attribute it to the consuming country, but since cross-border electricity trade will continue to increase, we need to quickly sort out whether CO_2 should be attributed to the generating country or the consuming country by establishing adequate calculation and distribution method as well as a regional system.

4.4. Issue of Carbon Intensity and Roles of Local SMEs Towards Decarbonisation

Furthermore, in order to achieve the decarbonisation target, it is necessary to promote measures in all sectors. In the industry sector, which emits a large amount of CO_2, most

companies in the sector are local small and medium-sized enterprises (SMEs). However, SMEs lag behind international companies in terms of knowledge, human resources, and know-how related to low-carbon and decarbonisation. The target of decarbonisation is impossible to achieve without raising the level of SMEs. Therefore, in lowering the carbon intensity of each country, it is crucial to support strengthening the capacity of local SMEs, which are different from large companies operating in the international market, to strengthen their ability to respond. Local SMEs should be provided with information on carbon neutrality, guidance from experts, and easy-to-use tools to help them measure and understand their emissions, and more financial support for the introduction of energy-saving and decarbonising equipment.

4.5. Country-specific Recommendations for ASEAN Member States

In addition to the above recommendations, we recommend the following based on the ESI characteristics of each selected ASEAN Member State:

For nine ASEAN Member States, improving energy efficiency is key to ensuring energy security and decarbonisation under the situation of expected high economic growth. As many countries have introduced laws and regulations on energy efficiency, it is crucial to regularly review performance standards or public awareness measures.

Cambodia needs to diversify its sources of fossil fuel imports, whilst fossil fuel imports are expected to increase to meet energy demand in the coming decades. Improving energy efficiency would also help to reduce energy dependence from abroad, and in this context, the target proposed in the National Energy Efficiency Policy 2022–2030 should be achieved. For *Indonesia*, promoting carbon capture and storage (CCS) projects at each stage of the oil and gas supply chain is important to improve CO_2 intensity. Realising CCS business as well as fuel switching to natural gas/LNG in power generation would contribute to achieving carbon neutrality by 2060. For *Lao PDR*, as a landlocked country, strengthening regional cooperation to diversify import infrastructure is crucial. As coal is expected to play a significant role in primary energy supply in the coming decades, the expansion of renewables alongside hydropower would improve CO_2 intensity. *Malaysia* should take advantage of abundant CCS capacity to reduce CO_2 intensity and achieve carbon neutrality by 2050, as natural gas will be a major energy source in the coming decades. *Myanmar* should consider biomass co-firing with coal-fired power plants with regional and international cooperation or pursue regional cooperation on CCS technology to reduce CO_2 intensity as hydropower and coal are expected to become major sources of electricity generation by 2050. It is important for the *Philippines* to further diversify its sources of fossil fuel imports, especially coal and natural gas, as coal power generation will remain at a certain level and LNG imports are expected to increase in the medium term. *Singapore* has continued its efforts to diversify its sources of fossil fuel imports and should continue

to do so as oil and natural gas will play an important role in its energy supply in the long term. For *Thailand*, promoting and developing CCS projects with regional cooperation will help improve CO_2 intensity and achieve carbon neutrality by 2060. In addition, further diversification of supply sources should be pursued along with the expansion of LNG imports. Viet Nam's domestic natural gas production is expected to decline, which will increase LNG import capacity in the medium term. Promoting fuel switching from coal to natural gas is necessary to achieve carbon neutrality by 2050, whilst keeping an eye on LNG supply diversification.

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