Chapter 2

Cost and Benefit of Energy Efficiency and Conservation Financing

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Chapter 2

Cost and Benefit of Energy Efficiency and Conservation Financing

In the Association of Southeast Asian Nations (ASEAN) member countries, demand for electricity is growing faster than the demand for any other type of energy. Thus, curbing the demand increase through efficiency improvement is a crucial part of the energy policy in this region. Against this background, this chapter focuses on assessing the cost and benefits of energy efficiency and conservation (EE&C) with respect to electricity.

The potential for electricity saving is calculated based on the scenarios in the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Outlook 2019. This chapter evaluates savings on electricity bills, a direct benefit of electricity saving, as well as avoided investment in power generation capacity and avoided carbon dioxide (CO_2) emissions, which are indirect benefits.

2.1. Estimation of Direct Benefit (Savings on Electricity Bills)

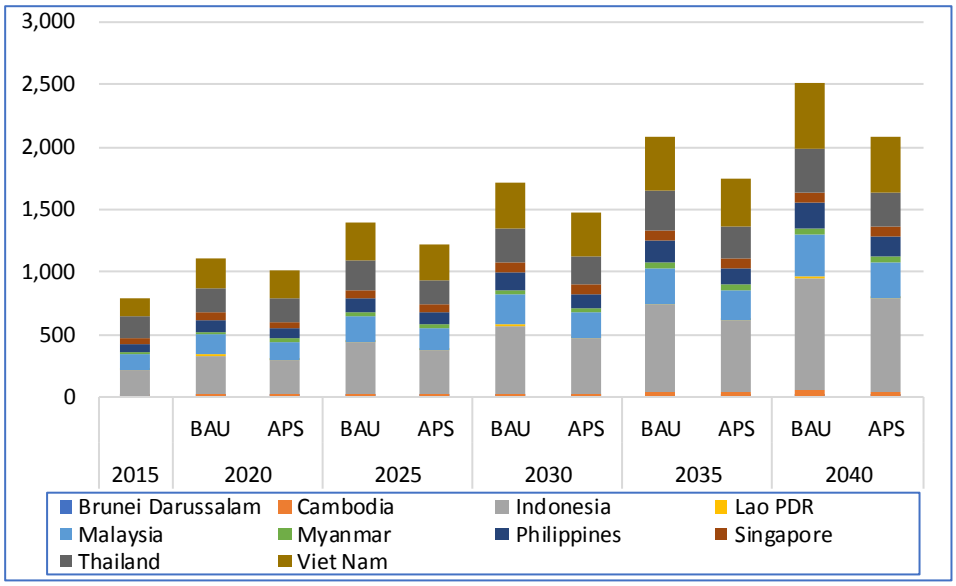
2.1.1. Electricity Saving Potential

The ERIA Energy Outlook 2019 considers two scenarios: business as usual (BAU) and the alternative policy scenario (APS). The APS reflects not only more ambitious energy saving targets but also the rapid advance of low-carbon energy technologies, especially renewable energy.

Figure 2.1 compares the electricity demand outlook in each scenario. Indonesia has the largest electricity demand in ASEAN, followed by Viet Nam, Thailand, and Malaysia.

Figure 2.1: Comparison of Electricity Demand Outlook by Scenario

(terawatt-hour)

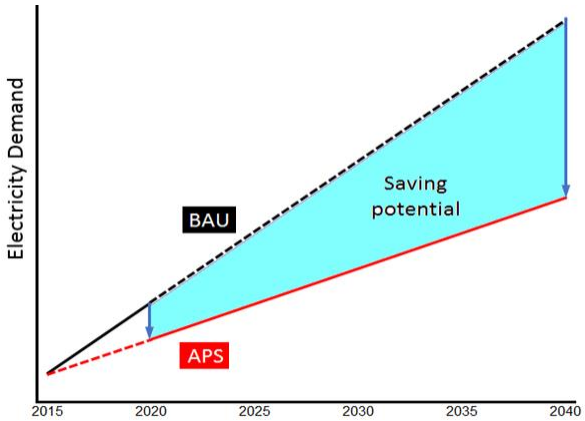


APS = alternative policy scenario, BAU = business as usual, Lao PDR = Lao People's Democratic Republic.

Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

In this section, the difference in electricity demand between BAU and the APS is regarded as the electricity saving potential (see Figure 2.2).

Figure 2.2: Electricity Saving Potential



APS = alternative policy scenario, BAU = business as usual.

Source: Author.

Table 2.1 shows the calculated electricity saving potential by country. In ASEAN, the cumulative electricity saving potential from 2020 to 2040 will reach 5,082 terawatt-hours (TWh), approximately twice the electricity demand by 2040 in the APS. Indonesia has the largest electricity saving potential in ASEAN, followed by Thailand. The calculation process is shown in Appendix 1.

Table 2.1: Electricity Saving Potential (Alternative Policy Scenario–Business as Usual)

(terawatt-hour)

Country	2020–2025	2025–2030	2030–2035	2035–2040	Total (2020–2040)
Brunei Darussalam	-3.1	-6.2	-15.1	-21.5	-45.9
Cambodia	-3.9	-8.4	-15.6	-24.2	-52.1
Indonesia	-253.4	-390.3	-542.9	-703.5	-1,890.2
Lao PDR	-2.7	-3.2	-4.0	-4.9	-14.7
Malaysia	-92.4	-130.2	-177.5	-234.3	-634.5
Myanmar	-12.2	-27.3	-41.0	-51.5	-131.9
Philippines	-99.0	-159.2	-168.0	-183.3	-609.5
Singapore	-4.2	-8.0	-12.6	-17.9	-42.8
Thailand	-130.3	-214.5	-289.2	-367.9	-1,001.9
Viet Nam	-55.6	-115.0	-193.6	-294.1	-658.3
ASEAN	-656.7	-1,062.4	-1,459.5	-1,903.2	-5,081.9

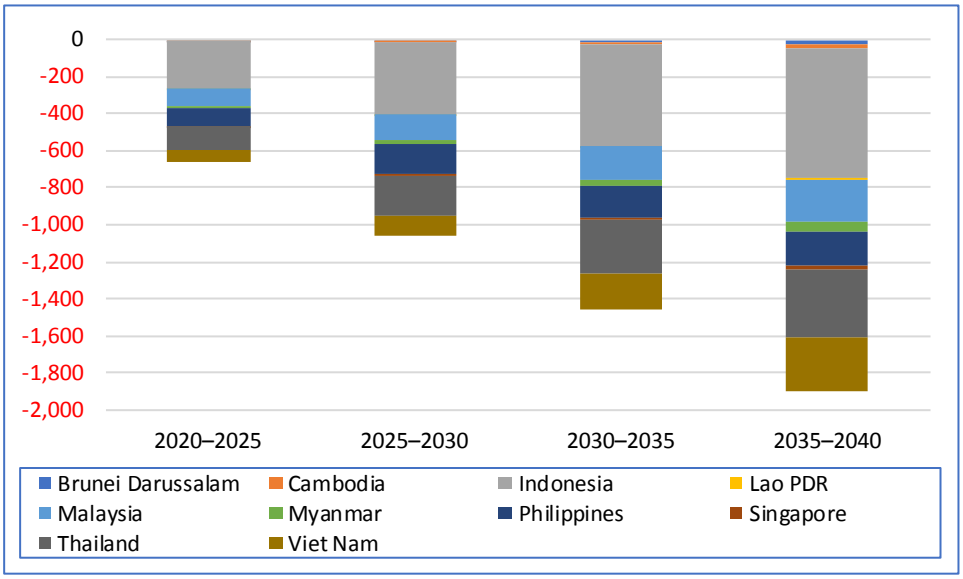
ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

Figure 2.3 shows the electricity saving potential by periods.

Figure 2.3: Electricity Saving Potential by Periods

(terawatt-hour)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.1.2. Savings on Electricity Bills through Investment in Electricity Saving Potential

Formula

A decrease in electricity demand will result in reduced electricity bills, which can be regarded as an economic benefit of EE&C investment. This section estimates two types of benefits, as follows:

Gross benefit [$] = saved electricity amount [(kilowatt-hour) kWh]
* Unit electricity price [$/kWh]

Net benefit [$] = gross benefit [$] – investment amount [$] (1)

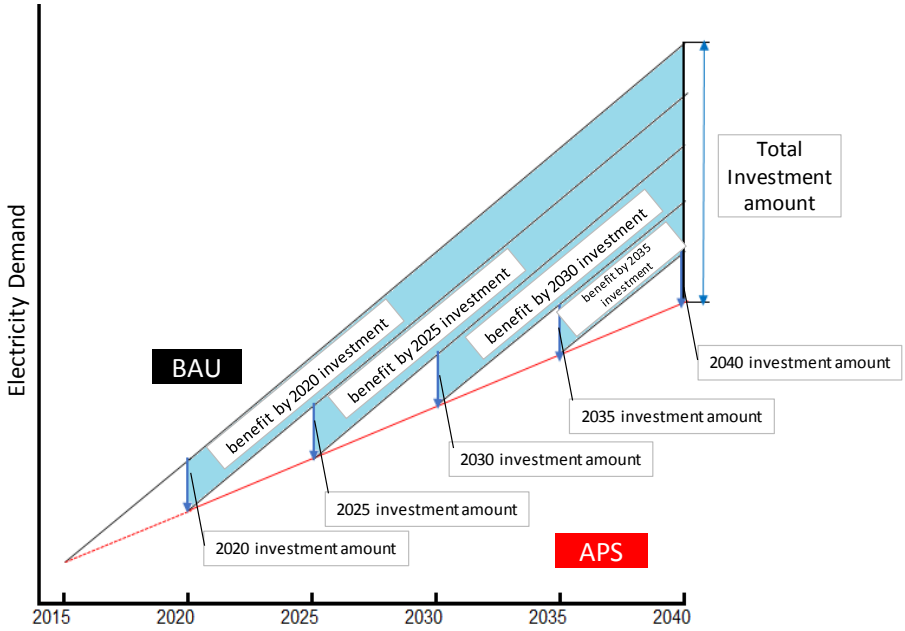
Saved Electricity Amount

The study assumes that the effect of EE&C investment will last without degression until the end of the evaluation period (in 2040). Here, the effect of EE&C investment means a reduction in electricity demand and, consequently, in electricity bills.

To simplify the calculation, we assume that the electricity saving investment will be made every 5 years, yielding a total of five investment activities. The initial investment will be made in 2020, additional investment-1 in 2025, additional investment-2 in 2030, additional investment-3 in 2035, and additional investment-4 in 2040.

Figure 2.4 depicts the investment timing and corresponding gross benefit based on the assumption outlined above. For example, the effect of initial investment made in 2020 is shown as 'benefit by 2020 investment'.

Figure 2.4: Image of Gross Benefits



APS = alternative policy scenario, BAU = business as usual.

Source: Author.

Unit Electricity Price

Table 2.2 shows the unit electricity price. The data source of the electricity prices is described in Appendix 2.

Table 2.2: Electricity Price by Country

Country	Year	Price ($0.01/kWh)
Cambodia	2017	17.1
Indonesia	2017	8.1
Lao PDR	2018	8.6
Malaysia	2016	9.6
Myanmar	2017	5.0
Philippines	2016	14.9
Thailand	2018	11.4
Viet Nam	2017	9.3

kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic.

Source: See Appendix 2.

Calculated Result

Tables 2.3–2.7 show the calculated results for gross benefits. The calculation process is described in Appendix 3.

Table 2.3: Effects of Initial Investment (Gross Benefit-1)

Country	Reduced electricity bill ($ billion)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-0.4	-0.4	-0.4	-0.4	-0.1
Indonesia	-15.9	-15.9	-15.9	-15.9	-3.2
Lao PDR	-0.2	-0.2	-0.2	-0.2	-0.0
Malaysia	-7.3	-7.3	-7.3	-7.3	-1.5
Myanmar	-0.3	-0.3	-0.3	-0.3	-0.1
Philippines	-6.7	-6.7	-6.7	-6.7	-1.3
Thailand	-9.0	-9.0	-9.0	-9.0	-1.8
Viet Nam	-2.8	-2.8	-2.8	-2.8	-0.6
ASEAN	-42.5	-42.5	-42.5	-42.5	-8.5

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Table 2.4: Effects of Additional Investment-1 (Gross Benefit-2)

Country	Reduced electricity bill ($ billion)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-0.6	-0.6	-0.6	-0.1
Indonesia	-	-9.1	-9.1	-9.1	-1.8
Lao PDR	-	-0.0	-0.0	-0.0	-0.0
Malaysia	-	-3.2	-3.2	-3.2	-0.6
Myanmar	-	-0.6	-0.6	-0.6	-0.1
Philippines	-	-16.1	-16.1	-16.1	-3.2
Thailand	-	-11.7	-11.7	-11.7	-2.3
Viet Nam	-	-4.6	-4.6	-4.6	-0.9
ASEAN	-	-46.0	-46.0	-46.0	-9.2

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Table 2.5: Effects of Additional Investment-2 (Gross Benefit-3)

Country	Reduced electricity bill ($ billion)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-0.9	-0.9	-0.2
Indonesia	-	-	-13.0	-13.0	-2.6
Lao PDR	-	-	-0.1	-0.1	-0.0
Malaysia	-	-	-4.1	-4.1	-0.8
Myanmar	-	-	-0.9	-0.9	-0.2
Philippines	-	-	-1.8	-1.8	-0.4
Thailand	-	-	-7.5	-7.5	-1.5
Viet Nam	-	-	-6.4	-6.4	-1.3
ASEAN	-	-	-34.5	-34.5	-6.9

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Table 2.6: Effects of Additional Investment-3 (Gross Benefit-4)

Country	Reduced electricity bill ($ billion)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-	-1.5	-0.3
Indonesia	-	-	-	-11.6	-2.3
Lao PDR	-	-	-	-0.1	-0.0
Malaysia	-	-	-	-5.0	-1.0
Myanmar	-	-	-	-0.5	-0.1
Philippines	-	-	-	-0.8	-0.2
Thailand	-	-	-	-9.6	-1.9
Viet Nam	-	-	-	-8.2	-1.6
ASEAN	-	-	-	-37.2	-7.4

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Table 2.7: Effects of Additional Investment-4 (Gross Benefit-5)

Country	Reduced electricity bill ($ billion)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-	-	-0.3
Indonesia	-	-	-	-	-2.8
Lao PDR	-	-	-	-	-0.0
Malaysia	-	-	-	-	-1.2
Myanmar	-	-	-	-	-0.1
Philippines	-	-	-	-	-0.8
Thailand	-	-	-	-	-1.7
Viet Nam	-	-	-	-	-2.1
ASEAN	-	-	-	-	-9.0

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Table 2.8 shows the cumulative gross benefit. The calculation process is described in Appendix 4.

Table 2.8: Cumulative Gross Benefit by Country

Country	Cumulative Gross Benefit ($ billion)					
	2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Cambodia	-0.4	-1.0	-1.9	-3.4	-1.0	-7.6
Indonesia	-15.9	-24.9	-37.9	-49.5	-12.8	-141.0
Lao PDR	-0.2	-0.3	-0.3	-0.4	-0.1	-1.2
Malaysia	-7.3	-10.4	-14.5	-19.5	-5.1	-56.8
Myanmar	-0.3	-0.9	-1.8	-2.3	-0.6	-5.9
Philippines	-6.7	-22.8	-24.6	-25.4	-5.8	-85.3
Thailand	-9.0	-20.7	-28.2	-37.7	-9.2	-104.9
Viet Nam	-2.8	-7.5	-13.8	-22.0	-6.5	-52.6
ASEAN	-42.5	-88.5	-123.0	-160.2	-41.0	-455.2

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

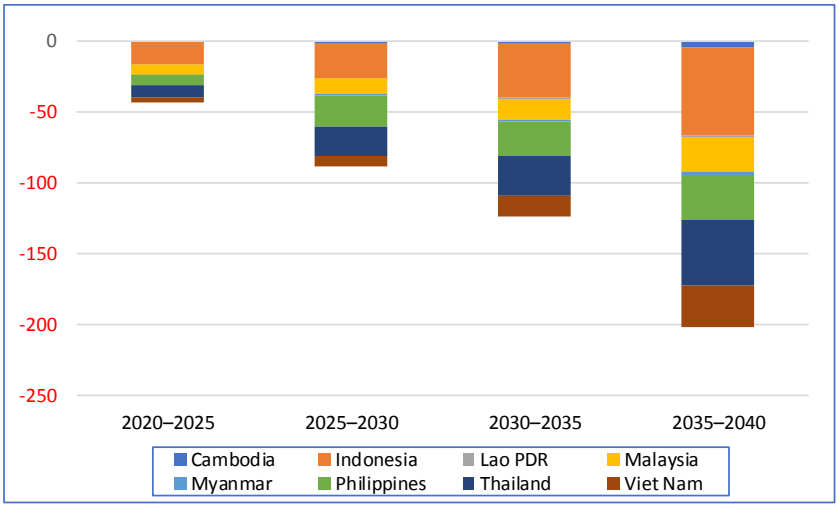
Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Figure 2.5 shows cumulative gross benefit by periods.

Figure 2.5: Cumulative Gross Benefit by Periods

($ billion)



Lao PDR = Lao People's Democratic Republic.

Note: 2035–2040 = 6 years, others = 5 years.

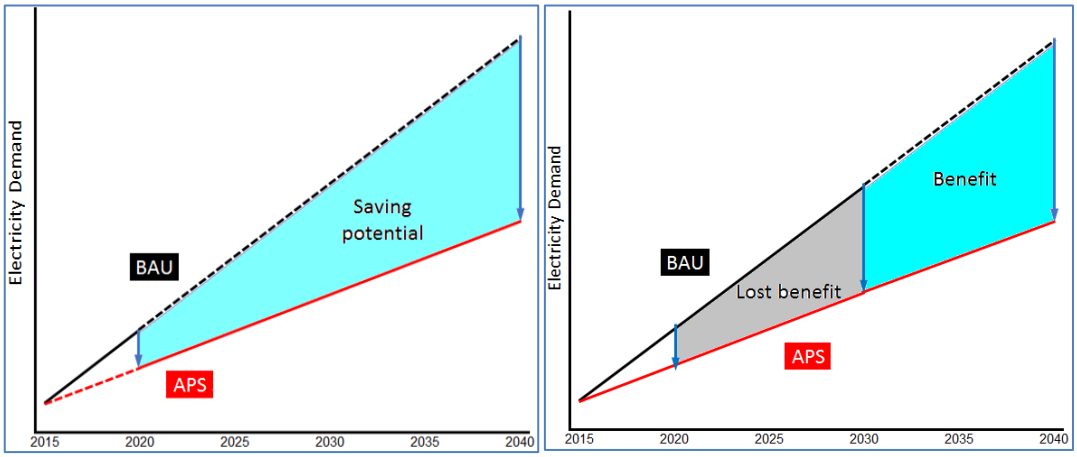
Source: Author.

Box 2.1 Relationship between Benefit and Investment

In this study, it is assumed that EE&C investment will begin in 2020. However, what if the timing of initial investments is delayed until after 2020? How do the investment and benefit amounts affect each other? Figure 2.6 compares two cases in which the initial investment will be made in 2020 and in 2030, respectively. As indicated in the figure, the delayed investment will result in a smaller benefit, although the same amount of investment will be necessary to attain the same level of electricity saving in 2040. This means that delayed investment timing slashes the economic efficiency of investment. In other words, earlier investment yields a greater benefit.

Figure 2.6: Investment and Benefit

Investment from 2020 Investment from 2030



APS = alternative policy scenario, BAU = business as usual.
Source: Author.

Table 2.9 shows the lost benefits by the investment start year in ASEAN. If the investments are delayed for 5 years, the value of the lost benefits will reach $42.5 billion. If the investments are delayed by 15 years, the value of the lost benefits will reach $123.0 billion.

Table 2.9: Lost Benefits by Investment Start Year (Association of Southeast Asian Nations)

Investment start	2020–2024	2025–2029	2030–2034	2035–2039	2040	Total ($ billion)
2020	42.5	42.5	42.5	42.5	8.5	178.4
2025		46.0	46.0	46.0	9.2	147.2
2030			34.5	34.5	6.9	76.0
2035				37.2	7.4	44.7
2040					9.0	9.0
Lost benefit	42.5	88.5	123.0	160.2	41.0	455.2

Source: Author.

2.1.3. Required Investment in Electricity Saving Potential

Average Unit Cost of Electricity Saving

Due to limited available information, this study refers to the case of Japan (see Chapter 1). In Japan, designated financing agencies disclose their annual results, including the amount of EE&C financing and corresponding energy savings, although the data are limited to the industry sector in a single year (fiscal year 2017). Furthermore, the disclosed information regarding the amount of saved energy does not distinguish between electricity and heat. Therefore in this calculation, we employed appliances that are assumed to consume only electricity, namely high-efficiency lighting, high-efficiency air conditioners, transformers, refrigerators and freezers, and industrial motors. The calculated average unit cost of electricity savings in Japan is shown below. The calculation process is shown in Appendix 5. We applied the unit cost to estimate the investment amount necessary to achieve a certain amount of electricity savings in ASEAN member countries. Application of the coefficient is thought to provide an assessment on the safe side, as commodity prices are higher in Japan than in the ASEAN countries, i.e. the average unit cost of electricity savings in ASEAN countries may be lower than assumed.

Average unit cost of electricity savings = $301 million/ TWh (2)

Required Investment Amount

The required investment amount can be calculated by the following equation:

Required investment amount [$] = Average unit cost of electricity saving [$/TWh] * Electricity saving potential [TWh] (3)

It is assumed that the electricity saving investment will be made every 5 years from 2020 to 2040, for a total of five investment activities. Table 2.10 shows the required EE&C investment amount by country. This calculation, which is made every 5 years, is complex; the process is described in Appendix 6. The cumulative required EE&C investment to materialise the electricity saving potential from 2020 to 2040 will reach $129 billion in ASEAN. Although the investment amount is not small, the gross benefit is far greater (Table 2.8).

Table 2.10: Required Amount of Energy Efficiency and Conservation Investment by Country

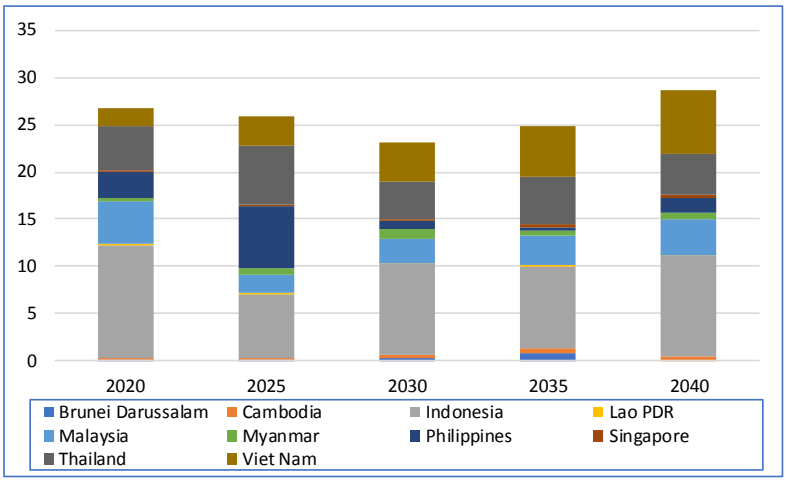
Country	Initial investment	Additional investment -1	Additional investment -2	Additional investment -3	Additional investment -4	**Total** ($ billion)
	2020	2025	2030	2035	2040	
Brunei Darussalam	0.2	0.1	0.3	0.8	0.0	**1.3**
Cambodia	0.1	0.2	0.3	0.5	0.5	**1.7**
Indonesia	11.9	6.8	9.7	8.7	10.7	**47.7**
Lao PDR	0.1	0.0	0.0	0.0	0.1	**0.3**
Malaysia	4.6	2.0	2.6	3.1	3.7	**16.0**
Myanmar	0.4	0.7	1.1	0.6	0.7	**3.5**
Philippines	2.7	6.5	0.7	0.3	1.5	**11.8**
Singapore	0.1	0.2	0.3	0.3	0.3	**1.3**
Thailand	4.7	6.2	3.9	5.1	4.4	**24.4**
Viet Nam	1.8	3.0	4.1	5.3	6.8	**21.1**
ASEAN	26.7	25.8	23.1	24.8	28.7	**129.1**

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.
Source: Author.

Figure 2.7 shows the required investment by investment timing.

Figure 2.7: Required Investment

($ billion)



Lao PDR = Lao People's Democratic Republic.
Source: Author.

Table 2.11 shows the net benefit (gross benefit − investment) by country.

Table 2.11: Net Benefit by Country

Country	Gross benefit ($ billion)	Required investment ($ billion)	Net benefit ($ billion)
Cambodia	-7.6	1.7	-5.9
Indonesia	-141.0	47.7	-93.2
Lao PDR	-1.2	0.3	-0.9
Malaysia	-56.8	16.0	-40.8
Myanmar	-5.9	3.5	-2.4
Philippines	-85.3	11.8	-73.5
Thailand	-104.9	24.4	-80.5
Viet Nam	-52.6	21.1	-31.5
ASEAN	-455.2	126.5	-328.7

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.2. Estimation of Indirect Benefits

This section examines avoided investment in power generation capacity and avoided CO_2 emissions as indirect benefits that can be gained as a result of electricity savings.

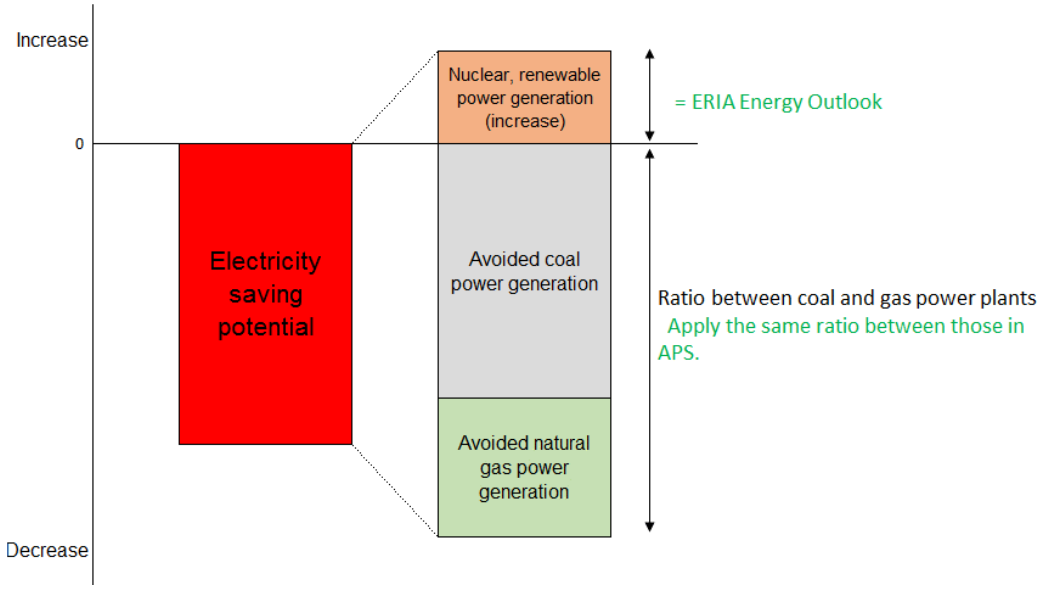
2.2.1. Avoided Investment in Power Generation Capacity

Method and Assumption

Materialising electricity saving potential (BAU–APS) leads to avoided investment in new power generation capacities. This section examines avoided power generation capacities based on the following assumptions:

(i) Nuclear and renewable power generation, as well as electricity imports and exports, will not be affected even after the electricity demand is reduced. Figure 2.8 depicts this assumption.

Figure 2.8: Image of Avoided Power Generation



APS = alternative policy scenario, ERIA = Economic Research Institute for ASEAN and East Asia.

Source: Author.

(ii) Avoided coal and natural gas power generation (in kWh) is calculated as follows:

Electricity saving potential – nuclear and renewable power generation (4)

(iii) Ratio of avoided coal and natural gas power generation is calculated by applying the same ratio of coal and natural gas power generation in APS.

(iv) The estimation will be made for the year 2040.

(v) The unit construction cost of coal and natural gas electricity generation capacity and capacity factor are referred to in the Southeast Asia Energy Outlook 2015 produced by the International Energy Agency (IEA). Table 2.12 shows the unit construction cost and capacity factor.

Table 2.12: Unit Construction Cost and Capacity Factor (Coal and Natural Gas)

Fuel	Unit construction cost	Capacity factor
Coal (SC)	$1,600/kW	75%
Natural gas (CCGT)	$700/kW	60%

CCGT = combined cycle gas turbine, kW = kilowatt, SC = super critical.

Source: International Energy Agency (2015), *Southeast Asia Energy Outlook 2015*. Paris: International Energy Agency.

Estimation of Avoided Coal and Natural Gas Power Plant Costs

Table 2.13 shows the avoided electricity generation. In ASEAN, 710 megawatt-hours will be avoided in 2040, or 27% of all electricity generated in ASEAN in that year.

Table 2.13: Avoided Electricity Generation (2040)

(terawatt-hour)

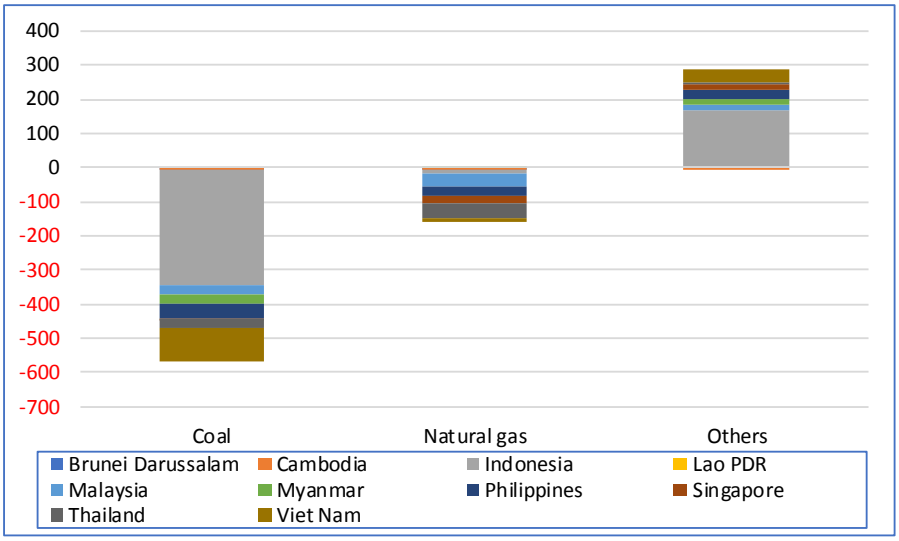
Country	APS–BAU					Avoided electricity generation
	Electricity saving potential	Electricity generation by fuel				
		Total	Coal	Natural gas	Others	
Brunei Darussalam	-4	-5	-3	-3	1	-5
Cambodia	-6	-12	-2	-6	-5	-1
Indonesia	-158	-176	-337	-9	170	-329
Lao PDR	-1	0	0	0	0	-1
Malaysia	-53	-56	-32	-39	15	-68
Myanmar	-11	-13	-26	0	13	-25
Philippines	-39	-43	-43	-27	26	-65
Singapore	-4	-4	-0	-22	18	-22
Thailand	-81	-61	-29	-40	7	-88
Viet Nam	-70	-75	-96	-15	35	-105
ASEAN	**-428**	**-446**	**-567**	**-161**	**282**	**-710**

APS = alternative policy scenario, ASEAN = Association for Southeast Asian Nations, BAU = business as usual, Lao PDR = Lao People's Democratic Republic.

Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

Figure 2.9: Avoided Electricity Generation by Fuel, Association of Southeast Asian Nations

(terawatt-hour)



Lao PDR = Lao People's Democratic Republic.
Source: Author.

Table 2.14 shows the avoided coal and natural gas electricity generation and capacity.

Table 2.14: Avoided Coal and Natural Gas Electricity Generation and Capacity

Country	Electricity generation APS (TWh)		Avoided electricity generation (TWh)			Avoided generation capacity (MW)	
	Coal	Natural gas	Coal	Natural gas	Total	Coal	Natural gas
Brunei Darussalam	1	11	-0	-5	-5	-54	-912
Cambodia	11	1	-1	-0	-1	-125	-14
Indonesia	344	211	-204	-125	-329	-31,021	-23,744
Lao PDR	45	0	-1	0	-1	-164	0
Malaysia	114	152	-29	-39	-68	-4,434	-7,409
Myanmar	1	14	-1	-24	-25	-136	-4,540
Philippines	62	29	-45	-21	-65	-6,774	-3,987
Singapore	1	63	-0	-22	-22	-57	-4,165
Thailand	43	121	-23	-65	-88	-3,521	-12,407
Viet Nam	281	95	-79	-27	-105	-12,003	-5,050
ASEAN	**903**	**697**	**-383**	**-327**	**-710**	**-58,290**	**-62,228**

APS = alternative policy scenario, ASEAN = Association for Southeast Asian Nations, BAU = business as usual, Lao PDR = Lao People's Democratic Republic, MW = megawatt, TWh = terawatt-hour.

Source: Author.

Table 2.15 shows the avoided coal and natural gas electricity generation capacity. Land cost is excluded because it varies greatly country by country, location by location, and condition by condition.

Table 2.15: Avoided Coal and Natural Gas Generation Capacity Construction Cost

Country	Avoided generation capacity (MW)		Avoided construction cost ($ billion)		
	Coal	Natural gas	Coal	Natural gas	Total
Brunei Darussalam	-54	-912	-0.1	-0.6	-0.7
Cambodia	-125	-14	-0.2	-0.0	-0.2
Indonesia	-31,021	-23,744	-49.6	-16.6	-66.3
Lao PDR	-164	0	-0.3	0.0	-0.3
Malaysia	-4,434	-7,409	-7.1	-5.2	-12.3
Myanmar	-136	-4,540	-0.2	-3.2	-3.4
Philippines	-6,774	-3,987	-10.8	-2.8	-13.6
Singapore	-57	-4,165	-0.1	-2.9	-3.0
Thailand	-3,521	-12,407	-5.6	-8.7	-14.3
Viet Nam	-12,003	-5,050	-19.2	-3.5	-22.7
ASEAN	**-58,290**	**-62,228**	**-93.3**	**-43.6**	**-136.8**

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, MW = megawatt.

Note: Land cost is excluded.

Source: Author.

Estimation of Increasing Nuclear and Renewable Power Plant Cost

Although coal and natural gas electricity generation will decrease due to a lower electricity demand, nuclear and renewable electricity generation will increase in APS compared to BAU in many cases. Table 2.16 shows the increase in nuclear and renewable electricity generation. As biomass, solar, and wind electricity generation are not distinguished in the ERIA Energy Outlook 2019, the generation fuel labelled 'Others' in the outlook is divided by the input share of these three fuels based on the energy balance table. The calculation method is described in Appendix 7.

Table 2.16: Increase of Nuclear and Renewable Electricity Generation (Alternative Policy Scenario–Business as Usual)

(terawatt-hour)

Country	Nuclear	Hydro	Geothermal	Biomass	Solar	Wind	Total
Brunei Darussalam	-	-	-	-	0.9	-	0.9
Cambodia	-	-6.7	-	1.4	0.5	0.0	-4.8
Indonesia	18.9	43.8	25.8	67.6	0.5	4.3	160.8
Lao PDR	-	-	-	-	-	-	-
Malaysia	8.3	1.5	0.0	1.0	4.3	0.0	15.0
Myanmar	0.0	7.5	0.0	1.8	3.8	0.1	13.3
Philippines	14.4	6.6	-1.4	-1.4	5.2	3.7	27.1
Singapore	-	-	-	-	17.7	-	17.7
Thailand	9.8	1.2	-	-3.3	1.0	0.8	9.5
Viet Nam	-	-7.0	-	15.0	15.0	12.3	35.4
ASEAN	**51.4**	**47.0**	**24.4**	**82.1**	**48.9**	**21.2**	**274.9**

ASEAN = Association of Southeast Asian Nations, Hydro = hydropower, Lao PDR = Lao People's Democratic Republic.

Note: It is not necessary to increase generation of all fuels.

Source: Author.

For wind, solar, hydropower, and geothermal electricity, the unit construction cost of electricity generation capacity and capacity factor are referred to in the Southeast Asia Energy Outlook 2015. However, comprehensive information on construction costs for nuclear and biomass electricity generation is quite limited. In this study, it is assumed that biomass is regarded as coal in the Southeast Asia Energy Outlook 2015. For nuclear, a 2015 study from Japan is used as a reference. Table 2.17 shows the unit construction cost of nuclear, hydropower, geothermal, biomass, solar, and wind electricity generation, as well as the capacity factor.

Table 2.17: Unit Construction Cost and Capacity Factor (Nuclear and Renewable)

Fuel	Unit construction cost ($)	Capacity factor (%)
Nuclear	3,298/kW[a]	70.0
Hydro (large)	2,500/ kW	33.0
Geothermal	3,200/kW	75.0
Biomass	1,600/kW	75.0
Solar PV (large scale)	1,600/kW	17.5
Wind (onshore)	1,700/kW	27.0

Hydro = hydropower, kW = kilowatt, PV = photovoltaics.
[a] ¥370,000 per kilowatt, exchange rate: ¥112.3/$ (2017 average).
Source: International Energy Agency (2015), *Southeast Asia Energy Outlook 2015*. Paris: International Energy Agency; Document 3 'Long-Term Energy Supply/Demand Outlook, Related Documents' p.83 at the 11th meeting (16 July 2015) of the Long-Term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy.

Table 2.18 shows the increase in plant construction costs for nuclear and renewable electricity generation. The total amount will reach $166 billion in ASEAN.

Table 2.18: Plant Construction Cost Increase of Nuclear Power Plant and Renewable Energies

($ billion)

Country	Nuclear	Hydro	Geothermal	Biomass	Solar	Wind	Total
Brunei Darussalam	-	-	-	-	0.9	-	0.9
Cambodia	-	-5.8	-	0.3	0.6	0.0	-4.9
Indonesia	10.2	37.9	12.6	16.5	0.5	3.1	80.7
Lao PDR	-	-	-	-	-	-	-
Malaysia	4.5	1.3	0.0	0.2	4.5	0.0	10.5
Myanmar	0.0	6.5	0.0	0.4	4.0	0.1	11.0
Philippines	7.8	5.7	-0.7	-0.3	5.4	2.7	20.5
Singapore	-	-	-	-	18.4	-	18.4
Thailand	5.3	1.1	-	-0.8	1.0	0.5	7.1
Viet Nam	-	-6.1	-	3.7	15.7	8.9	22.2
ASEAN	**27.7**	**40.6**	**11.9**	**20.0**	**51.0**	**15.2**	**166.3**

ASEAN = Association of Southeast Asian Nations, Hydro = hydropower, Lao PDR = Lao People's Democratic Republic.
Note: Land cost is excluded.
Source: Author.

Estimation of Net Avoided Power Plant Cost

Table 2.19 shows the net avoided electricity generation capacity construction cost, which is calculated as follows:

> Net avoided power plant cost = avoided coal and natural gas power plant cost - increasing nuclear and renewable power plant cost (6)

The calculation result indicates that EE&C investment and the corresponding reduced electricity demand can offset, on average, around 80% of investment in clean power generation, renewable power plants, and nuclear power plants. In the case of Cambodia, the Lao People's Democratic Republic, Malaysia, Thailand, and Viet Nam, investment in clean power generation can be completely offset by the reduced electricity demand.

The high cost of such clean power sources against conventional fossil power generation is challenging its mass deployment, which is every country is pursuing. EE&C investment is not only a profitable business; it can also help develop clean power sources by reducing electricity demand, thus slashing the total amount of investment in power generation.

Table 2.19: Net Electricity Generation Capacity Construction Cost, 2040

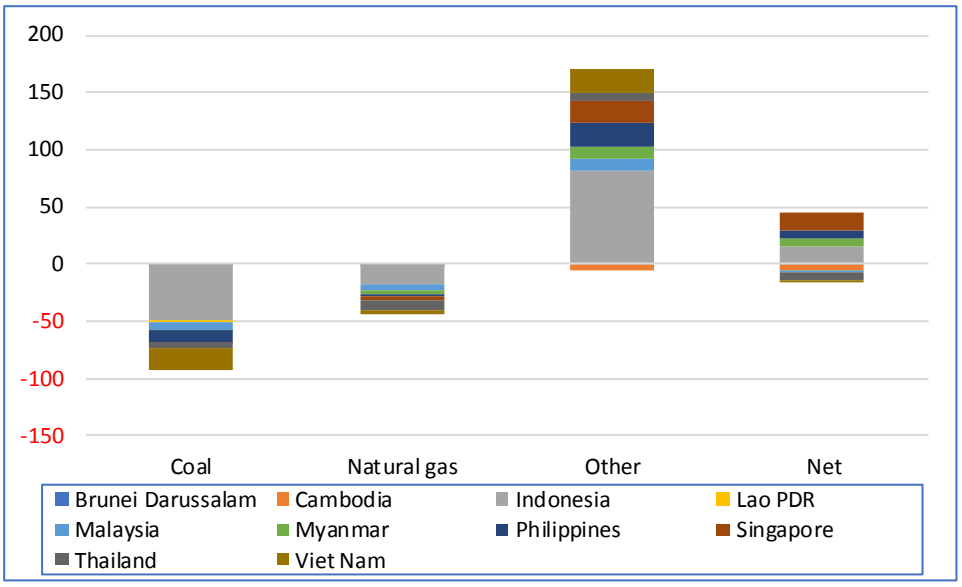
($ billion)

Country	Coal	Natural gas	Other	Total
Brunei Darussalam	-0.1	-0.6	0.9	0.2
Cambodia	-0.2	-0.0	-4.9	-5.1
Indonesia	-49.6	-16.6	80.7	14.4
Lao PDR	-0.3	0.0	-	-0.3
Malaysia	-7.1	-5.2	10.5	-1.8
Myanmar	-0.2	-3.2	11.0	7.6
Philippines	-10.8	-2.8	20.5	6.8
Singapore	-0.1	-2.9	18.4	15.4
Thailand	-5.6	-8.7	7.1	-7.2
Viet Nam	-19.2	-3.5	22.2	-0.6
ASEAN	**-93.3**	**-43.6**	**166.3**	**29.5**

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.
Note: Land cost is excluded.
Source: Author.

Figure 2.10: Net Generation Capacity Construction Cost

($ billion)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.2.2. Avoided Carbon Dioxide Emissions

Reduced electricity generation from coal and natural gas power plants thanks to electricity savings will eventually mitigate CO_2 emissions. This section will estimate this effect under the following conditions:

(i) 1 MWh = 0.086 tonne of oil equivalent (toe)

(ii) Thermal efficiency[2]

Coal power plant: 43%

Natural gas power plant: 55%

(iii) Net calorific value of coal

0.6138 toe/tonne (IEA, 2018d)

(iv) Conversion factor for natural gas

1 Mtoe/y of natural gas = 1.047 billion cubic metres per year of natural gas (IEA, 2018b)

[2] Average of 17 East Asia Summit countries in 2040, APS, ERIA Outlook 2019.

(v) Carbon content (IEA, 2018a)

Coal: 3.961 tonnes of CO_2/toe-input

Natural gas: 2.349 tonnes of CO_2/toe-input

Table 2.20 shows the avoided CO_2 emissions relative to the increase in electricity demand. In ASEAN, total avoided CO_2 emissions will reach 424 million tonnes.

Table 2.20: Avoided Carbon Dioxide Emissions by Electricity Demand Decrease

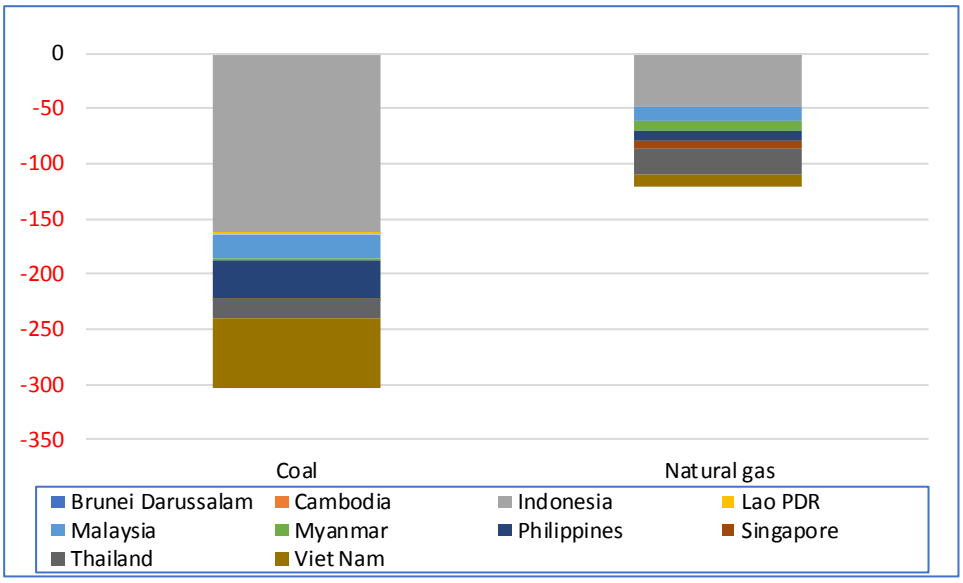
Country	Avoided electricity generation (terawatt-hour)		Avoided input energy (million tonnes of oil equivalent)		Avoided CO_2 emission (million tonnes)		
	Coal	Natural gas	Coal	Natural gas	Coal	Natural gas	Total
Brunei Darussalam	-0	-5	-0.1	-0.7	-0.3	-1.8	-2.0
Cambodia	-1	-0	-0.2	-0.0	-0.7	-0.0	-0.7
Indonesia	-204	-125	-40.8	-19.5	-161.5	-45.8	-207.3
Lao PDR	-1	0	-0.2	0.0	-0.9	0.0	-0.9
Malaysia	-29	-39	-5.8	-6.1	-23.1	-14.3	-37.4
Myanmar	-1	-24	-0.2	-3.7	-0.7	-8.8	-9.5
Philippines	-45	-21	-8.9	-3.3	-35.3	-7.7	-43.0
Singapore	-0	-22	-0.1	-3.4	-0.3	-8.0	-8.3
Thailand	-23	-65	-4.6	-10.2	-18.3	-24.0	-42.3
Viet Nam	-79	-27	-15.8	-4.2	-62.5	-9.8	-72.2
ASEAN	**-383**	**-327**	**-76.6**	**-51.1**	**-303.4**	**-120.1**	**-423.6**

ASEAN = Association of Southeast Asian Nations, CO_2 = carbon dioxide, Lao PDR = Lao People's Democratic Republic.

Source: Author.

Figure 2.11: Avoided Carbon Dioxide Emissions

(million tonnes of carbon dioxide)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.3. Evaluation of the Significance of the Benefits

In sections 2.1 and 2.2, direct benefits and indirect benefits induced by electricity saving are calculated. In this section, the significance of the benefits is evaluated. The analysis by country is described in Appendix 9.

2.3.1. Electricity Bill Savings

Direct benefits, i.e. savings on electricity bills, can be regarded as cash inflow gained by investment, making it possible to calculate the internal rate of return (IRR) of electricity saving investment as an indication of its profitability. Another means of evaluation is comparing the effect of the same amount of money used for other purposes. To this end we selected the energy subsidy as another use of money, since it is a common policy in many ASEAN countries.

Internal Rate of Return of Electricity Saving Investment

Table 2.21 shows the annual levelised gross benefit, required investment amount, net benefit, and IRR (20 years) based on the study described in section 2.2. The IRR calculation process is described in Appendix 2.8.

Annual investment in ASEAN was $6.3 billion, equalling 0.3% of the region's GDP in 2015 and 0.1% of the region's forecasted GDP in 2040.[3] On the other hand, the net benefit in ASEAN was $14.8 billion, 0.7% of the region's GDP in 2015 and 0.2% of the region's forecasted GDP in 2040.

The estimated average IRR in the ASEAN countries under consideration is significantly high at 29%, meaning that investment efficiency is very high. It is even higher in countries with high electricity prices in particular. It should be remembered that we employed a 'safe-side' cost assumption, in reference to the high cost of electricity in Japan.

Although high profitability can be expected from EE&C investment, the amount of investment required is not small, and financial assistance may be required to materialise such investment.

Table 2.21: Annual Net Benefit and Internal Rate of Return of Energy Efficiency and Conservation Investment

Country	Gross benefit/yr ($ billion)	Required investment/ yr ($ billion)	Net benefit/yr ($ billion)	IRR (%)	(Reference) Electricity price ($0.01/kWh)
Cambodia	-0.4	0.1	-0.3	57	17.1
Indonesia	-6.7	2.4	-4.3	26	8.1
Lao PDR	-0.1	0.0	-0.0	28	8.6
Malaysia	-2.7	0.8	-1.9	31	9.6
Myanmar	-0.3	0.2	-0.1	13	5.0
Philippines	-4.1	0.6	-3.5	49	14.9
Thailand	-5.0	1.2	-3.8	49	11.4
Viet Nam	-2.5	1.1	-1.4	37	9.3
ASEAN	-21.7	6.3	-15.4	29	-

ASEAN = Association of Southeast Asian Nations, IRR = internal rate of return, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic, yr = year.
Note: Brunei Darussalam and Singapore are not included in ASEAN.
Source: Author.

[3] The ASEAN GDP was $2,224 billion in 2015, and $8,035 billion in 2040. Brunei Darussalam and Singapore are not included in both years.

Comparison of the Effect of Money for Other Purposes

Next, we compare the effects of investment in electricity savings and energy subsidies. As information on actual energy subsidies is quite limited, the IEA's fossil fuel subsidies database is utilised as a reference. The subsidy amount in the IEA database is calculated as follows:[4]

$$\text{Subsidy} = (\text{reference price} - \text{end-user price}) \times \text{consumed amount} \quad (7)$$

In addition, a limited number of countries are listed. Of the ASEAN countries considered in this study, Indonesia, Malaysia, Thailand, and Viet Nam are selected. Table 2.22 shows fossil fuel subsidies in the selected countries. Energy subsidies in these four countries amounted to around $20 billion per year.

Comparing the value of the energy subsidies against the required investment in electricity saving reported in Table 2.21 reveals that the annual required electricity saving investment in ASEAN is one-third of the annual energy subsidies.

Table 2.22: Energy Subsidies in Selected Association of Southeast Asian Nations Countries

($ billion)

Country	Product	2015	2016	2017
Indonesia	Oil	8.82	6.31	12.36
	Electricity	9.04	12.16	5.24
	Total	17.86	18.47	17.60
Malaysia	Oil	0.31	0.39	1.42
	Total	0.31	0.39	1.42
Thailand	Oil	0.71	0.43	0.70
	Gas	0.21	0.00	0.09
	Total	0.92	0.43	0.80
Viet Nam	Oil	-	0.00	0.00
	Electricity	0.04	-	-
	Gas	0.16	0.04	0.10
	Coal	0.04	0.11	0.16
	Total	0.23	0.15	0.26
Total of selected ASEAN countries	Oil	9.84	7.13	14.48
	Electricity	9.08	12.16	5.24
	Gas	0.37	0.04	0.19
	Coal	0.04	0.11	0.16
	Total	19.33	19.44	20.08

ASEAN = Association of Southeast Asian Nations.
Source: International Energy Agency Fossil Fuel Subsidies Database. https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

[4] Details are described on the IEA's website. https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

From another perspective, how much can gasoline and diesel prices be reduced if the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy? Table 2.23 shows the calculated result. In the case of Indonesia, where retail energy prices are published as statistics, the price of gasoline was $0.483 per litre (L) and that of diesel $0.380/L in 2017.[5] Based on these prices, the impact of unit price reduction is 11% for gasoline and 14% for diesel.

If a country spends a certain amount of money on a fuel subsidy each year, it can reduce fuel prices by a few cents. Meanwhile, if a country spends the same amount of money on electricity saving, it can reduce electricity bills for decade or longer and the efficiency of this investment is equivalent to approximately 30% of the IRR. Thus it should be obvious which is the wiser way of spending a precious national budget.

Table 2.23: Tentative Calculation of Gasoline and Diesel Price Reductions

Country	2015 Gasoline ('000 kL)	2015 Diesel ('000 kL)	2015 Total ('000 kL)	Required investment = fuel subsidy ($ billion/y)	Unit reduction ($/L)
Cambodia	657	779	1,435	0.1	0.06
Indonesia	30,589	13,713	44,303	2.4	0.05
Lao PDR	214	838	1,052	0.0	0.02
Malaysia	15,732	8,290	24,022	0.8	0.03
Myanmar	949	121	1,070	0.2	0.16
Philippines	4,393	6,119	10,512	0.6	0.06
Thailand	7,996	12,238	20,234	1.2	0.06
Viet Nam	6,401	6,195	12,597	1.1	0.08
ASEAN	66,931	48,294	115,225	6.3	0.05

ASEAN = Association of Southeast Asian Nations, kL = kilolitre, L = litre, Lao PDR = Lao People's Democratic Republic, yr = year.
Notes: Brunei Darussalam and Singapore are not included in ASEAN.
Density – gasoline: 0.76 kilogram per L, diesel: 0.84 kilogram per L.
Calorific value – gasoline: 34.6 gigajoules per kilolitre, diesel: 37.7 gigajoules per kilolitre.
Source: Calculation from International Energy Agency (2018), *World Energy Statistics.* Paris: International Energy Agency; (Lao PDR) Calculation from the Energy Balance Table, Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

[5] Calculation from the Handbook of Energy and Economic Statistics of Indonesia 2018 – gasoline: $82.96 per barrel of oil equivalent, diesel: $58.60 per barrel of oil equivalent.

2.3.2. Net Electricity Generation Capacity Construction Cost

In section 2.2.1, it is demonstrated that the net electricity generation capacity construction cost will increase to $30 billion in ASEAN. Table 2.24 shows the ratio of net electricity generation capacity construction cost against GDP in 2015, and forecasted GDP in 2040. Net capital expenditure in ASEAN is equivalent to 1.2% of GDP in 2015, and 0.3% of GDP in 2040.

Table 2.24: Net Generation Capacity Construction Cost and Gross Domestic Product

Country	Net cost ($ billion)	2015 GDP ($ billion)	2040F GDP ($ billion)	Impact vs. 2015 GDP (%)	Impact vs. 2040F GDP (%)
Brunei Darussalam	0.2	14	55	1.2	0.3
Cambodia	-5.1	16	61	-32.2	-8.4
Indonesia	14.4	988	4,052	1.5	0.4
Lao PDR	-0.3	5	23	-5.1	-1.1
Malaysia	-1.8	330	775	-0.5	-0.2
Myanmar	7.6	71	316	10.8	2.4
Philippines	6.8	266	1,147	2.6	0.6
Singapore	15.4	289	511	5.3	3.0
Thailand	-7.2	394	999	-1.8	-0.7
Viet Nam	-0.6	155	663	-0.4	-0.1
ASEAN	29.5	2,527	8,601	1.2	0.3

ASEAN = Association of Southeast Asian Nations, F = forecasted, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.3.3. Avoided Carbon Dioxide Emissions

Table 2.25 shows the ratio of avoided CO_2 emissions against total CO_2 emissions in 2015 and 2040 BAU. Avoided CO_2 emissions in ASEAN are equivalent to 20% of actual emissions in 2015, and 7% of projected emissions in 2040 BAU.

Table 2.25: Avoided Carbon Dioxide Emissions and Total Carbon Dioxide Emissions

Country	Avoided CO_2 emissions (mil. ton-CO_2/yr)	2015 Total CO_2 emissions (mil. ton-CO_2)	2040 BAU Total CO_2 emissions (mil. ton-CO_2)	Impact	
				vs. 2015 emissions (%)	vs. 2040 BAU emissions (%)
Brunei Darussalam	0.1	0.3	0.8	29	12
Cambodia	0.03	0.4	1.4	9	2
Indonesia	9.9	22.4	87.3	44	11
Lao PDR	0.0	0.1	7.5	40	1
Malaysia	1.8	9.5	21.3	19	8
Myanmar	0.5	1.2	4.3	37	11
Philippines	2.0	17.4	49.8	12	4
Singapore	0.4	2.3	3.1	17	13
Thailand	2.0	40.4	75.2	5	3
Viet Nam	3.4	9.0	35.8	38	10
ASEAN	20.2	103.0	286.5	20	7

ASEAN = Association of Southeast Asian Nations, BAU = business as usual, CO_2 = carbon dioxide, Lao PDR = Lao People's Democratic Republic, mil. ton-CO_2 = million tonnes of carbon dioxide, yr = year.

Source: Author.

For reference, Table 2.26 shows the estimated value of annual avoided CO_2 emissions based on the price of $41 per tonne CO_2[6] and the forecasted 2040 GDP. Compared to the forecasted GDP, the estimated annual value of avoided CO_2 emissions is 0.01% of GDP.

[6] 2040 (2017 price) (IEA, 2018c). Average of China, the European Union, and the Republic of Korea.

Table 2.26: Estimated Value of Avoided Carbon Dioxide Emissions

Country	Total avoided CO_2 emissions value ($ billion)	Annual avoided CO_2 emissions value ($ billion/yr)	2040F GDP ($ billion)	Impact (%)
Brunei Darussalam	0.1	0.00	55	0.01
Cambodia	0.0	0.00	61	0.00
Indonesia	8.5	0.40	4,052	0.01
Lao PDR	0.0	0.00	23	0.01
Malaysia	1.5	0.07	775	0.01
Myanmar	0.4	0.02	316	0.01
Philippines	1.8	0.08	1,147	0.01
Singapore	0.3	0.02	511	0.00
Thailand	1.7	0.08	999	0.01
Viet Nam	3.0	0.14	663	0.02
ASEAN	17.4	0.83	8,601	0.01

ASEAN = Association of Southeast Asian Nations, CO_2 = carbon dioxide, F = forecasted, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, yr = year.

Source: Author.