Appendices

Appendix 1: Electricity Demand by Scenario

Table A1.1: Electricity Demand by Scenario

(million tonnes of oil equivalent)

Country		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Brunei Darussalam	0.3	0.4	0.7	0.9	1.1	1.3	0.4	0.7	0.7	0.8	0.9
Cambodia	0.4	1.0	1.3	1.7	2.3	3.2	1.0	1.2	1.5	2.0	2.8
Indonesia	17.2	27.3	35.5	46.2	60.2	77.5	23.9	30.2	38.1	49.6	63.9
Lao PDR	0.3	0.4	0.5	0.6	0.7	0.9	0.4	0.5	0.6	0.7	0.8
Malaysia	11.4	14.0	17.1	20.6	24.5	28.6	12.7	15.2	18.0	21.0	24.0
Myanmar	1.2	1.8	2.4	3.1	3.9	4.9	1.7	2.1	2.5	3.1	3.9
Philippines	5.8	7.7	10.5	12.6	14.7	16.8	6.9	7.9	9.8	11.7	13.5
Singapore	4.1	5.0	5.8	6.5	7.1	7.7	5.0	5.7	6.3	6.9	7.3
Thailand	15.0	17.6	20.5	23.6	26.8	30.4	16.3	17.4	19.3	21.2	23.5
Viet Nam	12.1	19.7	26.1	32.2	38.0	44.2	19.2	24.7	29.7	33.9	38.1
ASEAN	67.9	95.0	120.6	148.1	179.4	215.5	87.4	105.6	126.5	150.8	178.7

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

Table A1.2: Electricity Demand by Scenario

(terawatt-hour)

Country	2015	BAU					APS				
		2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Brunei Darussalam	3.0	4.7	8.6	10.4	13.1	14.7	4.2	7.9	8.6	8.8	10.4
Cambodia	5.0	11.8	15.0	19.7	26.8	37.7	11.4	13.9	17.5	22.8	32.1
Indonesia	200.3	317.0	413.4	537.1	700.4	901.1	277.6	351.5	442.9	577.4	742.7
Lao PDR	4.0	4.8	5.9	7.1	8.7	10.8	4.3	5.3	6.4	7.8	9.7
Malaysia	132.6	162.9	198.7	239.8	284.8	332.3	147.7	176.9	209.5	244.1	279.3
Myanmar	13.4	21.3	28.4	36.3	45.7	57.3	20.0	24.7	29.0	36.5	45.9
Philippines	67.8	89.6	122.5	146.9	170.7	195.9	80.7	91.9	113.9	136.5	156.8
Singapore	47.5	58.6	67.7	75.9	82.7	89.1	58.1	66.5	73.8	79.7	85.0
Thailand	174.9	204.9	238.4	273.9	312.2	354.0	189.1	202.0	224.5	246.0	273.0
Viet Nam	141.2	229.0	303.9	375.0	441.6	513.5	222.9	287.8	345.1	394.0	443.4
ASEAN	789.6	1,104.6	1,402.5	1,722.1	2,086.7	2,506.5	1,016.1	1,228.4	1,471.3	1,753.7	2,078.2

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

Note: 1 tonne of oil equivalent = 11,630 kilowatt-hours.

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.

Appendix 2: Data Sources of Electricity Prices

Country	Data Source of Electricity Prices
Cambodia	Salient Feature of Power Development in Kingdom of Cambodia (Electricity Agency of Cambodia's Consolidated Report for Year 2017 'Shedding an Emission from Coal-fired Power Plant' [provided by the 2017 working group])
Indonesia	Calculation from the Handbook of Energy and Economic Statistics of Indonesia 2018. (price ($/BOE): p.37) (conversion from BOE to kWh: p.129) Ministry of Energy and Mineral Resources, Republic of Indonesia (2017), *Handbook of Energy and Economic Statistics of Indonesia*. Jakarta: Ministry of Energy and Mineral Resources. https://www.esdm.go.id/assets/media/content/content-handbook-of-energy-economic-statistics-of-indonesia-2017--1.pdf (accessed 19 March 2019).
Lao PDR	Average of actual sales prices from the Finance Department of Électricité du Laos (2018)
Malaysia	Provided by a 2017 working group member
Myanmar	2018 Myanmar Statistical Yearbook Ministry of Planning and Finance (p.392) Central Statistical Organization, Ministry of Planning and Finance. https://www.csostat.gov.mm/csocd.asp (accessed 30 August 2019).
Philippines	Provided by a 2017 working group member (2015 ASEAN Electricity Rate)
Thailand	Provincial Electricity Authority Electricity Tariffs (November 2018) https://www.pea.co.th/Portals/1/demand_response/Electricity%20Tariffs%20Nov61.pdf?ver=2018-11-21-145427-433 (accessed 12 April 2018). Residential --> Residential Commercial --> Small general service Industry --> Large general service Exchange rate: $1.00 = B32.4 (28 December 2018)
Viet Nam	Vietnam Electricity Retail Electricity Tariff. http://en.evn.com.vn/d6/gioi-thieu-d/RETAIL-ELECTRICITY-TARIFF-9-28-252.aspx (accessed 10 May 2019). Average monthly electricity consumption: (Reference data = Indonesia electricity statistics 2018 Statistik

	Ketenagalistrikan 2018) Direktorat Jeneral Ketenagalistrikan. http://www.djk.esdm.go.id/index.php/statistik-ketenagalistrikan (accessed 10 May 2019). Residential 131 kWh/month/customer Commercial 1,031 kWh/month/customer Industry 81,558 kWh/month/customer Electricity price Residential: calculation based on 131 kWh consumption Commercial: voltage of 22 kV and above, standard hour Industry: voltage of 22 kV to below 110 KV, standard hour Exchange rate: $1.00 = D21,935 (2016)

BOE = barrel of oil equivalent, KV = kilovolt, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic.

Source: Author.

Appendix 3: Calculation of Gross Benefits

A3.1 Effect of the Initial Investment

The decrease in electricity demand of the period 2020-2024 is calculated as follows: (alternative policy scenario (APS) 2020 − business as usual (BAU) 2020) * 5 years. The calculation method is applied to the periods, 2025–2029, 2030–2034, and 2035–2039.

Table A3.1: Electricity Demand in the Association of Southeast Asian Nations, Initial Investment

(terawatt-hour)

Country	BAU 2020	APS 2020
Brunei Darussalam	4.7	4.2
Cambodia	11.8	11.4
Indonesia	317.0	277.6
Lao PDR	4.8	4.3
Malaysia	162.9	147.7
Myanmar	21.3	20.0
Philippines	89.6	80.7
Singapore	58.6	58.1
Thailand	204.9	189.1
Viet Nam	229.0	222.9
ASEAN	1,104.6	1,016.1

APS = alternative policy scenario, ASEAN = Association of 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.

Table A3.2: Electricity Demand Decrease and Reduced Electricity Bill

Country	Electricity demand decrease (TWh)					Electricity price	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040	($0.01/kWh)	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-2.2	-2.2	-2.2	-2.2	-0.4	17.1	-377	-377	-377	-377	-75
Indonesia	-197.0	-197.0	-197.0	-197.0	-39.4	8.1	-15,859	-15,859	-15,859	-15,859	-3,172
Lao PDR	-2.4	-2.4	-2.4	-2.4	-0.5	8.6	-206	-206	-206	-206	-41
Malaysia	-75.8	-75.8	-75.8	-75.8	-15.2	9.6	-7,266	-7,266	-7,266	-7,266	-1,453
Myanmar	-6.1	-6.1	-6.1	-6.1	-1.2	5.0	-304	-304	-304	-304	-61
Philippines	-44.8	-44.8	-44.8	-44.8	-9.0	14.9	-6,669	-6,669	-6,669	-6,669	-1,334
Thailand	-78.8	-78.8	-78.8	-78.8	-15.8	11.4	-8,980	-8,980	-8,980	-8,980	-1,796
Viet Nam	-30.5	-30.5	-30.5	-30.5	-6.1	9.3	-2,824	-2,824	-2,824	-2,824	-565
ASEAN	-437.6	-437.6	-437.6	-437.6	-87.5		-42,485	-42,485	-42,485	-42,485	-8,497

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

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.

A3.2 Effect of the Additional Investment-1

The decrease in electricity demand of the period 2025–2029 is calculated as follows: (APS 2025 − revised APS 2025) * 5 years. The calculation method is applied to the periods 2030–2034 and 2035–2039.

Table A3.3: Electricity Demand in the Association of Southeast Asian Nations, Additional Investment-1

(terawatt-hour)

Country	BAU 2025	Revised APS 2025
Brunei Darussalam	7.9	8.1
Cambodia	13.9	14.6
Indonesia	351.5	374.0
Lao PDR	5.3	5.4
Malaysia	176.9	183.5
Myanmar	24.7	27.1
Philippines	91.9	113.6
Singapore	66.5	67.2
Thailand	202.0	222.6
Viet Nam	287.8	297.8
ASEAN	1,228.4	1,314.0

APS = alternative policy scenario, ASEAN = Association of 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.

Table A3.4: Electricity Demand Decrease and Reduced Electricity Bill

Country	Electricity demand decrease (TWh)					Electricity price	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040	($0.01/kWh)	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-3.4	-3.4	-3.4	-0.7	17.1	-	-583	-583	-583	-117
Indonesia	-	-112.9	-112.9	-112.9	-22.6	8.1	-	-9,087	-9,087	-9,087	-1,817
Lao PDR	-	-0.5	-0.5	-0.5	-0.1	8.6	-	-46	-46	-46	-9
Malaysia	-	-33.2	-33.2	-33.2	-6.6	9.6	-	-3,176	-3,176	-3,176	-635
Myanmar	-	-12.2	-12.2	-12.2	-2.4	5.0	-	-608	-608	-608	-122
Philippines	-	-108.3	-108.3	-108.3	-21.7	14.9	-	-16,121	-16,121	-16,121	-3,224
Thailand	-	-103.0	-103.0	-103.0	-20.6	11.4	-	-11,742	-11,742	-11,742	-2,348
Viet Nam	-	-50.1	-50.1	-50.1	-10.0	9.3	-	-4,636	-4,636	-4,636	-927
ASEAN	-	-423.6	-423.6	-423.6	-84.7		-	-45,998	-45,998	-45,998	-9,200

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

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.

A3.3 Effect of the Additional Investment-2

The decrease in electricity demand of the period 2030-2034 is calculated as follows: (APS 2030 − revised APS 2030) * 5 years. The calculation method is applied to the period 2035–2039.

Table A3.5: Electricity Demand in the Association of Southeast Asian Nations, Additional Investment-2

(terawatt-hour)

Country	BAU 2030	Revised APS 2030
Brunei Darussalam	8.6	9.6
Cambodia	17.5	18.6
Indonesia	442.9	475.1
Lao PDR	6.4	6.5
Malaysia	209.5	218.0
Myanmar	29.0	32.6
Philippines	113.9	116.3
Singapore	73.8	74.7
Thailand	224.5	237.6
Viet Nam	345.1	358.9
ASEAN	1,471.3	1,548.0

APS = alternative policy scenario, ASEAN = Association of 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.

Table A3.6: Electricity Demand Decrease and Reduced Electricity Bill

Country	Electricity demand decrease (TWh)					Electricity price	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040	($0.01/kWh)	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-5.5	-5.5	-1.1	17.1	-	-	-934	-934	-187
Indonesia	-	-	-160.9	-160.9	-32.2	8.1	-	-	-12,954	-12,954	-2,591
Lao PDR	-	-	-0.6	-0.6	-0.1	8.6	-	-	-54	-54	-11
Malaysia	-	-	-42.5	-42.5	-8.5	9.6	-	-	-4,068	-4,068	-814
Myanmar	-	-	-18.1	-18.1	-3.6	5.0	-	-	-903	-903	-181
Philippines	-	-	-12.1	-12.1	-2.4	14.9	-	-	-1,808	-1,808	-362
Thailand	-	-	-65.5	-65.5	-13.1	11.4	-	-	-7,466	-7,466	-1,493
Viet Nam	-	-	-68.7	-68.7	-13.7	9.3	-	-	-6,353	-6,353	-1,271
ASEAN	-	-	-373.9	-373.9	-74.8		-	-	-34,539	-34,539	-6,908

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

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.

A3.4 Effect of the Additional Investment-3

The decrease in electricity demand of the period 2035–2039 is calculated as follows: (APS 2035 − revised APS 2035) * 5 years.

Table A3.7: Electricity Demand in the Association of Southeast Asian Nations, Additional Investment-3

(terawatt-hour)

(TWh) Country	BAU 2035	Revised APS 2035
Brunei Darussalam	8.8	11.3
Cambodia	22.8	24.6
Indonesia	577.4	606.2
Lao PDR	7.8	8.0
Malaysia	244.1	254.5
Myanmar	36.5	38.4
Philippines	136.5	137.6
Singapore	79.7	80.7
Thailand	246.0	262.8
Viet Nam	394.0	411.7
ASEAN	1,753.7	1,835.9

APS = alternative policy scenario, ASEAN = Association of 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.

Table A3.8: Electricity Demand Decrease and Reduced Electricity Bill

Country	Electricity demand decrease (TWh)					Electricity price	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040	($0.01/kWh)	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-	-9.0	-1.8	17.1	-	-	-	-1,536	-307
Indonesia	-	-	-	-144.2	-28.8	8.1	-	-	-	-11,612	-2,322
Lao PDR	-	-	-	-0.8	-0.2	8.6	-	-	-	-69	-14
Malaysia	-	-	-	-52.1	-10.4	9.6	-	-	-	-4,990	-998
Myanmar	-	-	-	-9.4	-1.9	5.0	-	-	-	-469	-94
Philippines	-	-	-	-5.4	-1.1	14.9	-	-	-	-801	-160
Thailand	-	-	-	-83.8	-16.8	11.4	-	-	-	-9,555	-1,911
Viet Nam	-	-	-	-88.6	-17.7	9.3	-	-	-	-8,195	-1,639
ASEAN	-	-	-	-393.3	-78.7		-	-	-	-37,227	-7,445

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

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.

A3.5 Effect of the Additional Investment-4

The decrease in electricity demand decrease is calculated as follows: APS 2040 − revised APS 2040.

Table A3.9: Electricity Demand in the Association of Southeast Asian Nations, Additional Investment-4

(terawatt-hour)

(TWh) Country	BAU 2040	Revised APS 2040
Brunei Darussalam	10.4	10.4
Cambodia	32.1	33.7
Indonesia	742.7	778.1
Lao PDR	9.7	9.9
Malaysia	279.3	291.6
Myanmar	45.9	48.2
Philippines	156.8	161.8
Singapore	85.0	86.1
Thailand	273.0	287.8
Viet Nam	443.4	465.9
ASEAN	2,078.2	2,173.5

APS = alternative policy scenario, ASEAN = Association of 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.

Table A3.10: Electricity Demand Decrease and Reduced Electricity Bill

Country	Electricity demand decrease (TWh)					Electricity price	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040	($0.01/kWh)	2020–2024	2025–2029	2030–2034	2035–2039	2040
Cambodia	-	-	-	-	-1.6	17.1	-	-	-	-	-280
Indonesia	-	-	-	-	-35.4	8.1	-	-	-	-	-2,850
Lao PDR	-	-	-	-	-0.2	8.6	-	-	-	-	-18
Malaysia	-	-	-	-	-12.3	9.6	-	-	-	-	-1,180
Myanmar	-	-	-	-	-2.3	5.0	-	-	-	-	-116
Philippines	-	-	-	-	-5.1	14.9	-	-	-	-	-752
Thailand	-	-	-	-	-14.7	11.4	-	-	-	-	-1,680
Viet Nam	-	-	-	-	-22.5	9.3	-	-	-	-	-2,077
ASEAN	-	-	-	-	-94.1		-	-	-	-	-8,952

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

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.

Appendix 4: Cumulative Gross Benefit

Table A4.1: Cumulative Gross Benefit, Cambodia

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-0.4	-0.4	-0.4	-0.4		-1.5
Additional investment-1	2025		-0.6	-0.6	-0.6		-1.7
Additional investment-2	2030			-0.9	-0.9		-1.9
Additional investment-3	2035				-1.5		-1.5
Additional investment-4	2040					-0.3	-0.3
Total		-0.4	-1.0	-1.9	-3.4	-0.3	-6.9

Source: Author.

Table A4.2: Cumulative Gross Benefit, Indonesia

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-15.9	-15.9	-15.9	-15.9		-63.4
Additional investment-1	2025		-9.1	-9.1	-9.1		-27.3
Additional investment-2	2030			-13.0	-13.0		-25.9
Additional investment-3	2035				-11.6		-11.6
Additional investment-4	2040					-2.8	-2.8
Total		-15.9	-24.9	-37.9	-49.5	-2.8	-131.1

Source: Author.

Table A4.3: Cumulative Gross Benefit, the Lao People's Democratic Republic

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-0.2	-0.2	-0.2	-0.2		-0.8
Additional investment-1	2025		-0.0	-0.0	-0.0		-0.1
Additional investment-2	2030			-0.1	-0.1		-0.1
Additional investment-3	2035				-0.1		-0.1
Additional investment-4	2040					-0.0	-0.0
Total		-0.2	-0.3	-0.3	-0.4	-0.0	-1.2

Source: Author.

Table A4.4: Cumulative Gross Benefit, Malaysia

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-7.3	-7.3	-7.3	-7.3		-29.1
Additional investment-1	2025		-3.2	-3.2	-3.2		-9.5
Additional investment-2	2030			-4.1	-4.1		-8.1
Additional investment-3	2035				-5.0		-5.0
Additional investment-4	2040					-1.2	-1.2
Total		-7.3	-10.4	-14.5	-19.5	-1.2	-52.9

Source: Author.

Table A4.5: Cumulative Gross Benefit, Myanmar

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-0.3	-0.3	-0.3	-0.3		-1.2
Additional investment-1	2025		-0.6	-0.6	-0.6		-1.8
Additional investment-2	2030			-0.9	-0.9		-1.8
Additional investment-3	2035				-0.5		-0.5
Additional investment-4	2040					-0.1	-0.1
Total		-0.3	-0.9	-1.8	-2.3	-0.1	-5.4

Source: Author.

Table A4.6: Cumulative Gross Benefit, Philippines

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-6.7	-6.7	-6.7	-6.7		-26.7
Additional investment-1	2025		-16.1	-16.1	-16.1		-48.4
Additional investment-2	2030			-1.8	-1.8		-3.6
Additional investment-3	2035				-0.8		-0.8
Additional investment-4	2040					-0.8	-0.8
Total		-6.7	-22.8	-24.6	-25.4	-0.8	-80.2

Source: Author.

Table A4.7: Cumulative Gross Benefit, Thailand

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-9.0	-9.0	-9.0	-9.0		-35.9
Additional investment-1	2025		-11.7	-11.7	-11.7		-35.2
Additional investment-2	2030			-7.5	-7.5		-14.9
Additional investment-3	2035				-9.6		-9.6
Additional investment-4	2040					-1.7	-1.7
Total		-9.0	-20.7	-28.2	-37.7	-1.7	-97.3

Source: Author.

Table A4.8: Cumulative Gross Benefit, Viet Nam

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-2.8	-2.8	-2.8	-2.8		-11.3
Additional investment-1	2025		-4.6	-4.6	-4.6		-13.9
Additional investment-2	2030			-6.4	-6.4		-12.7
Additional investment-3	2035				-8.2		-8.2
Additional investment-4	2040					-2.1	-2.1
Total		-2.8	-7.5	-13.8	-22.0	-2.1	-48.2

Source: Author.

Table A4.9: Cumulative Gross Benefit, Association of Southeast Asian Nations

($ billion)

Investment	Investment year	Electricity bill decrease					
		2020–2024	2025–2029	2030–2034	2035–2039	2040	Total
Initial investment	2020	-42.5	-42.5	-42.5	-42.5		-169.9
Additional investment-1	2025		-46.0	-46.0	-46.0		-138.0
Additional investment-2	2030			-34.5	-34.5		-69.1
Additional investment-3	2035				-37.2		-37.2
Additional investment-4	2040					-9.0	-9.0
Total		-42.5	-88.5	-123.0	-160.2	-9.0	-423.2

Source: Author.

Appendix 5: Calculation of the Unit Cost of Investment in the Area of Energy Efficiency and Conservation

	Description	Unit	High-efficiency lighting	High-efficiency air conditioners	Transformers	Refrigerators and freezers	Industrial motors	Total
a	Estimated grant amount	¥ million	2,494	3,931	222	22	272	6,940
b=a*3	Estimated investment amount	¥ million	7,481	11,793	665	67	815	20,820
c	Average of cost effectiveness	kL/¥ million	63.27	19.19	20.13	5.84	14.46	-
d=b*c	Estimated energy saving amount (Total of useful life)	kL	473,293	226,300	13,386	391	11,783	725,154
e	Useful life	year	15	10	13	6	6	-
f=d/e	Energy saving amount per year	kL	31,553	22,630	1,030	65	1,964	57,242
g	Energy saving amount per year	TWh	0.34	0.24	0.01	0.00	0.02	0.62
h=b/g	Unit cost of investment in EE&C	¥ million/TWh	-	-	-	-	-	33,816
i	**Unit cost of investment in EE&C**	**$ million/TWh**	**-**	**-**	**-**	**-**	**-**	**301**

EE&C = energy efficiency and conservation, kL = kiloliter, TWh = terawatt-hour.

Notes: Year: fiscal year 2017; grant rate = one-third of investment amount; kL: kL of crude oil equivalent; 1 kL of crude oil equivalent = 10755.8 kWh; exchange rate: ¥112.2/$ (average of 2017).

Sources: Sustainable Open Innovation Initiative, SII; Adoption List of FY2017 (language: Japanese). https://sii.or.jp/file/cutback29/koufuketteianken(setsubi).pdf?0831 (accessed 8 November 2018); Document for Brief Meeting of FY2017 Result (language: Japanese). https://sii.or.jp/file/cutback29/00_sii_seikahoukoku.pdf (accessed 8 November 2018).

Appendix 6: Process of Calculating Required Investment in the Area of Energy Efficiency and Conservation

A6.1 Initial Investment

Initial Investment = ([business as usual] BAU 2020 – alternative policy scenario [APS] 2020) * Unit cost of investment in the area of energy efficiency and conservation (EE&C).

Table A6.1: Initial Investment in Energy Efficiency and Conservation

($ million)

Country	Initial investment 2020
Brunei Darussalam	**154**
Cambodia	**133**
Indonesia	**11,875**
Lao PDR	**144**
Malaysia	**4,572**
Myanmar	**366**
Philippines	**2,701**
Singapore	**149**
Thailand	**4,748**
Viet Nam	**1,841**
ASEAN	**26,683**

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

Source: Author.

A6.2 Additional Investment-1

Once countries invest in 2020, the demand for electricity will decrease to the APS. However, electricity demand will increase at the BAU growth rate after 2025.

Revised demand 2025 = BAU 2025 - (BAU 2020 - APS 2020)

Additional Investment-1 = (Revised demand 2025 - APS 2025) * Unit cost of investment in the area of EE&C

Table A6.2: Revised Electricity Demand (after 2025)

(terawatt-hour)

Country	Electricity demand				
	2020 (=APS)	r2025	r2030	r2035	r2040
Brunei Darussalam	4	8	10	13	14
Cambodia	11	15	19	26	37
Indonesia	278	374	498	661	862
Lao PDR	4	5	7	8	10
Malaysia	148	184	225	270	317
Myanmar	20	27	35	44	56
Philippines	81	114	138	162	187
Singapore	58	67	75	82	89
Thailand	189	223	258	296	338
Viet Nam	223	298	369	436	507
ASEAN	1,016	1,314	1,634	1,998	2,418

APS = alternative policy scenario, ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, r = revised.
Source: Author.

Table A6.2: Additional Investment-1 (2025) in Energy Efficiency and Conservation

($ million)

Country	Initial investment	**Additional investment-1**
	2020	**2025**
Brunei Darussalam	154	**66**
Cambodia	133	**206**
Indonesia	11,875	**6,804**
Lao PDR	144	**32**
Malaysia	4,572	**1,998**
Myanmar	366	**733**
Philippines	2,701	**6,531**
Singapore	149	**208**
Thailand	4,748	**6,209**
Viet Nam	1,841	**3,021**
ASEAN	26,683	**25,808**

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

A6.3 Additional Investment-2

Once countries invest in 2025, electricity demand will decrease to the APS. However, electricity demand will increase at the BAU growth rate after 2030.

Revised demand 2030 = BAU 2030 - (BAU 2025 - APS 2025)

Additional Investment-2 = (Revised demand 2030 - APS 2030) * Unit cost of investment in the are of EE&C

Table A6.3: Revised Electricity Demand (after 2030)

(terawatt-hour)

Country	Electricity demand				
	2020	2025 (=APS)	r2030	r2035	r2040
Brunei Darussalam		8	10	12	14
Cambodia		14	19	26	37
Indonesia		351	475	638	839
Lao PDR		5	7	8	10
Malaysia		177	218	263	311
Myanmar		25	33	42	54
Philippines		92	116	140	165
Singapore		67	75	82	88
Thailand		202	238	276	318
Viet Nam		288	359	425	497
ASEAN		1,228	1,548	1,913	2,332

APS = alternative policy scenario, ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, TWh = terawatt-hour.

Source: Author.

Table A6.4: Additional Investment-2 (2030) in Energy Efficiency and Conservation

($ million)

Country	Initial investment 2020	Additional investment -1 2025	**Additional investment-2 2030**
Brunei Darussalam	154	66	**309**
Cambodia	133	206	**330**
Indonesia	11,875	6,804	**9,699**
Lao PDR	144	32	**38**
Malaysia	4,572	1,998	**2,559**
Myanmar	366	733	**1,089**
Philippines	2,701	6,531	**732**
Singapore	149	208	**256**
Thailand	4,748	6,209	**3,948**
Viet Nam	1,841	3,021	**4,140**
ASEAN	26,683	25,808	**23,101**

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

Source: Author.

A6.4 Additional Investment-3

Once countries invest in 2030, electricity demand will decrease to the APS. However, electricity demand will increase at the BAU growth rate after 2035.

Revised demand 2035 = BAU 2035 - (BAU 2030 - APS 2030)

Additional Investment-3 = (Revised demand 2035 - APS 2035) * Unit cost of investment in the area of EE&C

Table A6.5: Revised Electricity Demand (after 2035)

(terawatt-hour)

Country	Electricity demand				
	2020)	2025	2030 (=APS)	r2035	r2040
Brunei Darussalam			9	11	13
Cambodia			18	25	36
Indonesia			443	606	807
Lao PDR			6	8	10
Malaysia			209	255	302
Myanmar			29	38	50
Philippines			114	138	163
Singapore			74	81	87
Thailand			224	263	305
Viet Nam			345	412	484
ASEAN			1,471	1,836	2,256

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

Table A6.6: Additional Investment-3 (2035) in Energy Efficiency and Conservation

($ million)

Country	Initial investment	Additional investment-1	Additional investment-2	**Additional investment-3**
	2020	2025	2030	**2035**
Brunei Darussalam	154	66	309	**767**
Cambodia	133	206	330	**542**
Indonesia	11,875	6,804	9,699	**8,695**
Lao PDR	144	32	38	**48**
Malaysia	4,572	1,998	2,559	**3,140**
Myanmar	366	733	1,089	**566**
Philippines	2,701	6,531	732	**325**
Singapore	149	208	256	**298**
Thailand	4,748	6,209	3,948	**5,052**
Viet Nam	1,841	3,021	4,140	**5,340**
ASEAN	26,683	25,808	23,101	**24,773**

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

A6.5 Additional Investment-4

Once countries invest in 2035, electricity demand will decrease to the APS. However, electricity demand will increase at the BAU growth rate after 2040.

Revised demand 2040 = BAU 2040 - (BAU 2035 - APS 2035)

Additional investment-4 = (Revised demand 2040 - APS 2040) * Unit cost of investment in the area of EE&C

Table A6.7: Revised Electricity Demand (after 2040)

(terawatt-hour)

Country	Electricity demand				
	2020)	2025	2030	2035 (=APS)	r2040
Brunei Darussalam				9	10
Cambodia				23	34
Indonesia				577	778
Lao PDR				8	10
Malaysia				244	292
Myanmar				37	48
Philippines				137	162
Singapore				80	86
Thailand				246	288
Viet Nam				394	466
ASEAN				1,754	2,173

APS = alternative policy scenario, ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, TWh = terawatt-hour.

Source: Author.

Table A6.5: Additional Investment-4 (2040) in Energy Efficiency and Conservation

($ million)

Country	Initial investment 2020	Additional investment -1 2025	Additional investment -2 2030	Additional investment -3 2035	**Additional investment-4 2040**
Brunei Darussalam	154	66	309	767	**0**
Cambodia	133	206	330	542	**494**
Indonesia	11,875	6,804	9,699	8,695	**10,669**
Lao PDR	144	32	38	48	**62**
Malaysia	4,572	1,998	2,559	3,140	**3,712**
Myanmar	366	733	1,089	566	**702**
Philippines	2,701	6,531	732	325	**1,523**
Singapore	149	208	256	298	**339**
Thailand	4,748	6,209	3,948	5,052	**4,441**
Viet Nam	1,841	3,021	4,140	5,340	**6,768**
ASEAN	26,683	25,808	23,101	24,773	**28,709**

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

Source: Author.

Appendix 7: Biomass, Solar, and Wind Electricity Generation

Table A7.1: Biomass, Solar, and Wind Electricity Generation – Business as Usual (2040)

Country	Input energy (Mtoe)			Electricity generation (Mtoe)			Others	Electricity generation (TWh)		
	Biomass	Solar	wind	Biomass	Solar	wind	(TWh)	Biomass	Solar	wind
Brunei Darussalam		0.0		-	0.0		0.0	-	0.0	-
Cambodia	0.1	0.0		0.0	0.0	0.0	0.7	0.4	0.3	0.0
Indonesia	1.8	0.0	0.0	0.7	0.0	0.0	6.5	5.8	0.4	0.3
Lao PDR	-	-	-	-	-	-	-	-	-	-
Malaysia	1.3	0.0		0.5	0.0	0.0	5.5	5.2	0.3	0.0
Myanmar	0.3	0.0	0.1	0.1	0.0	0.1	4.3	2.5	0.6	1.3
Philippines	1.0	0.2	0.3	0.4	0.2	0.3	8.2	3.7	2.0	2.5
Singapore	-	0.4	-	-	0.4	-	7.6	-	7.6	-
Thailand	10.9	1.0	0.6	4.4	1.0	0.6	44.1	32.3	7.7	4.2
Viet Nam	0.0	-	0.0	0.0	-	0.0	0.4	0.2	-	0.2
ASEAN	15.4	1.8	0.9	6.2	1.8	0.9	77.3	50.0	18.9	8.4

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Note: The assumed thermal efficiency of biomass is 40%, of solar, 100%, and of wind, 100%.

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.

Table A7.2: Biomass, Solar, and Wind Electricity Generation – Alternative Policy Scenario (2040)

Country	Input energy (Mtoe)			Electricity generation (Mtoe)			Others	Electricity generation (TWh)		
	Biomass	Solar	wind	Biomass	Solar	wind	(TWh)	Biomass	Solar	wind
Brunei Darussalam	-	0.1	-	-	0.1	-	0.9	-	0.9	-
Cambodia	0.5	0.1		0.2	0.1	0.0	2.6	1.8	0.8	0.0
Indonesia	29.0	0.1	0.7	11.6	0.1	0.7	78.8	73.4	0.9	4.6
Lao PDR	-	-	-	-	-	-	-	-	-	-
Malaysia	1.3	0.4	-	0.5	0.4	-	10.7	6.1	4.6	-
Myanmar	0.6	0.2	0.1	0.2	0.2	0.1	10.1	4.3	4.4	1.3
Philippines	0.5	0.6	0.5	0.2	0.6	0.5	15.7	2.3	7.2	6.2
Singapore	-	1.9	-	-	1.9	-	25.3	-	25.3	-
Thailand	8.6	1.0	0.6	3.5	1.0	0.6	42.6	29.0	8.7	5.0
Viet Nam	3.4	1.4	1.1	1.4	1.4	1.1	42.7	15.2	15.0	12.5
ASEAN	44.0	5.9	3.0	17.6	5.9	3.0	229.4	132.1	67.7	29.6

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Note: The assumed thermal efficiency of biomass is 40%, of solar, 100%, and of wind, 100%.

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.

Appendix 8: Calculation of Internal Rates of Return

Table A8.1: Calculation of Internal Rates of Return, Cambodia

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		11.8	11.8	11.8	11.8	11.8	15.0	15.0	15.0	15.0	15.0	19.7	19.7	19.7	19.7	19.7	26.8	26.8	26.8	26.8	26.8	37.7	
APS	TWh		11.4	11.4	11.4	11.4	11.4	13.9	13.9	13.9	13.9	13.9	17.5	17.5	17.5	17.5	17.5	22.8	22.8	22.8	22.8	22.8	32.1	
Saving Potential	TWh		0.4	0.4	0.4	0.4	0.4	1.1	1.1	1.1	1.1	1.1	2.2	2.2	2.2	2.2	2.2	4.0	4.0	4.0	4.0	4.0	5.7	44.7
Benefit	$ billion		0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.7	0.7	0.7	0.7	0.7	1.0	7.6
Investment	$ billion	0.1					0.2					0.3					0.5					0.5		1.7
Net Benefit	$ billion	-0.1	0.1	0.1	0.1	0.1	-0.1	0.2	0.2	0.2	0.2	-0.1	0.4	0.4	0.4	0.4	-0.2	0.7	0.7	0.7	0.7	0.2	1.0	5.9
IRR																								57%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.2: Calculation of Internal Rates of Return, Indonesia

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		317.0	317.0	317.0	317.0	317.0	413.4	413.4	413.4	413.4	413.4	537.1	537.1	537.1	537.1	537.1	700.4	700.4	700.4	700.4	700.4	901.1	
APS	TWh		277.6	277.6	277.6	277.6	277.6	351.5	351.5	351.5	351.5	351.5	442.9	442.9	442.9	442.9	442.9	577.4	577.4	577.4	577.4	577.4	742.7	
Saving Potential	TWh		39.4	39.4	39.4	39.4	39.4	62.0	62.0	62.0	62.0	62.0	94.2	94.2	94.2	94.2	94.2	123.0	123.0	123.0	123.0	123.0	158.4	1,751.1
Benefit	$ billion		3.2	3.2	3.2	3.2	3.2	5.0	5.0	5.0	5.0	5.0	7.6	7.6	7.6	7.6	7.6	9.9	9.9	9.9	9.9	9.9	12.8	141.0
Investment	$ billion	11.9					6.8					9.7					8.7					10.7		47.7
Net Benefit	$ billion	-11.9	3.2	3.2	3.2	3.2	-3.6	5.0	5.0	5.0	5.0	-4.7	7.6	7.6	7.6	7.6	-1.1	9.9	9.9	9.9	9.9	-0.8	12.8	93.2
IRR																								26%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.3: Calculation of Internal Rates of Return, Lao People's Democratic Republic

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		4.8	4.8	4.8	4.8	4.8	5.9	5.9	5.9	5.9	5.9	7.1	7.1	7.1	7.1	7.1	8.7	8.7	8.7	8.7	8.7	10.8	
APS	TWh		4.3	4.3	4.3	4.3	4.3	5.3	5.3	5.3	5.3	5.3	6.4	6.4	6.4	6.4	6.4	7.8	7.8	7.8	7.8	7.8	9.7	
Saving Potential	TWh		0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.9	0.9	1.1	14.3
Benefit	$ billion		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.2
Investment	$ billion	0.1					0.0					0.0					0.0					0.1		0.3
Net Benefit	$ billion	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.9
IRR																								28%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, Lao PDR = Lao People's Democratic Republic, TWh = terawatt-hour.

Source: Author.

Table A8.4: Calculation of Internal Rates of Return, Malaysia

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		162.9	162.9	162.9	162.9	162.9	198.7	198.7	198.7	198.7	198.7	239.8	239.8	239.8	239.8	239.8	284.8	284.8	284.8	284.8	284.8	332.3	
APS	TWh		147.7	147.7	147.7	147.7	147.7	176.9	176.9	176.9	176.9	176.9	209.5	209.5	209.5	209.5	209.5	244.1	244.1	244.1	244.1	244.1	279.3	
Saving Potential	TWh		15.2	15.2	15.2	15.2	15.2	21.8	21.8	21.8	21.8	21.8	30.3	30.3	30.3	30.3	30.3	40.7	40.7	40.7	40.7	40.7	53.0	592.9
Benefit	$ billion		1.5	1.5	1.5	1.5	1.5	2.1	2.1	2.1	2.1	2.1	2.9	2.9	2.9	2.9	2.9	3.9	3.9	3.9	3.9	3.9	5.1	56.8
Investment	$ billion	4.6					2.0					2.6					3.1					3.7		16.0
Net Benefit	$ billion	-4.6	1.5	1.5	1.5	1.5	-0.5	2.1	2.1	2.1	2.1	-0.5	2.9	2.9	2.9	2.9	-0.2	3.9	3.9	3.9	3.9	0.2	5.1	40.8
IRR																								31%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.5: Calculation of Internal Rates of Return, Myanmar

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		21.3	21.3	21.3	21.3	21.3	28.4	28.4	28.4	28.4	28.4	36.3	36.3	36.3	36.3	36.3	45.7	45.7	45.7	45.7	45.7	57.3	
APS	TWh		20.0	20.0	20.0	20.0	20.0	24.7	24.7	24.7	24.7	24.7	29.0	29.0	29.0	29.0	29.0	36.5	36.5	36.5	36.5	36.5	45.9	
Saving Potential	TWh		1.2	1.2	1.2	1.2	1.2	3.6	3.6	3.6	3.6	3.6	7.3	7.3	7.3	7.3	7.3	9.1	9.1	9.1	9.1	9.1	11.5	117.7
Benefit	$ billion		0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	5.9
Investment	$ billion	0.4					0.7					1.1					0.6					0.7		3.5
Net Benefit	$ billion	-0.4	0.1	0.1	0.1	0.1	-0.7	0.2	0.2	0.2	0.2	-0.9	0.4	0.4	0.4	0.4	-0.2	0.5	0.5	0.5	0.5	-0.2	0.6	2.4
IRR																								13%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.6: Calculation of Internal Rates of Return, Philippines

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		89.6	89.6	89.6	89.6	89.6	122.5	122.5	122.5	122.5	122.5	146.9	146.9	146.9	146.9	146.9	170.7	170.7	170.7	170.7	170.7	195.9	
APS	TWh		80.7	80.7	80.7	80.7	80.7	91.9	91.9	91.9	91.9	91.9	113.9	113.9	113.9	113.9	113.9	136.5	136.5	136.5	136.5	136.5	156.8	
Saving Potential	TWh		9.0	9.0	9.0	9.0	9.0	30.6	30.6	30.6	30.6	30.6	33.1	33.1	33.1	33.1	33.1	34.1	34.1	34.1	34.1	34.1	39.2	573.2
Benefit	$ billion		1.3	1.3	1.3	1.3	1.3	4.6	4.6	4.6	4.6	4.6	4.9	4.9	4.9	4.9	4.9	5.1	5.1	5.1	5.1	5.1	5.8	85.3
Investment	$ billion	2.7					6.5					0.7					0.3					1.5		11.8
Net Benefit	$ billion	-2.7	1.3	1.3	1.3	1.3	-5.2	4.6	4.6	4.6	4.6	3.8	4.9	4.9	4.9	4.9	4.6	5.1	5.1	5.1	5.1	3.6	5.8	73.5
IRR																								49%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.7: Calculation of Internal Rates of Return, Thailand

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		204.9	204.9	204.9	204.9	204.9	238.4	238.4	238.4	238.4	238.4	273.9	273.9	273.9	273.9	273.9	312.2	312.2	312.2	312.2	312.2	354.0	
APS	TWh		189.1	189.1	189.1	189.1	189.1	202.0	202.0	202.0	202.0	202.0	224.5	224.5	224.5	224.5	224.5	246.0	246.0	246.0	246.0	246.0	273.0	
Saving Potential	TWh		15.8	15.8	15.8	15.8	15.8	36.4	36.4	36.4	36.4	36.4	49.5	49.5	49.5	49.5	49.5	66.2	66.2	66.2	66.2	66.2	81.0	919.8
Benefit	$ billion		2.3	2.3	2.3	2.3	2.3	5.4	5.4	5.4	5.4	5.4	7.4	7.4	7.4	7.4	7.4	9.9	9.9	9.9	9.9	9.9	12.0	136.9
Investment	$ billion	4.7					6.2					3.9					5.1					4.4		24.4
Net Benefit	$ billion	-4.7	2.3	2.3	2.3	2.3	-3.9	5.4	5.4	5.4	5.4	1.5	7.4	7.4	7.4	7.4	2.3	9.9	9.9	9.9	9.9	5.4	12.0	112.5
IRR																								49%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.8: Calculation of Internal Rates of Return, Viet Nam

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		229.0	229.0	229.0	229.0	229.0	303.9	303.9	303.9	303.9	303.9	375.0	375.0	375.0	375.0	375.0	441.6	441.6	441.6	441.6	441.6	513.5	
APS	TWh		222.9	222.9	222.9	222.9	222.9	287.8	287.8	287.8	287.8	287.8	345.1	345.1	345.1	345.1	345.1	394.0	394.0	394.0	394.0	394.0	443.4	
Saving Potential	TWh		6.1	6.1	6.1	6.1	6.1	16.1	16.1	16.1	16.1	16.1	29.9	29.9	29.9	29.9	29.9	47.6	47.6	47.6	47.6	47.6	70.0	568.5
Benefit	$ billion		0.7	0.7	0.7	0.7	0.7	1.8	1.8	1.8	1.8	1.8	3.4	3.4	3.4	3.4	3.4	5.4	5.4	5.4	5.4	5.4	8.0	64.8
Investment	$ billion	1.8					3.0					4.1					5.3					6.8		21.1
Net Benefit	$ billion	-1.8	0.7	0.7	0.7	0.7	-2.3	1.8	1.8	1.8	1.8	-2.3	3.4	3.4	3.4	3.4	-1.9	5.4	5.4	5.4	5.4	-1.3	8.0	43.7
IRR																								37%

APS = alternative policy scenario, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Table A8.9: Calculation of Internal Rates of Return, Association of Southeast Asian Nations

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Year		Initial investment	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
BAU	TWh		1,041.3	1,041.3	1,041.3	1,041.3	1,041.3	1,326.2	1,326.2	1,326.2	1,326.2	1,326.2	1,635.9	1,635.9	1,635.9	1,635.9	1,635.9	1,990.9	1,990.9	1,990.9	1,990.9	1,990.9	2,402.6	
APS	TWh		953.7	953.7	953.7	953.7	953.7	1,153.9	1,153.9	1,153.9	1,153.9	1,153.9	1,388.9	1,388.9	1,388.9	1,388.9	1,388.9	1,665.2	1,665.2	1,665.2	1,665.2	1,665.2	1,982.8	
Saving Potential	TWh		87.5	87.5	87.5	87.5	87.5	172.2	172.2	172.2	172.2	172.2	247.0	247.0	247.0	247.0	247.0	325.7	325.7	325.7	325.7	325.7	419.8	4,582.2
Benefit	$ billion		7.8	7.8	7.8	7.8	7.8	14.8	14.8	14.8	14.8	14.8	22.0	22.0	22.0	22.0	22.0	30.3	30.3	30.3	30.3	30.3	39.5	414.2
Investment	$ billion	26.4					25.5					22.5					23.7					28.4		126.5
Net Benefit	$ billion	-26.4	7.8	7.8	7.8	7.8	-17.7	14.8	14.8	14.8	14.8	-7.8	22.0	22.0	22.0	22.0	-1.7	30.3	30.3	30.3	30.3	1.9	39.5	287.7
IRR																								29%

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

APS = alternative policy scenario, ASEAN = Association of Southeast Asian Nations, BAU = business as usual, IRR = internal rate of return, TWh = terawatt-hour.

Source: Author.

Appendix 9: Country Analysis

A9.1 Brunei Darussalam

A9.1.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.1 and A9.2 show the electricity demand outlook and electricity generation outlook of Brunei Darussalam in the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Outlook 2019.

Table A9.1: Electricity Demand Outlook, Brunei Darussalam

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	3.0	4.7	8.6	10.4	13.1	14.7	4.2	7.9	8.6	8.8	10.4

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

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.

Table A9.2: Electricity Generation Outlook, Brunei Darussalam

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	3.8	5.8	11.0	12.9	15.9	17.7	5.4	10.3	11.1	11.3	13.1
Coal	0.0	0.8	3.6	3.6	3.6	3.6	0.8	0.8	0.8	0.8	0.8
Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	3.7	5.0	7.3	9.3	12.3	14.1	4.3	9.1	9.7	9.6	11.4
Nuclear											
Hydro											
Geothermal											
Others	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.8	0.9

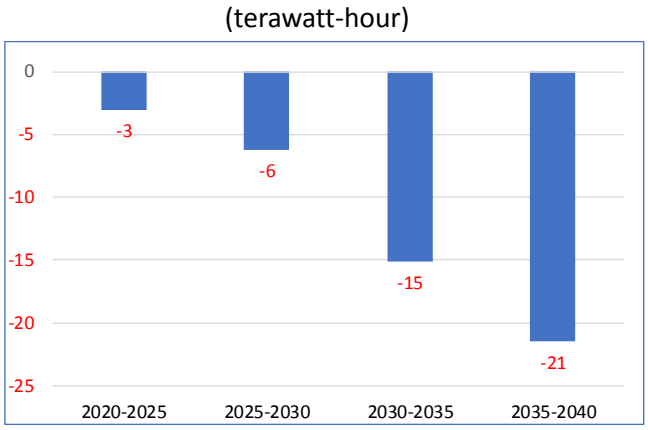
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower.

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.

A9.1.2 Electricity Demand Saving Potential

The electricity saving potential of Brunei Darussalam will be 3 TWh in 2020–2025, 6 TWh in 2025–2030, 15 TWh in 2020– 2035, and 21 TWh in 2035–2040.

Figure A9.1: Electricity Demand Saving Potential, Brunei Darussalam



Source: Author.

A9.1.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

The gross benefit, investment, net benefit, and internal rate of return (IRR) are not analysed due to a lack of information on electricity prices.

A9.1.4 Avoided Generation Capacity Construction Cost

Table A9.3: Avoided Generation Capacity Construction Cost, Brunei Darussalam

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kW)	($ billion)
Coal	-0.4	75.0	-54	1,600	-0.1
Natural gas	-4.8	60.0	-912	700	-0.6
(Sub-total)	(-5.1)		(-966)		(-0.7)
Nuclear	-	70.0	-	3,298	-
Hydro	-	33.0	-	2,500	-
Geothermal	-	75.0	-	3,200	-
Biomass	-	75.0	-	1,600	-
Solar	0.9	17.5	558	1,600	0.9
Wind	-	27.0	-	1,700	-
(Sub-total)	(0.9)		(558)		(0.9)
Net	-4.3		-408		0.2

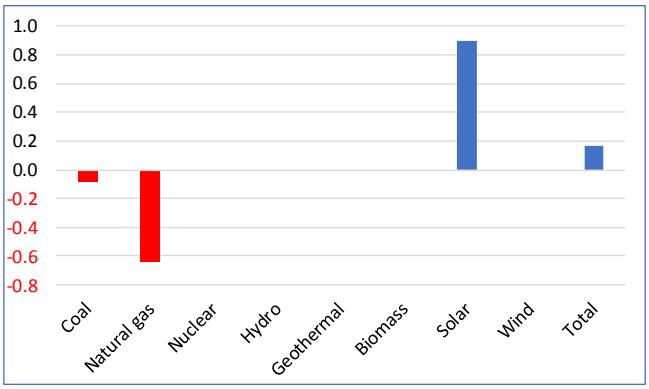
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.
Source: Author.

In 2040, avoided electricity from coal and natural gas will reach 5.1 TWh, and solar generation will increase to 0.9 TWh. In 2040, the avoided generation capacity from coal and natural gas will be 966 MW, and the required solar generation capacity will be 558 MW.

In 2040, the avoided generation capacity construction cost of coal and natural gas will reach $0.7 billion, the required solar generation capacity construction cost will increase to $0.9 billion, and the net generation capacity construction cost will increase to $0.2 billion.

Figure A9.2: Avoided Generation Capacity Construction Cost, Brunei Darussalam

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($14 billion) and forecasted 2040 GDP ($55 billion). The impact of of net capital expenditure increase is 1.2% compared against the 2015 GDP and 0.3% compared against the forecasted 2040 GDP.

A9.1.5 Avoided Carbon Dioxide Emissions

Table A9.4: Avoided Carbon Dioxide Emissions, Brunei Darussalam

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-0.4	43%	-0.1	-0.3
Natural gas	-4.8	55%	-0.7	-1.8
Total	-5.1	-	-0.8	-2.0

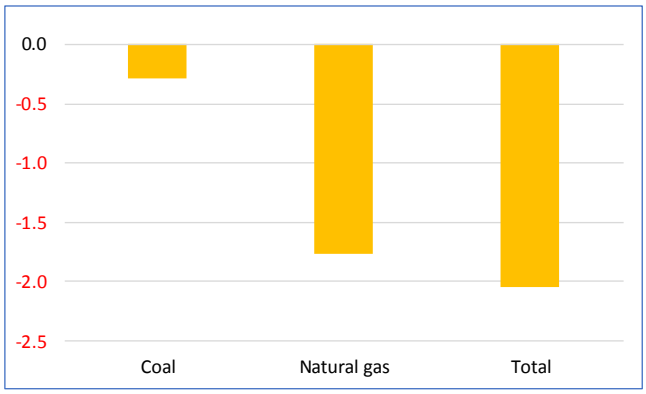
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided carbon dioxide (CO_2) emissions from coal will be 0.3 million tonnes-CO_2 and that from natural gas will be 1.8 million tonnes-CO_2. Total avoided CO_2 emissions will be 2.0 million tonnes-CO_2.

Figure A9.3: Avoided Carbon Dioxide Emissions, Brunei Darussalam

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Brunei Darussalam is 29% compared against 2015 and 12% compared against 2040 BAU. As a reference, the estimated value of annual avoided CO_2 emissions is calculated and tentatively compared with the forecasted 2040 GDP ($55 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($4.0 million) is 0.01% of GDP in Brunei Darussalam.

A9.2 Cambodia

A9.2.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.5 and A9.6 show the electricity demand outlook and electricity generation outlook of Cambodia in the ERIA Energy Outlook 2019.

Table A9.5: Electricity Demand Outlook, Cambodia

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	5.0	11.8	15.0	19.7	26.8	37.7	11.4	13.9	17.5	22.8	32.1

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

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.

Table A9.6: Electricity Generation Outlook, Cambodia

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	4.4	10.6	14.0	19.1	26.6	38.2	9.0	10.6	13.0	17.2	25.7
Coal	2.1	4.5	5.9	6.9	9.8	13.0	3.2	5.0	4.7	4.9	11.3
Oil	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	0.0	0.0	0.0	2.4	3.1	7.0	1.1	1.0	0.8	0.8	1.0
Nuclear											
Hydro	2.0	5.7	7.8	9.6	13.0	17.5	4.1	3.6	6.2	9.7	10.8
Geothermal											
Others	0.0	0.3	0.3	0.2	0.6	0.7	0.6	1.0	1.4	1.9	2.6

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, TWh = terawatt-hour.

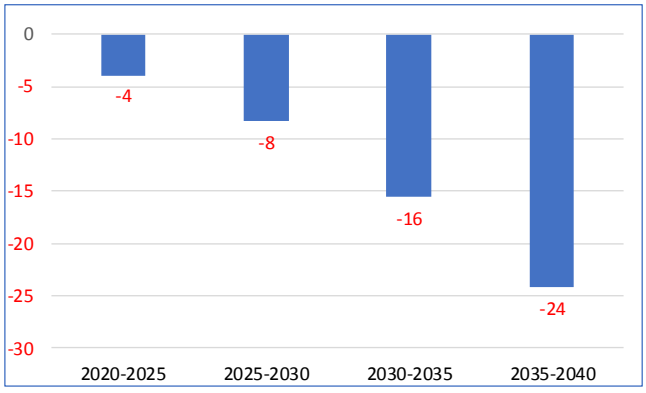
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.2.2 Electricity Demand Saving Potential

The electricity saving potential of Cambodia will be 4 TWh in 2020–2025, 8 TWh in 2025–2030, 16 TWh in 2020–2035, and 24 TWh in 2035–2040.

Figure A9.4: Electricity Demand Saving Potential, Cambodia

(terawatt-hour)



Source: Author.

A9.2.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.7: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Cambodia

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(Annual)
-0.4	-1.0	-1.9	-3.4	-1.0	-7.6	-0.4

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(Annual)
0.1	0.2	0.3	0.5	0.5	1.7	0.1

Net Benefit

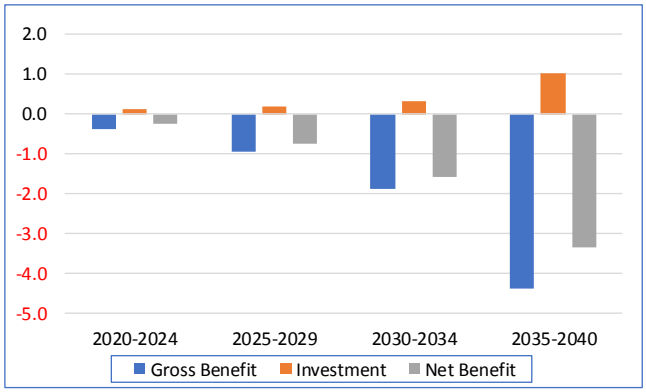
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(Annual)
-0.2	-0.8	-1.6	-2.9	-0.5	-5.9	-0.3
IRR						57%
Electricity price (2017, $0.01/kWh)						17.1

kWh = kilowatt-hour, IRR = internal rate of return.
Source: Author.

The cumulative gross benefit in Cambodia will reach $7.6 billion. The total required investment in electricity saving will be $1.7 billion. Thus, the total net benefit will reach $5.9 billion. Based on this result, the IRR will be 57%, and a very high return will be expected because the price of electricity in Cambodia is based on the market, making it the highest in the subject countries.

Figure A9.5: Gross Benefit, Investment, and Net Benefit, Cambodia

($ billion)



Note: 2040 is included in 2035–2040.
Source: Author.

If the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Cambodia, it can tentatively reduce the price of gasoline and diesel to only $0.06 per litre in a year.

A9.2.4 Avoided Generation Capacity Construction Cost

Table A9.8: Avoided Generation Capacity Construction Cost, Cambodia

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kW)	($ billion)
Coal	-0.8	75.0	-125	1,600	-0.2
Natural gas	-0.1	60.0	-14	700	-0.0
(Sub-total)	(-0.9)		(-140)		(-0.2)
Nuclear	-	70.0	-	3,298	-
Hydro	-6.7	33.0	-2,324	2,500	-5.8
Geothermal	-	75.0	-	3,200	-
Biomass	1.4	75.0	217	1,600	0.3
Solar	0.5	17.5	347	1,600	0.6
Wind	-	27.0	-	1,700	-
(Sub-total)	(-4.8)		(-1,760)		(-4.9)
Net	-5.7		-1,899		-5.1

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

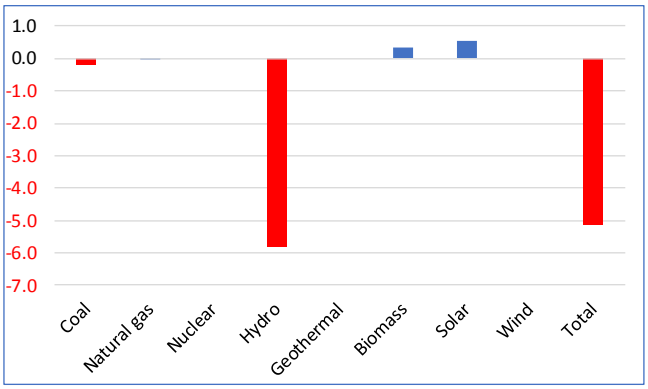
Source: Author.

In 2040, avoided electricity from coal and natural gas will be 0.9 TWh, hydropower generation will decrease to 6.7 TWh, biomass generation will increase to 1.4 TWh, and solar generation will increase to 0.5 TWh. Avoided generation capacity of coal and natural gas will be 140 MW, required hydropower generation capacity will decrease to 2,324 MW, required biomass generation capacity will increase to 217 MW, and solar generation capacity will increase to 347 MW. The avoided generation capacity construction cost of coal and natural gas will be $0.2 billion, required hydropower generation capacity construction cost will decrease to $5.8 billion,

required biomass generation capacity construction cost will increase to $0.3 billion, solar generation capacity construction cost will increase to $0.6 billion, and net generation capacity construction cost will decrease to $5.1 billion.

Figure A9.6: Avoided Generation Capacity Construction Cost, Cambodia

($ billion)



Hydro = hydropower

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($16 billion) and forecasted 2040 GDP ($61 billion). The impact of net capital expenditure decrease is -32.2% compared against the 2015 GDP and -8.4% compared against the forecasted 2040 GDP.

A9.2.5 Avoided Carbon Dioxide Emissions

Table A9.9: Avoided Carbon Dioxide Emissions, Cambodia

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO_2 emissions (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-0.8	43%	-0.2	-0.7
Natural gas	-0.1	55%	-0.0	-0.03
Total	-0.9	-	-0.2	-0.7

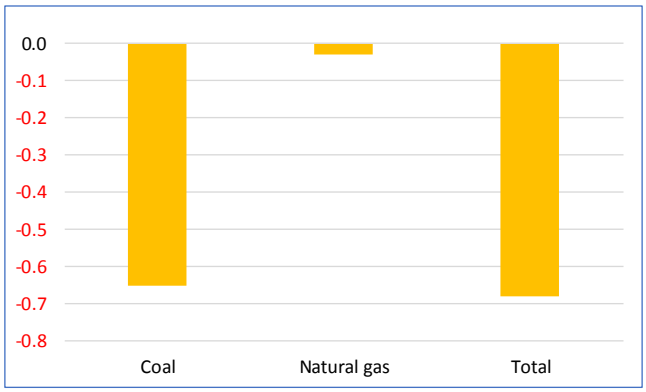
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 0.7 million tonnes-CO_2 and that from natural gas will be 0.03 million tonnes-CO_2. Total avoided CO_2 emissions will be 0.7 million tonnes-CO_2.

Figure A9.7: Avoided Carbon Dioxide Emissions, Cambodia

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Cambodia is 9% compared against 2015 and 2% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared with the forecasted 2040 GDP ($61 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($1.3 million) is 0.002% of Cambodia's GDP.

A9.3 Indonesia

A9.3.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.17 and A9.18 show the electricity demand outlook and electricity generation outlook of Indonesia as reported in the ERIA Energy Outlook 2019.

Table A9.10: Electricity Demand Outlook, Indonesia

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	200.3	317.0	413.4	537.1	700.4	901.1	277.6	351.5	442.9	577.4	742.7

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

Table A9.11: Electricity Generation Outlook, Indonesia

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	233.3	357.1	454.3	577.4	753.0	968.7	311.0	384.3	472.6	616.1	792.5
Coal	130.5	264.5	334.2	452.1	558.3	681.3	152.9	178.5	226.6	270.6	344.1
Oil	19.7	13.0	15.0	12.7	14.1	15.4	25.4	26.4	24.7	22.2	24.7
Natural gas	58.9	64.1	76.5	85.7	134.2	220.0	83.4	89.7	94.3	124.0	210.7
Nuclear							0.0	9.4	9.4	16.9	18.9
Hydro	13.7	9.3	19.1	18.0	24.2	26.4	24.1	36.3	50.5	63.0	70.2
Geothermal	10.0	5.5	8.6	7.9	17.6	19.2	17.0	27.5	40.9	48.4	45.0
Others	0.5	0.7	0.9	0.9	4.7	6.5	8.2	16.5	26.1	70.9	78.8

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

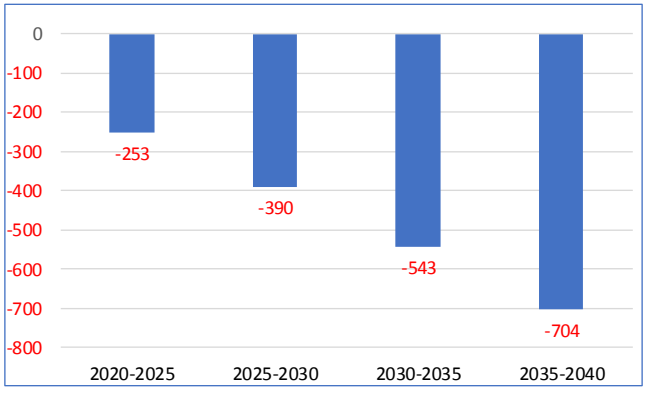
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.3.2 Electricity Demand Saving Potential

Indonesia's electricity saving potential will be 253 TWh in 2020–2025, 390 TWh in 2025–2030, 543 TWh in 2020–2035, and 704 TWh in 2035–2040.

Table A9.12: Electricity Demand Saving Potential, Indonesia

(terawatt-hour)



Source: Author.

A9.3.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.13: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Indonesia

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-15.9	-24.9	-37.9	-49.5	-12.8	-141.0	-6.7

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
11.9	6.8	9.7	8.7	10.7	47.7	2.3

Net benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-4.0	-18.1	-28.2	-40.8	-2.1	-93.2	-4.4
IRR						26%
Electricity price (2017, $0.01/kWh)						8.1

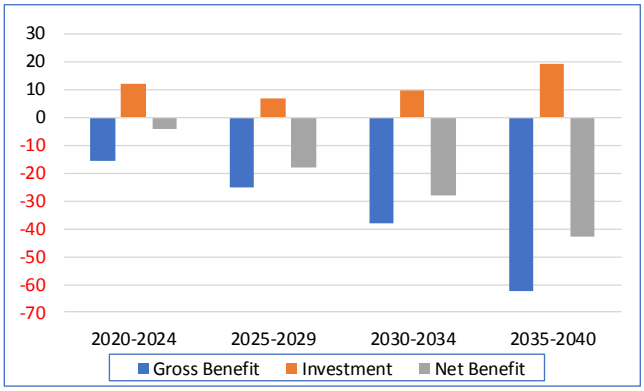
kWh = kilowatt-hour, IRR = internal rate of return.

Source: Author.

The cumulative gross benefit in Indonesia will reach $141.0 billion. The total required investment in electricity saving will be $147.7 billion. Thus, the total net benefit will reach $93.2 billion. Based on this result, the IRR will be 27%, and a high return will be expected; it is close to the ASEAN average (29%). The price of electricity in Indonesia is subsidised.

Figure A9.8: Gross Benefit, Investment, and Net Benefit, Indonesia

($ billion)



Note: 2040 is included in 2035–2040.
Source: Author.

Table A9.14 shows the energy subsidy calculated by the IEA. Compared to the required annual investment in electricity saving ($2.3 billion), the energy subsidy is larger than the investment.

Table A9.14: Energy Subsidy, Indonesia

($ 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

Source: International Energy Agency Fossil Fuel Subsidies Database. https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

From another aspect, if the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Indonesia, it can tentatively reduce the price of gasoline and diesel to only $0.05/L in a year.

A9.3.4 Avoided Generation Capacity Construction Cost

Table A9.15: Avoided Generation Capacity Construction Cost, Indonesia

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kW)	($ billion)
Coal	-203.8	75.0	-31,021	1,600	-49.6
Natural gas	-124.8	60.0	-23,744	700	-16.6
(Sub-total)	(-328.6)		(-54,765)		(-66.3)
Nuclear	18.9	70.0	3,079	3,298	10.2
Hydro	43.8	33.0	15,162	2,500	37.9
Geothermal	25.8	75.0	3,923	3,200	12.6
Biomass	67.6	75.0	10,284	1,600	16.5
Solar	0.5	17.5	312	1,600	0.5
Wind	4.3	27.0	1,826	1,700	3.1
(Sub-total)	(160.8)		(34,586)		(80.7)
Net	-167.8		-20,179		14.4

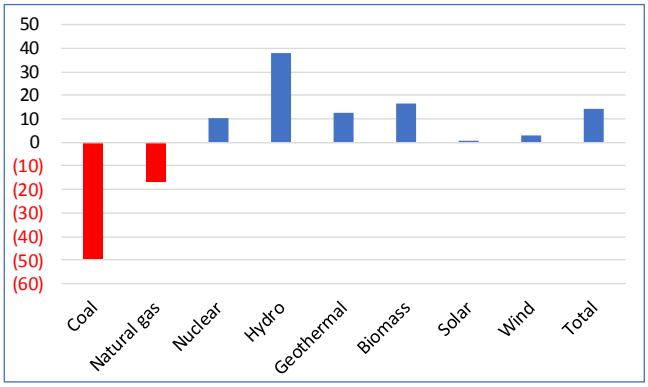
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

Source: Author.

In 2040, avoided electricity from coal and natural gas will be 329 TWh, and nuclear and total renewable generation will increase to 161 TWh. The avoided generation capacity of coal and natural gas will be 55 gigawatts (GW), and the required nuclear and total renewable generation capacity will increase the 35 GW. The avoided generation capacity construction cost of coal and natural gas will be $66.3 billion, the required nuclear and total renewable generation capacity construction cost will increase to $80.73 billion, and the net generation capacity construction cost will increase to $14.4 billion.

Figure A9.9: Avoided Generation Capacity Construction Cost, Indonesia

($ billion)



Hydro = hydropower.
Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($988 billion) and the forecasted 2040 GDP ($4,052 billion). The impact of the net capital expenditure increase is 1.5% compared against the 2015 GDP and 0.4% compared against the forecasted 2040 GDP.

A9.3.5 Avoided Carbon Dioxide Emissions

Table A9.16: Avoided Carbon Dioxide Emissions, Indonesia

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-203.8	43%	-40.8	-161.5
Natural gas	-124.8	55%	-19.5	-45.8
Total	-328.6	-	-60.3	-207.3

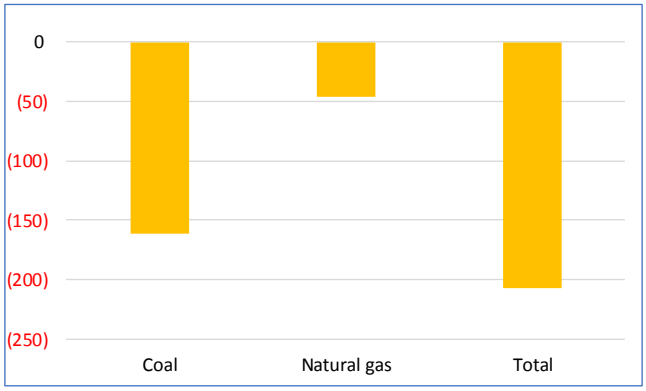
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 162 million tonnes-CO_2 and that from natural gas will be 46 million tonnes-CO_2. Total avoided CO_2 emissions will be 207 million tonnes-CO_2.

Figure A9.10: Avoided Carbon Dioxide Emissions, Indonesia

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Indonesia is 44% compared against 2015 and 11% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared to the forecasted 2040 GDP ($4,052 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($405 million) is 0.01% of Indonesia's GDP.

A9.4 Lao People's Democratic Republic

A9.4.1 Electricity Demand and Generation Outlook, Economic Research Institute of ASEAN and East Asia Energy Outlook 2019

Tables A9.27 and A9.28 show the electricity demand outlook and electricity generation outlook of the Lao PDR in the ERIA Energy Outlook 2019.

Table A9.17: Electricity Demand Outlook, the Lao People's Democratic Republic

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	4.0	4.8	5.9	7.1	8.7	10.8	4.3	5.3	6.4	7.8	9.7

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

Table A9.18: Electricity Generation Outlook, the Lao People's Democratic Republic

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	17.8	41.1	33.6	42.3	42.3	71.9	41.8	33.6	42.3	42.3	71.9
Coal	2.3	13.0	20.7	20.7	20.7	45.2	13.0	20.7	20.7	20.7	45.2
Oil											
Natural gas											
Nuclear											
Hydro	15.5	28.1	12.9	21.6	21.6	26.7	28.7	12.9	21.6	21.6	26.7
Geothermal											
Others											

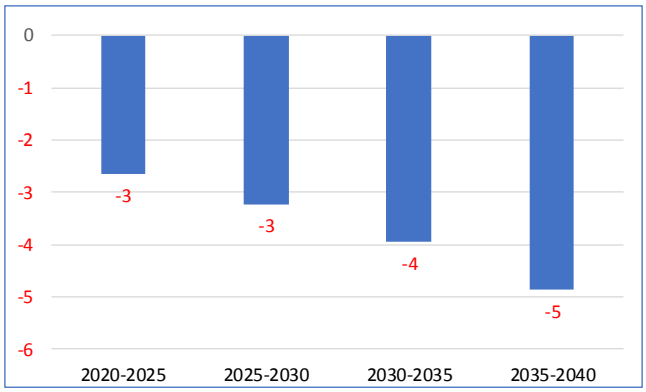
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower.
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.4.2 Electricity Demand Saving Potential

The electricity saving potential of the Lao PDR will be 3 TWh in 2020–2025, 3 TWh in 2025–2030, 4 TWh in 2020–2035, and 5 TWh in 2035–2040.

Figure A9.11: Electricity Demand Saving Potential, the Lao People's Democratic Republic

(terawatt-hour)



Source: Author.

A9.4.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.19: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, the Lao People's Democratic Republic

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(Annual)
-0.2	-0.3	-0.3	-0.4	-0.1	-1.2	-0.06

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(Annual)
0.1	0.0	0.0	0.0	0.1	0.3	0.02

Net benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(Annual)
-0.1	-0.2	-0.3	-0.3	-0.0	-0.9	-0.04
IRR						28%
Electricity price (2018, $0.01/kilowatt-hour)						8.6

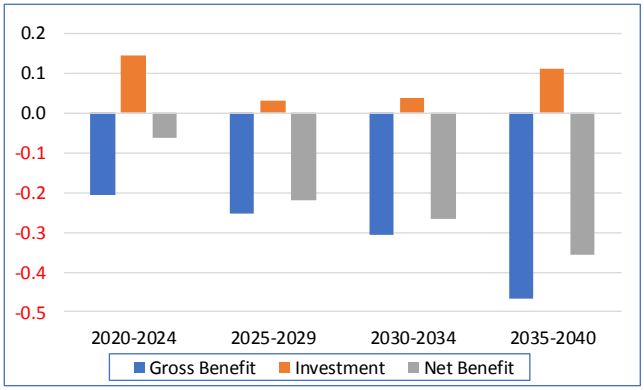
IRR = internal rate of return.

Source: Author.

The cumulative gross benefit of the Lao PDR will reach $1.2 billion. The total required investment in electricity saving will be $0.3 billion. Thus, the total net benefit will reach $0.9 billion. Based on this result, the IRR will be 28% and a high return will be expected; it is close to the ASEAN average (29%).

Figure A9.12: Gross Benefit, Investment, and Net Benefit, the Lao People's Democratic Republic

($ billion)



Note: '2040' is included in '2035–2040'.

Source: Author.

If the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in the Lao PDR, it can tentatively reduce gasoline and diesel prices to only $0.02 per litre in a year.

A9.4.4 Avoided Generation Capacity Construction Cost

Table A9.20: Avoided Generation Capacity Construction Cost, the Lao People's Democratic Republic

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-1.1	75.0	-164	1,600	-0.3
Natural gas	-	60.0	-	700	-
(Sub-total)	(-1.1)		(-164)		(-0.3)
Nuclear	-	70.0	-	3,298	-
Hydro	-	33.0	-	2,500	-
Geothermal	-	75.0	-	3,200	-
Biomass	-	75.0	-	1,600	-
Solar	-	17.5	-	1,600	-
Wind	-	27.0	-	1,700	-
(Sub-total)	(0.0)		(0)		(0.0)
Net	-1.1		-164		-0.3

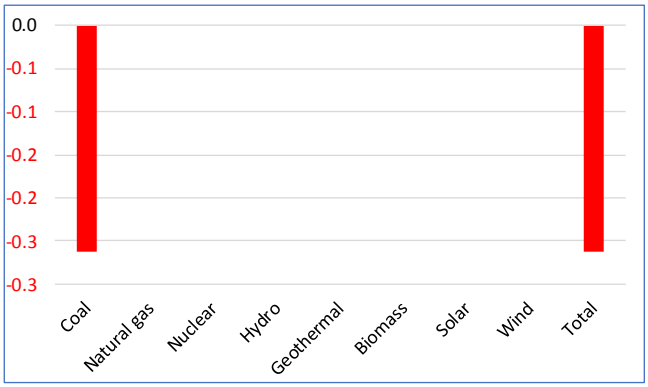
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

Source: Author.

The Lao PDR has no plan to introduce natural gas, nuclear, and renewable electricity generation. In 2040, avoided electricity from coal will be 1.1 TWh, the avoided generation capacity of coal will be 164 MW, and the avoided generation capacity construction cost of coal will be $0.3 billion.

Figure A9.13: Avoided Generation Capacity Construction Cost , the Lao People's Democratic Republic

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($5 billion) and forecasted 2040 GDP ($23 billion). The impact of the net capital expenditure decrease is -5.1% compared against the 2015 GDP and -1.1% compared against the forecasted 2040 GDP.

A9.4.5 Avoided Carbon Dioxide Emissions

Table A9.21: Avoided Carbon Dioxide Emissions, the Lao People's Democratic Republic

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO_2 emissions (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-1.1	43%	-0.2	-0.9
Natural gas	-	55%	-	-
Total	-1.1	-	-0.2	-0.9

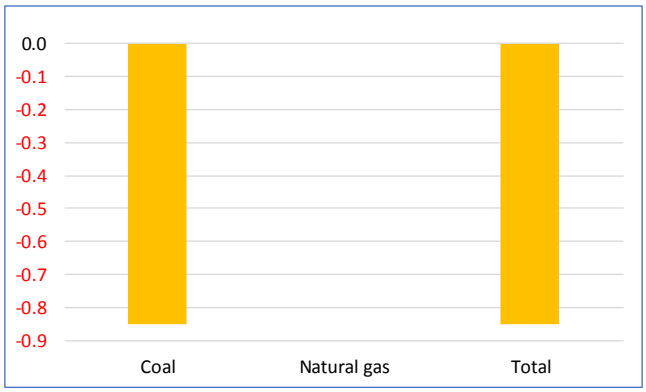
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 0.9 million tonnes-CO_2.

Figure A9.14: Avoided Carbon Dioxide Emissions, the Lao People's Democratic Republic

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in the Lao PDR is 40% compared against 2015 and 1% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared with the forecasted 2040 GDP ($23 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($1.7 million) is 0.01% of the Lao PDR's GDP.

A9.5 Malaysia

A9.5.1 Electricity Demand and Generation Outlook, Economic Research Institute of ASEAN and East Asia Energy Outlook 2019

Tables A9.35 and A9.36 show the electricity demand outlook and electricity generation outlook of Malaysia in the ERIA Energy Outlook 2019.

Table A9.22: Electricity Demand Outlook, Malaysia

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	132.6	162.9	198.7	239.8	284.8	332.3	147.7	176.9	209.5	244.1	279.3

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

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.

Table A9.23: Electricity Generation Outlook, Malaysia

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	150.4	182.2	222.8	267.5	316.5	368.1	166.6	200.5	236.2	273.9	312.2
Coal	63.5	76.9	87.3	103.0	121.7	145.8	68.1	74.1	84.8	100.0	113.9
Oil	1.7	1.8	1.6	1.5	1.6	1.6	1.9	1.6	1.6	1.7	1.7
Natural gas	70.0	81.0	104.9	133.7	163.8	191.4	70.9	90.2	114.1	136.2	152.3
Nuclear							0.0	0.0	0.0	0.0	8.3
Hydro	14.2	16.9	23.4	23.8	23.8	23.8	17.6	24.6	25.2	25.3	25.3
Geothermal											
Others	1.0	5.5	5.5	5.5	5.5	5.5	8.1	10.0	10.5	10.7	10.7

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

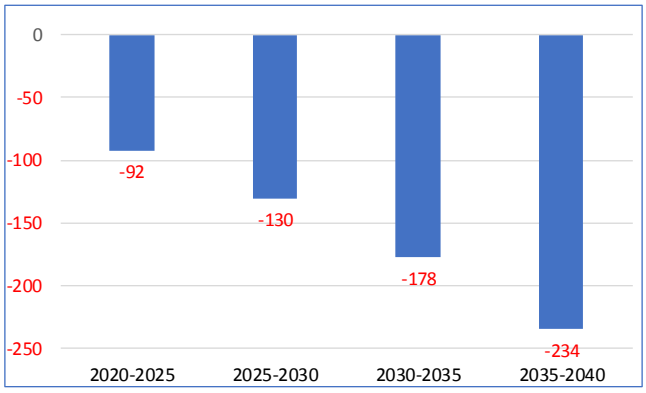
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.5.2 Electricity Demand Saving Potential

Malaysia's electricity saving potential will be 92 TWh in 2020–2025, 130 TWh in 2025–2030, 178 TWh in 2020–2035, and 234 TWh in 2035–2040.

Figure A9.15: Electricity Demand Saving Potential, Malaysia

(terawatt-hour)



Source: Author.

A9.5.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.24: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Malaysia

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-7.3	-10.4	-14.5	-19.5	-5.1	-56.8	-2.7

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
4.6	2.0	2.6	3.1	3.7	16.0	0.8

Net benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-2.7	-8.4	-12.0	-16.4	-1.4	-40.8	-1.9
IRR						31%
Electricity price (2016, $0.01/kilowatt-hour)						9.6

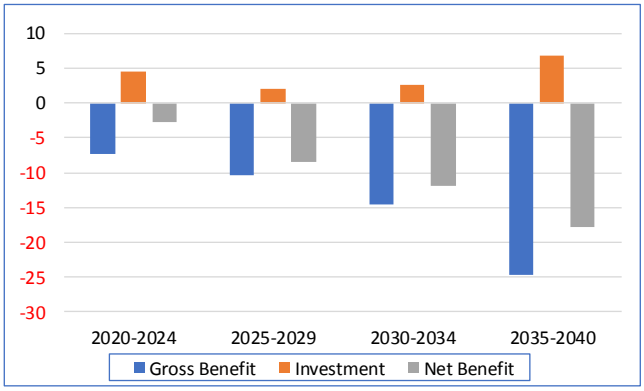
IRR = internal rate of return.

Source: Author.

The cumulative gross benefit of Malaysia will reach $56.8 billion. The total required investment in electricity saving will be $16.0 billion. Thus, the total net benefit will reach $40.8 billion. Based on this result, the IRR will be 31%, and a high return will be expected; it is slightly higher that the ASEAN average (29%). The price of electricity in Malaysia is subsidised.

Figure A9.16: Gross Benefit, Investment, and Net Benefit, Malaysia

($ billion)



Note: 2040 is included in 2035–2040.

Source: Author.

Table A9.25 shows the energy subsidy calculated by the IEA. Compared to the required annual investment in electricity saving ($0.8 billion), the energy subsidy is larger than the investment.

Table A9.25: Energy Subsidy, Malaysia

($ billion)

Country	Product	2015	2016	2017
Malaysia	Oil	0.31	0.39	1.42
	Total	0.31	0.39	1.42

Source: International Energy Agency Fossil Fuel Subsidies Database. https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

From another aspect, if the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Malaysia, it can tentatively reduce the price of gasoline and diesel to only $0.03/L in a year.

A9.5.4 Avoided Generation Capacity Construction Cost

Table A9.26: Avoided Generation Capacity Construction Cost, Malaysia

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-29.1	75.0	-4,434	1,600	-7.1
Natural gas	-38.9	60.0	-7,409	700	-5.2
(Sub-total)	(-68.1)		(-11,843)		(-12.3)
Nuclear	8.3	70.0	1,350	3,298	4.5
Hydro	1.5	33.0	531	2,500	1.3
Geothermal	-	75.0	-	3,200	-
Biomass	1.0	75.0	145	1,600	0.2
Solar	4.3	17.5	2,785	1,600	4.5
Wind	-	27.0	-	1,700	-
(Sub-total)	(15.0)		(4,811)		(10.5)
Net	-53.0		-7,032		-1.8

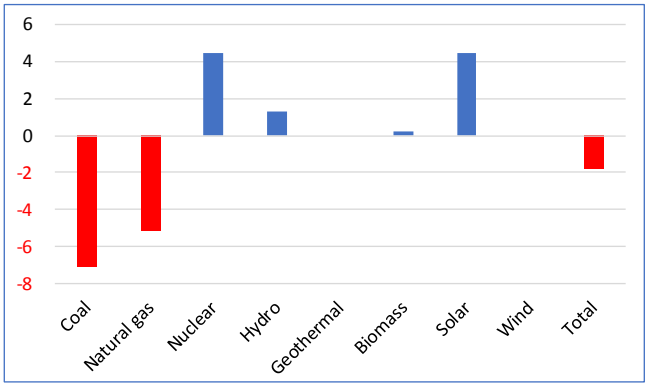
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

Source: Author.

In 2040, avoided electricity from coal and natural gas will be 68 TWh, and nuclear and total renewable generation will increase to 15 TWh. The avoided generation capacity of coal and natural gas will be 12 GW, and required nuclear and total renewable generation capacity will increase to 5 GW. The avoided generation capacity construction cost of coal and natural gas will be $12.3 billion, the required nuclear and total renewable generation capacity construction cost will increase to $10.5 billion, and the net generation capacity construction cost will decrease to $1.8 billion.

Figure A9.17: Avoided Generation Capacity Construction Cost, Malaysia

($ billion)



Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($330 billion) and forecasted 2040 GDP ($775 billion). The impact of of net capital expenditure decrease is -0.5% compared against 2015 GDP, and -0.2% compared against forecasted 2040 GDP.

A9.5.5 Avoided Carbon Dioxide Emissions

Table A9.27: Avoided Carbon Dioxide Emissions, Malaysia

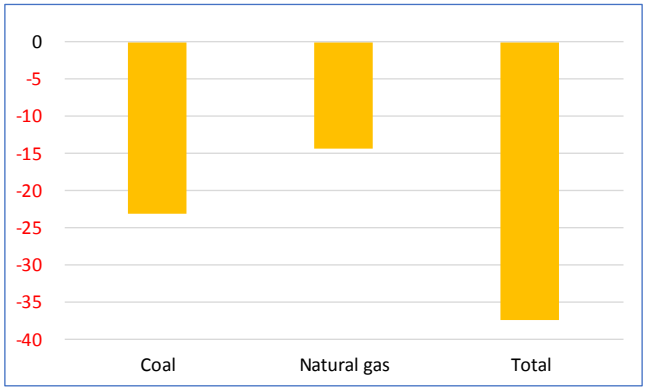
Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-29.1	43%	-5.8	-23.1
Natural gas	-38.9	55%	-6.1	-14.3
Total	-68.1	-	-11.9	-37.4

CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.
Source: Author.

Avoided CO_2 emissions from coal will be 23 million tonnes-CO_2 and that from natural gas will be 14 million tonnes-CO_2. Total avoided CO_2 emissions will be 37 million tonnes-CO_2.

Figure A9.18: Avoided Carbon Dioxide Emissions, Malaysia

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. Compared against 2015, The impact of avoided CO_2 emissions in Malaysia is 19% compared against 2015 and 8% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared with the forecasted 2040 GDP ($775 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($73 million) is 0.01% of Malaysia's GDP.

A9.6 Myanmar

A9.6.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.28 and A9.29 show the electricity demand outlook and electricity generation outlook of Myanmar in the ERIA Energy Outlook 2019.

Table A9.28: Electricity Demand Outlook, Myanmar

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	13.4	21.3	28.4	36.3	45.7	57.3	20.0	24.7	29.0	36.5	45.9

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

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.

Table A9.29: Electricity Generation Outlook, Myanmar

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	16.0	23.6	31.5	40.3	50.5	63.0	23.5	28.4	32.6	40.6	50.4
Coal	0.0	0.1	0.2	14.5	17.9	26.6	0.1	0.2	0.3	0.4	0.5
Oil	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Natural gas	6.5	12.6	13.7	9.3	12.3	13.7	11.9	11.6	8.6	11.2	13.9
Nuclear											
Hydro	9.4	10.5	16.0	13.4	16.4	18.4	11.0	15.1	17.1	20.9	25.9
Geothermal											
Others	0.0	0.3	1.5	3.1	3.8	4.3	0.3	1.4	6.7	8.1	10.1

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

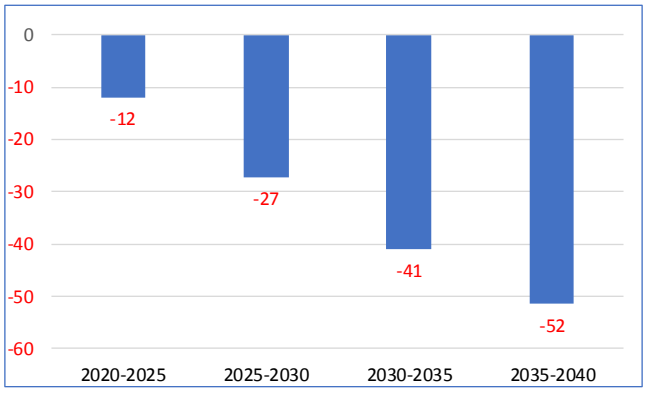
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.6.2 Electricity Demand Saving Potential

Myanmar's electricity saving potential will be 12 TWh in 2020–2025, 27 TWh in 2025–2030, 41 TWh in 2020–2035, and 52 TWh in 2035–2040.

Figure A9.19: Electricity Demand Saving Potential, Myanmar

(terawatt-hour)



Source: Author.

A9.6.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.30: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Myanmar

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-0.3	-0.9	-1.8	-2.3	-0.6	-5.9	-0.3

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
0.4	0.7	1.1	0.6	0.7	3.5	0.2

Net benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
0.1	-0.2	-0.7	-1.7	0.1	-2.4	-0.1
IRR						13%
Electricity price (2017, $0.01 per kilowatt-hour)						5.0

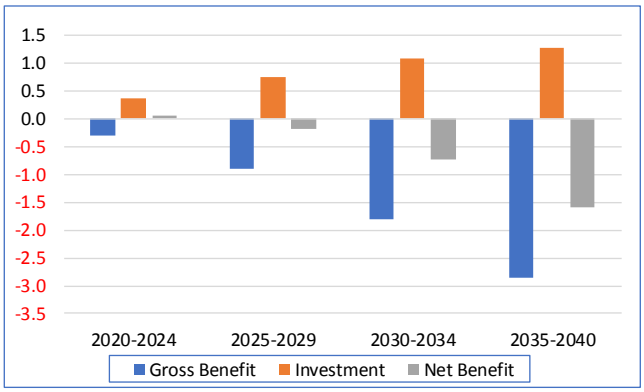
IRR = internal rate of return.

Source: Author.

The cumulative gross benefit of Myanmar will reach $5.9 billion. The total required investment in electricity saving will be $3.5 billion. Thus, the total net benefit will reach $2.4 billion. Based on this result, the IRR will be 13%, the lowest level amongst the subject countries. The price of electricity in Myanmar is the lowest amongst the subject countries.

Figure A9.20: Gross Benefit, Investment, and Net Benefit, Myanmar

($ billion)



Note: 2040 is included in 2035–2040.
Source: Author.

If the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Myanmar it can tentatively reduce the price of gasoline and diesel to $0.16/L in a year.

A9.6.4 Avoided Generation Capacity Construction Cost

Table A9.31: Avoided Generation Capacity Construction Cost, Myanmar

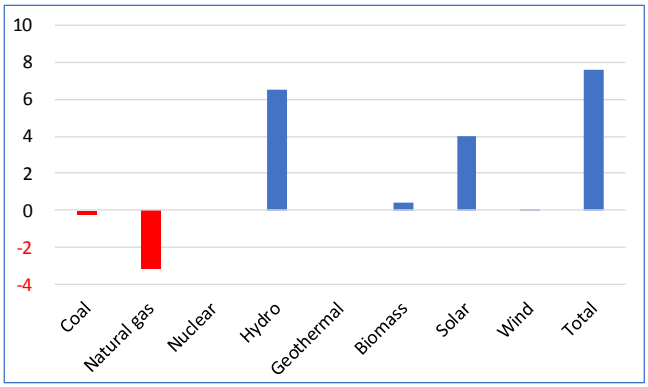
Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-0.9	75.0	-136	1,600	-0.2
Natural gas	-23.9	60.0	-4,540	700	-3.2
(Sub-total)	(-24.8)		(-4,677)		(-3.4)
Nuclear	-	70.0	-	3,298	-
Hydro	7.5	33.0	2,605	2,500	6.5
Geothermal	-	75.0	-	3,200	-
Biomass	1.8	75.0	280	1,600	0.4
Solar	3.8	17.5	2,511	1,600	4.0
Wind	0.1	27.0	32	1,700	0.1
(Sub-total)	(13.3)		(5,428)		(11.0)
Net	-11.5		751		7.6

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.
Source: Author.

In 2040, avoided electricity from coal and natural gas will be 25 TWh, and total renewable generation will increase to 13 TWh. The avoided generation capacity of coal and natural gas will be 4,677 MW, and the required total renewable generation capacity will increase to 5,428 MW. The avoided generation capacity construction cost of coal and natural gas will be $3.4 billion, the required total renewable generation capacity construction cost will increase to $11.0 billion, and the net generation capacity construction cost will increase to $7.6 billion.

Figure A9.21: Avoided Generation Capacity Construction Cost, Myanmar

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP (71 billion) and forecasted 2040 GDP (316 billion). The impact of of net capital expenditure increase is 10.8% compared against the 2015 GDP, and 2.4% compared against the forecasted 2040 GDP.

A9.6.5 Avoided Carbon Dioxide Emissions

Table A9.32: Avoided Carbon Dioxide Emissions, Myanmar

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-0.9	43%	-0.2	-0.7
Natural gas	-23.9	55%	-3.7	-8.8
Total	-24.8	-	-3.9	-9.5

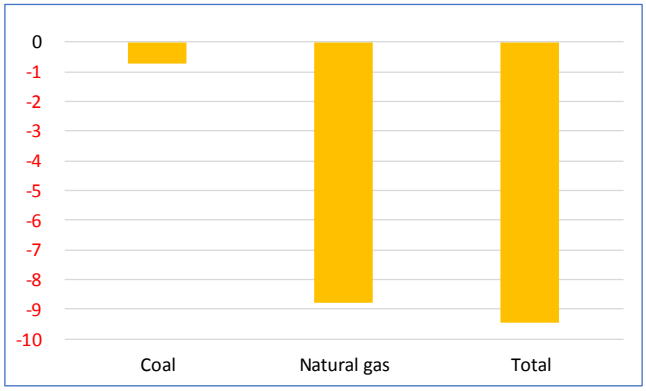
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

The avoided CO_2 emissions from coal will be 0.7 million tonnes-CO_2 and that from natural gas will be 8.8 million tonnes-CO_2. The total avoided CO_2 emissions will be 9.5 million tonnes-CO_2.

Figure A9.22: Avoided Carbon Dioxide Emissions, Myanmar

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Myanmar is 37% compared against 2015, and 11% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared with the forecasted 2040 GDP ($316 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($18.5 million) is 0.01% of Myanmar's GDP.

7. Philippines

A9.7.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.33 and A9.34 show the electricity demand outlook and electricity generation outlook of Philippines in the ERIA Energy Outlook 2019.

Table A9.33: Electricity Demand Outlook, Philippines

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	67.8	89.6	122.5	146.9	170.7	195.9	80.7	91.9	113.9	136.5	156.8

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

Table A9.34: Electricity Generation Outlook, Philippines

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	82.4	98.5	134.6	161.5	187.6	215.3	88.7	101.0	125.1	150.1	172.3
Coal	36.7	44.7	65.0	80.0	94.2	105.0	35.8	32.5	45.9	60.7	62.2
Oil	5.9	5.0	6.2	6.3	6.5	7.4	4.6	3.5	4.6	6.1	6.6
Natural gas	18.9	18.1	24.1	33.0	42.0	55.8	13.6	13.9	19.3	26.5	29.3
Nuclear								1.6	4.3	5.7	14.4
Hydro	8.7	11.5	15.7	16.3	17.1	17.6	11.2	15.5	15.5	15.5	24.2
Geothermal	11.0	13.8	17.1	18.8	20.2	21.4	14.2	19.0	19.9	19.9	19.9
Others	1.3	5.4	6.5	7.0	7.7	8.2	9.2	15.0	15.7	15.7	15.7

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

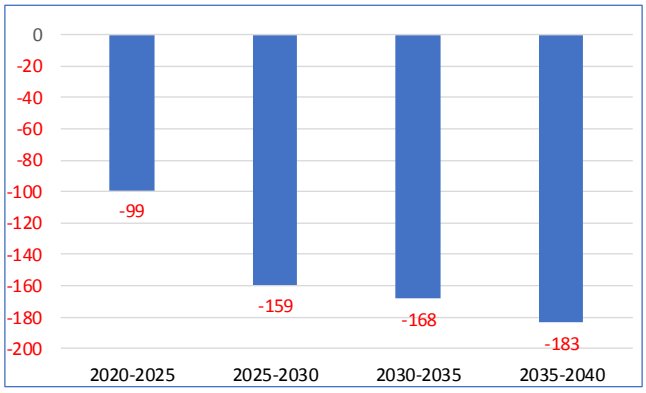
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.7.2 Electricity Demand Saving Potential

The Philippines' electricity saving potential will be 99 TWh in 2020–2025, 159 TWh in 2025–2030, 168 TWh in 2020–2035, and 183 TWh in 2035–2040.

Figure A9.23: Electricity Demand Saving Potential, the Philippines

(terawatt-hour)



Source: Author.

A9.7.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.35: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Philippines

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-6.7	-22.8	-24.6	-25.4	-5.8	-85.3	-4.1

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
2.7	6.5	0.7	0.3	1.5	11.8	0.6

Net benefit

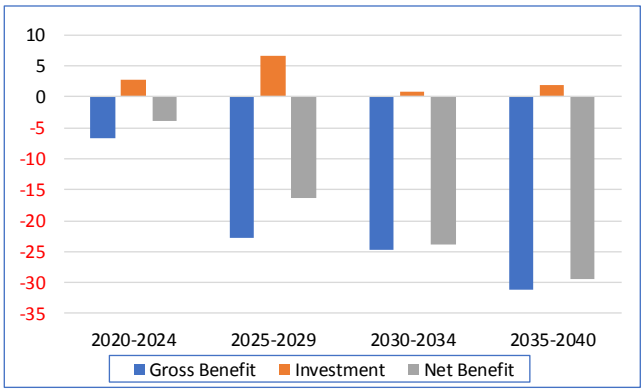
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-4.0	-16.3	-23.9	-25.1	-4.3	-73.5	-3.5
IRR						49%
Electricity price (2016, $0.01 per kilowatt-hour)						14.9

IRR = internal rate of return.
Source: Author.

The cumulative gross benefit of the Philippines will reach $85 billion. The total required investment in electricity saving will be $12 billion. Thus, the total net benefit will reach $74 billion. Based on this result, the IRR will be 49%, and a high return will be expected; it is the second highest level amongst the subject countries. The price of electricity in the Philippines is based on the market.

Table A9.36: Gross Benefit, Investment, and Net Benefit, the Philippines

($ billion)



Note: 2040 is included in 2035–2040.

Source: Author.

If the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in the Philippines, it can tentatively reduce the price of gasoline and diesel for only $0.06/L in a year.

A9.7.4 Avoided Generation Capacity Construction Cost

Table A9.37: Avoided Generation Capacity Construction Cost, the Philippines

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-44.5	75.0	-6,774	1,600	-10.8
Natural gas	-21.0	60.0	-3,987	700	-2.8
(Sub-total)	(-65.5)		(-10,761)		(-13.6)
Nuclear	14.4	70.0	2,353	3,298	7.8
Hydro	6.6	33.0	2,267	2,500	5.7
Geothermal	-1.4	75.0	-217	3,200	-0.7
Biomass	-1.4	75.0	-209	1,600	-0.3
Solar	5.2	17.5	3,371	1,600	5.4
Wind	3.7	27.0	1,563	1,700	2.7
(Sub-total)	(27.1)		(9,129)		(20.5)
Net	-38.4		-1,632		6.8

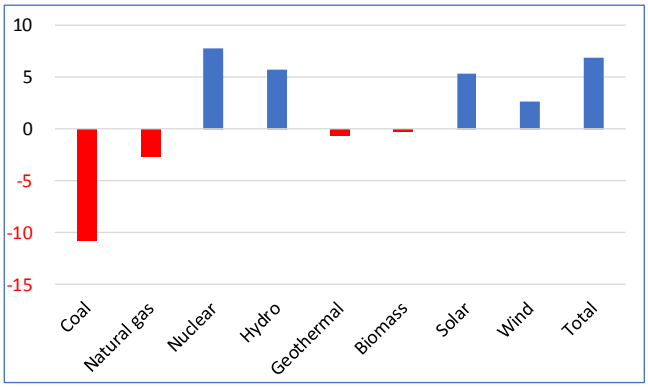
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

Source: Author.

In 2040, avoided electricity from coal and natural gas will be 66 TWh, and geothermal and biomass electricity generation will both decrease 1.4 TWh. Nuclear will increase to 14.4 TWh, hydropower to 6.6 TWh, solar to 5.2 TWh, and wind to 3.7 TWh. The avoided generation capacity of coal and natural gas will be 11 GW, the required geothermal generation capacity will decrease to 217 MW, and the required biomass generation capacity will decrease to 209 MW. The required nuclear will increase to 2,353 MW, , hydropower to 2,267 MW, solar to 3,371 MW, and wind to 1,563 MW, respectively. The avoided generation capacity construction cost of coal and natural gas will be $14 billion, required net nuclear and renewable generation capacity construction cost will increase to $21 billion, and the net generation capacity construction cost will increase $7 billion.

Figure A9.24: Avoided Generation Capacity Construction Cost, the Philippines

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with 2015 GDP ($266 billion) and forecasted 2040 GDP ($1,147 billion). The impact of the net capital expenditure increase is 2.6% compared against the 2015 GDP, and 0.6% compared against forecasted 2040 GDP.

A9.7.5 Avoided Carbon Dioxide Emissions

Table A9.38: Avoided Carbon Dioxide Emissions, the Philippines

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-44.5	43%	-8.9	-35.3
Natural gas	-21.0	55%	-3.3	-7.7
Total	-65.5	-	-12.2	-43.0

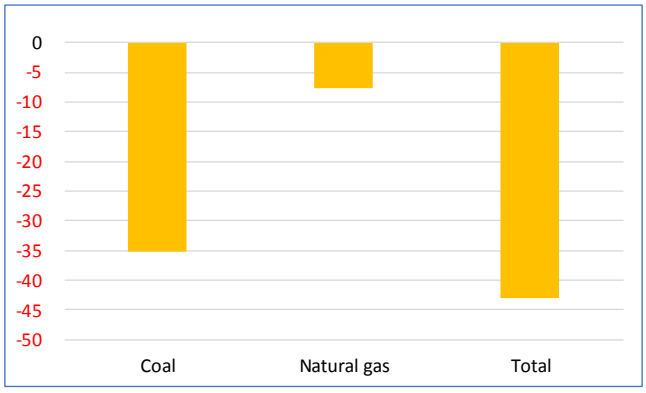
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 35 million tonnes-CO_2 and that from natural gas will be 8 million tonnes-CO_2. Total avoided CO_2 emissions will be 43 million tonnes-CO_2.

Figure A9.25: Avoided Carbon Dioxide Emissions, the Philippines

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in the Philippines is 12% compared against 2015, and 4% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared to the forecasted 2040 GDP ($1,147 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($84 million) is 0.01% of the Philippines's GDP.

A9.8 Singapore

A9.8.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.39 and A9.40 show the electricity demand outlook and electricity generation outlook of Singapore in the ERIA Energy Outlook 2019.

Table A9.39: Electricity Demand Outlook, Singapore

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	47.5	58.6	67.7	75.9	82.7	89.1	58.1	66.5	73.8	79.7	85.0

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

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.

Table A9.40: Electricity Generation Outlook, Singapore

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	50.4	62.2	71.8	80.5	87.7	94.5	61.7	70.6	78.3	84.5	90.1
Coal	0.6	0.7	0.9	1.0	1.0	1.1	0.7	0.8	0.9	1.0	1.1
Oil	0.4	0.4	0.4	0.3	0.3	0.2	0.4	0.4	0.5	0.6	0.7
Natural gas	47.9	58.5	67.0	74.3	80.2	85.6	55.5	60.0	62.7	63.4	63.1
Nuclear											
Hydro											
Geothermal											
Others	1.6	2.5	3.6	4.9	6.2	7.6	5.0	9.3	14.2	19.5	25.3

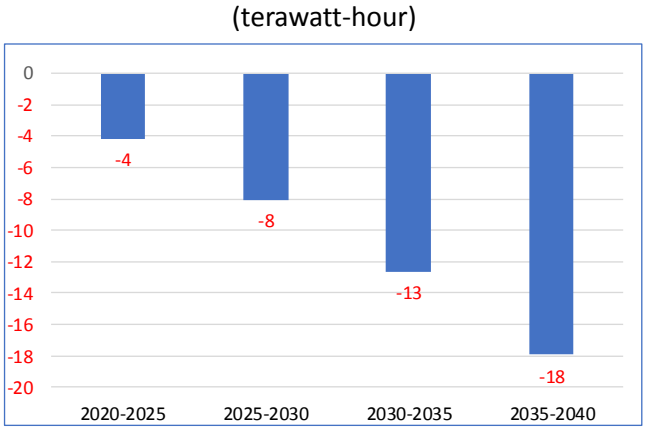
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower.

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.

A9.8.2 Electricity Demand Saving Potential

Singapore's electricity saving potential will be 4 TWh in 2020–2025, 8 TWh in 2025–2030, 13 TWh in 2020–2035, and 18 TWh in 2035–2040.

Figure A9.26: Electricity Demand Saving Potential, Singapore



Source: Author.

A9.8.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

The gross benefit, investment, net benefit, and internal rate of return are not analysed due to a lack of information on the price of electricity.

A9.8.4 Avoided Generation Capacity Construction Cost

Table A9.41: Avoided Generation Capacity Construction Cost, Singapore

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-0.4	75.0	-57	1,600	-0.1
Natural gas	-21.9	60.0	-4,165	700	-2.9
(Sub-total)	(-22.3)		(-4,222)		(-3.0)
Nuclear	-	70.0	-	3,298	-
Hydro	-	33.0	-	2,500	-
Geothermal	-	75.0	-	3,200	-
Biomass	-	75.0	-	1,600	-
Solar	17.7	17.5	11,528	1,600	18.4
Wind	-	27.0	-	1,700	-
(Sub-total)	(17.7)		(11,528)		(18.4)
Net	-4.6		7,307		15.4

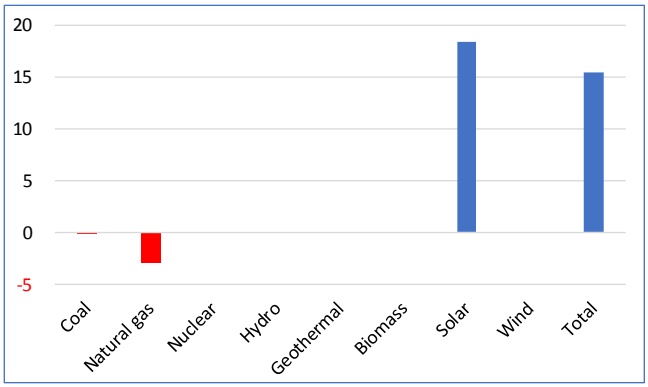
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

Source: Author.

In 2040, avoided electricity from coal and natural gas will be 22 TWh, and solar generation will increase to 18 TWh. The avoided generation capacity of coal and natural gas will be 4 GW, and required solar generation capacity will increase to 12 GW. The avoided generation capacity construction cost of coal and natural gas will be $3.0 billion, the required solar generation capacity construction cost will increase to $18.4 billion, and the net generation capacity construction cost will increase to $15.4 billion.

Figure A9.27: Avoided Generation Capacity Construction Cost, Singapore

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($289 billion) and forecasted 2040 GDP ($511 billion). The impact of the net capital expenditure increase is 5.3% compared against the 2015 GDP and 3.0% compared against the forecasted 2040 GDP.

A9.8.5 Avoided Carbon Dioxide Emissions

Table A9.42: Avoided Carbon Dioxide Emissions, Singapore

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-0.4	43%	-0.1	-0.3
Natural gas	-21.9	55%	-3.4	-8.0
Total	-22.3	-	-3.5	-8.3

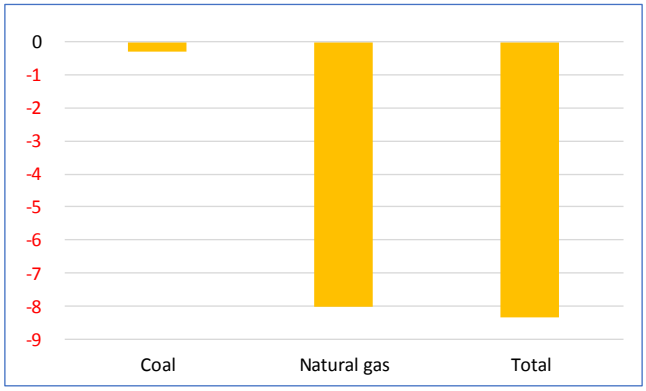
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 0.3 million tonnes-CO_2 and that from natural gas will be 8.0 million tonnes-CO_2. Total avoided CO_2 emissions will be 8.3 million tonnes-CO_2.

Figure A9.28: Avoided Carbon Dioxide Emissions, Singapore

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Singapore is 17% compared against 2015, and 13% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared to the forecasted 2040 GDP ($511 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value CO_2 emissions avoided annually ($16 million) is 0.003% of Singapore's GDP.

A9.9 Thailand

A9.9.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.43 and A9.44 show the electricity demand outlook and electricity generation outlook of Thailand in the ERIA Energy Outlook 2019.

Table A9.43: Electricity Demand Outlook, Thailand

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	174.9	204.9	238.4	273.9	312.2	354.0	189.1	202.0	224.5	246.0	273.0

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

Table A9.44: Electricity Generation Outlook, Thailand

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	165.7	193.5	222.4	237.2	251.3	294.6	177.0	189.9	197.0	206.7	233.2
Coal	32.9	31.9	35.7	38.1	49.0	71.8	29.3	30.9	31.5	38.3	43.0
Oil	1.7	0.2	0.6	0.6	1.8	3.0	0.0	0.0	0.0	0.0	0.9
Natural gas	117.0	134.3	145.4	150.6	145.8	161.0	123.6	126.0	124.3	114.0	121.1
Nuclear							0.0	0.0	0.0	4.5	9.8
Hydro	5.7	10.3	12.0	13.2	14.3	14.6	10.6	11.9	13.2	14.6	15.8
Geothermal											
Others	8.4	16.8	28.7	34.6	40.4	44.1	13.5	21.1	28.0	35.3	42.6

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

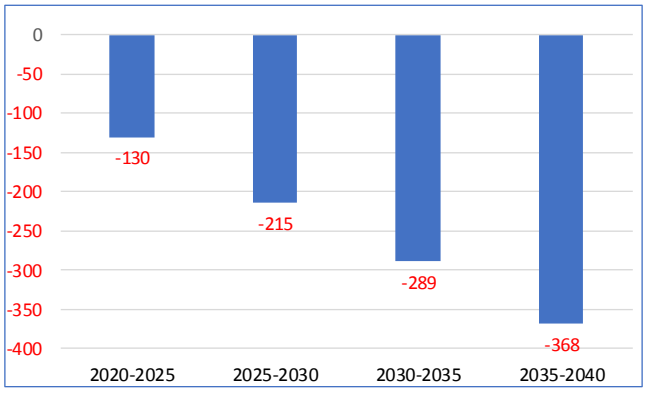
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.9.2 Electricity Demand Saving Potential

Thailand's electricity saving potential will be 130 TWh in 2020–2025, 215 TWh in 2025–2030, 289 TWh in 2020–2035, and 368 TWh in 2035–2040.

Figure A9.29: Electricity Demand Saving Potential, Thailand

(terawatt-hour)



Source: Author.

A9.9.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.45: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Thailand

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-9.0	-20.7	-28.2	-37.7	-9.2	-104.9	-5.0

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
4.7	6.2	3.9	5.1	4.4	24.4	1.2

Net benefit

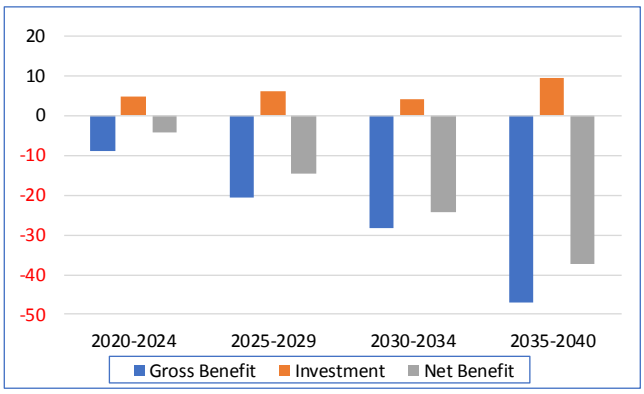
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-4.2	-14.5	-24.2	-32.7	-4.8	-80.5	-3.8
IRR						49%
Electricity price (2018, $0.01 per kilowatt-hour)						11.4

IRR = internal rate of return.
Source: Author.

The cumulative gross benefit of Thailand will reach $105 billion. The total required investment in electricity saving will be $24 billion. Thus, the total net benefit will reach $81 billion. Based on this result, IRR will be 49%, and a high return will be expected; it is the second highest amongst the subject countries.

Figure A9.30: Gross Benefit, Investment, and Net Benefit, Thailand

($ billion)



Note: 2040is included in 2035–2040.
Source: Author.

Table A9.46 shows the energy subsidy calculated by the IEA. Compared to the required annual investment in electricity saving ($3.8 billion), the energy subsidy is smaller than the investment.

Table A9.46: Energy Subsidy, Thailand

($ billion)

Country	Product	2015	2016	2017
Thailand	Oil	0.71	0.43	0.70
	Gas	0.21	0.00	0.09
	Total	0.92	0.43	0.80

Source: International Energy Agency Fossil Fuel Subsidies Database.
https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

From another aspect, if the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Thailand, it can tentatively reduce the price of gasoline and diesel to only $0.06/L in a year.

A9.9.4 Avoided Generation Capacity Construction Cost

Table A9.47: Avoided Generation Capacity Construction Cost, Thailand

Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-23.1	75.0	-3,521	1,600	-5.6
Natural gas	-65.2	60.0	-12,407	700	-8.7
(Sub-total)	(-88.3)		(-15,928)		(-14.3)
Nuclear	9.8	70.0	1,602	3,298	5.3
Hydro	1.2	33.0	427	2,500	1.1
Geothermal	-	75.0	-	3,200	-
Biomass	-3.3	75.0	-502	1,600	-0.8
Solar	1.0	17.5	651	1,600	1.0
Wind	0.8	27.0	322	1,700	0.5
(Sub-total)	(9.5)		(2,500)		(7.1)
Net	-78.8		-13,427		-7.2

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

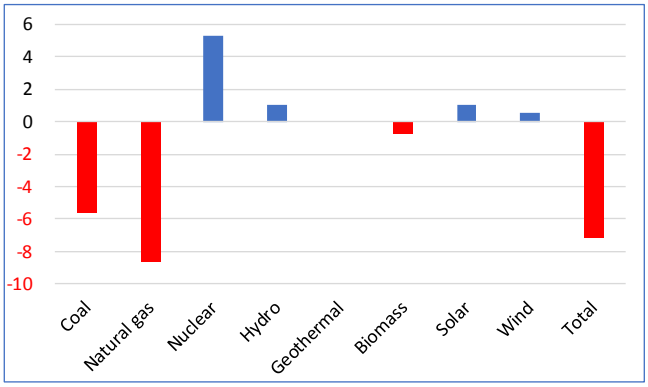
Source: Author.

In 2040, avoided electricity from coal and natural gas will be 88 TWh, and biomass electricity generation will decrease to 3.3 TWh. Nuclear generation will increase to 9.8 TWh, hydro to 1.2

TWh, solar to 1.0 TWh, and wind to 0.8 TWh. The avoided generation capacity of coal and natural gas will be 16 GW and the required geothermal generation capacity will decrease to 502 MW. The required nuclear generation capacity will increase to 1,602 MW, hydropower to 427 MW, solar to 651 MW, and wind to 322 MW. The avoided generation capacity construction cost of coal and natural gas will be $14 billion, the required net nuclear and renewable generation capacity construction cost will increase to $7 billion, and the net generation capacity construction cost will decrease to $7 billion.

Figure A9.31: Avoided Generation Capacity Construction Cost, Thailand

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP (@394 billion) and forecasted 2040 GDP ($999 billion). The impact of the net capital expenditure decrease is -1.8% compared against the 2015 GDP, and -0.7% compared against the forecasted 2040 GDP.

A9.9.5 Avoided Carbon Dioxide Emissions

Table A9.48: Avoided Carbon Dioxide Emissions, Thailand

Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO_2 emissions (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-23.1	43%	-4.6	-18.3
Natural gas	-65.2	55%	-10.2	-24.0
Total	-88.3	-	-14.8	-42.3

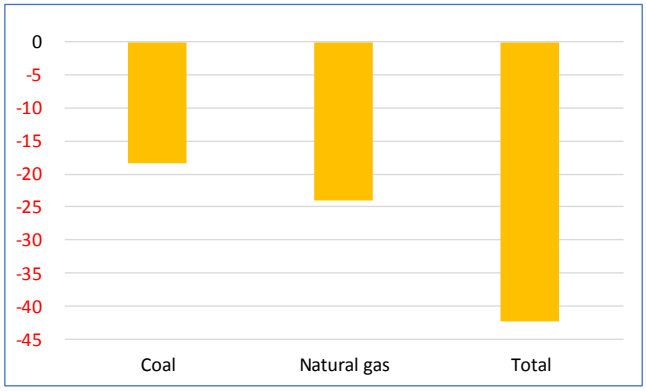
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author.

Avoided CO_2 emissions from coal will be 18 million tonnes-CO_2 and that from natural gas will be 24 million tonnes-CO_2. Total avoided CO_2 emissionsa will be 42 million tonnes-CO_2.

Figure A9.32: Avoided Carbon Dioxide Emissions, Thailand

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Thailand is 5% compared against 2015, and 3% compared against 2040 BAU. As a reference, the estimated value of annual avoided CO_2 emissions is calculated and tentatively compared against the forecasted 2040 GDP ($999 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($83 million) is 0.01% of Thailand's GDP.

A9.10 Viet Nam

A9.10.1 Electricity Demand and Generation Outlook, Economic Research Institute for ASEAN and East Asia Energy Outlook 2019

Tables A9.49 and A9.50 show the electricity demand outlook and electricity generation outlook of Viet Nam in the ERIA Energy Outlook 2019.

Table A9.49: Electricity Demand Outlook, Viet Nam

(terawatt-hour)

		BAU					APS				
	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Electricity Demand	141.2	229.0	303.9	375.0	441.6	513.5	222.9	287.8	345.1	394.0	443.4

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

Table A9.50: Electricity Generation Outlook, Viet Nam

(terawatt-hour)

		BAU					APS				
Fuel	2015	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total	159.8	242.8	323.3	398.9	469.8	546.1	236.2	305.8	366.7	418.6	470.8
Coal	51.0	155.3	200.3	253.4	313.1	376.4	148.2	176.5	209.7	245.3	280.8
Oil	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	44.9	37.6	65.1	85.0	96.7	109.6	36.7	61.9	77.4	85.9	94.5
Nuclear											
Hydro	63.2	49.6	57.6	60.1	59.6	59.8	48.3	54.8	56.4	54.3	52.8
Geothermal											
Others	0.4	0.3	0.4	0.4	0.4	0.4	2.9	12.7	23.1	33.1	42.7

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

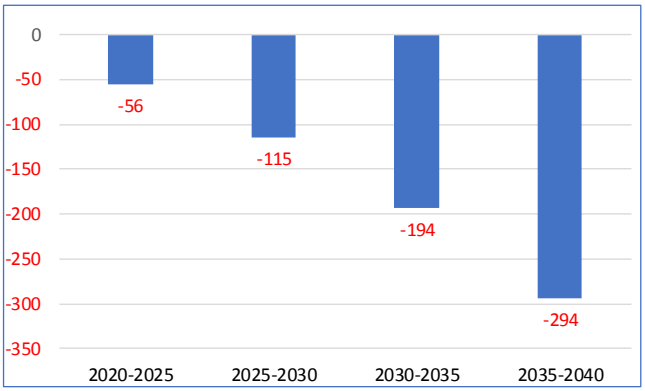
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

A9.10.2 Electricity Demand Saving Potential

Viet Nam's electricity saving potential will be 56 TWh in 2020– 2025, 115 TWh in 2025–2030, 194 TWh in 2020–2035, and 294 TWh in 2035–2040.

Figure A9.33: Electricity Demand Saving Potential, Viet Nam

(terawatt-hour)



Source: Author.

A9.10.3 Gross Benefit, Investment, Net Benefit, and Internal Rate of Return

Table A9.51: Gross Benefit, Investment, Net Benefit, and Internal Rate of Return, Viet Nam

($ billion)

Cumulative gross benefit

2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-2.8	-7.5	-13.8	-22.0	-6.5	-52.6	-2.5

Required investment

Initial investment (2020)	Additional investment-1 (2025)	Additional investment-2 (2030)	Additional investment-3 (2035)	Additional investment-4 (2040)	Total	(annual)
1.8	3.0	4.1	5.3	6.8	21.1	1.0

Net benefit

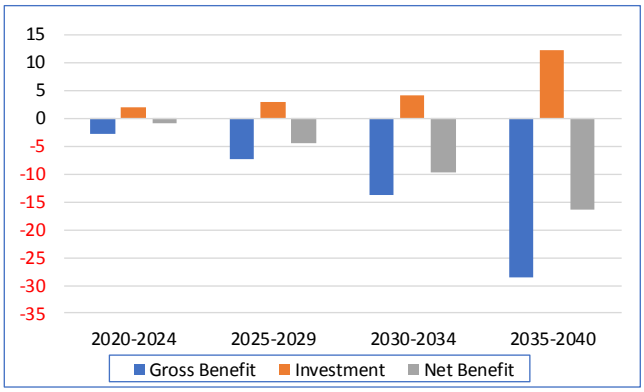
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-1.0	-4.4	-9.7	-16.7	0.3	-31.5	-1.5
IRR						37%
Electricity price (2017, $0.01 per kilowatt-hour)						9.3

IRR = internal rate of return.
Source: Author.

The cumulative gross benefit of Viet Nam will reach $53 billion. The total required investment in electricity saving will be $21 billion. Thus, the total net benefit will reach $32 billion. Based on this result, the IRR will be 37%, and a high return will be expected.

Figure A9.34: Gross Benefit, Investment, and Net Benefit, Viet Nam

($ billion)



Note: 2040 is included in 2035–2040.

Source: Author.

Table A9.52 shows the energy subsidy calculated by the IEA. Compared to the required annual investment in electricity saving ($1.0 billion), the energy subsidy is smaller than the investment.

Table A9.52: Energy Subsidy, Viet Nam

($ billion)

Country	Product	2015	2016	2017
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

Source: International Energy Agency Fossil Fuel Subsidies Database. https://www.iea.org/weo/energysubsidies/ (accessed 10 May 2019).

From another aspect, if the same amount of money relative to the required electricity saving investment is injected as a fuel subsidy in Viet Nam, it can tentatively reduce the price of gasoline and diesel for only $0.08/L in a year.

A9.10.4 Avoided Generation Capacity Construction Cost

Table A9.53: Avoided Generation Capacity Construction Cost, Viet Nam

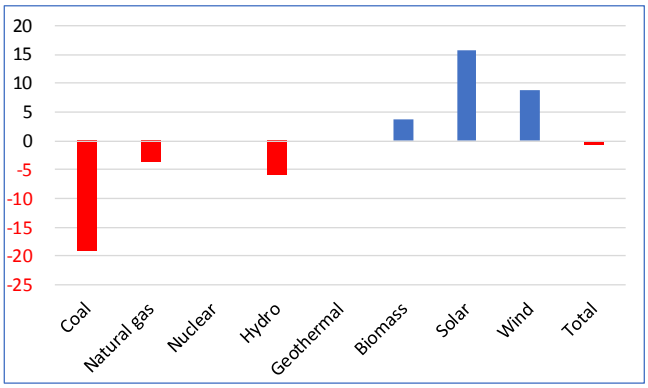
Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-78.9	75.0	-12,003	1,600	-19.2
Natural gas	-26.5	60.0	-5,050	700	-3.5
(Sub-total)	(-105.4)		(-17,053)		(-22.7)
Nuclear	-	70.0	-	3,298	-
Hydro	-7.0	33.0	-2,424	2,500	-6.1
Geothermal	-	75.0	-	3,200	-
Biomass	15.0	75.0	2,282	1,600	3.7
Solar	15.0	17.5	9,806	1,600	15.7
Wind	12.3	27.0	5,218	1,700	8.9
(Sub-total)	(35.4)		(14,883)		(22.2)
Net	-70.0		-2,170		-0.6

APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.
Source: Author.

In 2040, avoided electricity from coal and natural gas will be 105 TWh, and hydroelectricity generation will decrease to 7 TWh. Biomass generation will increase to 15 TWh, solar to 15 TWh, and wind to 12 TWh. The avoided generation capacity of coal and natural gas will be 17 GW and required hydropower generation capacity will decrease to 2 GW. The required biomass generation capacity will increase 2GW, solar to 10GW, and wind 5 GW. The avoided generation capacity construction cost of coal and natural gas will be $23 billion, the required net nuclear and renewable generation capacity construction cost will increase to $22 billion, and the net generation capacity construction cost will decrease to $1 billion.

Figure A9.35: Avoided Generation Capacity Construction Cost, Viet Nam

($ billion)



Hydro = hydropower.

Source: Author.

The net generation capacity construction cost is compared with the 2015 GDP ($155 billion) and forecasted 2040 GDP ($663 billion). The impact of the net capital expenditure decrease is -0.4% compared against the 2015 GDP, and -0.1% compared against the forecasted 2040 GDP.

A9.10.5 Avoided Carbon Dioxide Emissions

Table A9.54: Avoided Carbon Dioxide Emissions, Viet Nam

($ billion)

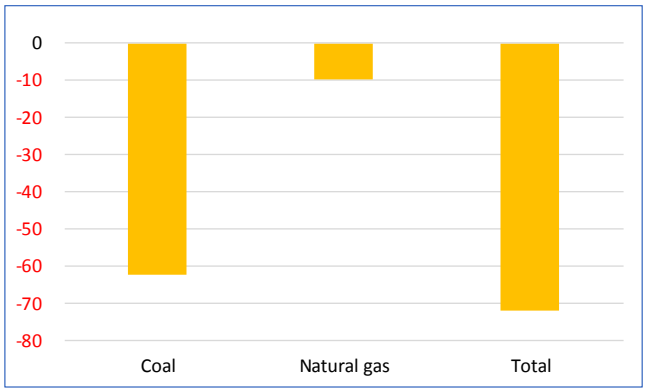
Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-78.9	43%	-15.8	-62.5
Natural gas	-26.5	55%	-4.2	-9.8
Total	-105.4	-	-19.9	-72.2

CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.
Source: Author.

Avoided CO_2 emissions from coal will be 63 million tonnes-CO_2 and that from natural gas will be 10 million tonnes-CO_2. Total avoided CO_2 emissions will be 72 million tonnes-CO_2.

Figure A9.36: Avoided Carbon Dioxide Emissions, Viet Nam

(million tonnes of carbon dioxide)



Source: Author.

Avoided CO_2 emissions are compared to total CO_2 emissions in 2015 and 2040 BAU. The impact of avoided CO_2 emissions in Viet Nam is 39% in Viet Nam compared against 2015, and 10% compared against 2040 BAU. As a reference, the estimated value of CO_2 emissions avoided annually is calculated and tentatively compared against the forecasted 2040 GDP ($663 billion). The price of CO_2 is assumed to be $41 per tonne of CO_2. Compared to the forecasted 2040 GDP, the estimated value of CO_2 emissions avoided annually ($141 million) is 0.02% of Viet Nam's GDP.