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Cost Effectiveness of the Energy Efficiency and Conservation Policy in the Association of Southeast Asian Nations

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Social Benefit of Clean Coal Technology

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This report was prepared by the working group for the 'Cost Effectiveness of EE&C Policy' under the Economic Research Institute for ASEAN and East Asia Energy Project. Members of the working group, who represent the participating East Asia Summit region countries, have discussed the energy efficiency and conservation policy and relevant financing mechanism. This study has not been developed for commercial or business use, but instead aims to derive policy implications. Therefore, neither the working group nor its study outcome is responsible for any loss caused by using this.

Foreword

No one disputes the importance of investment in energy efficiency and conservation (EE&C). However, in reality, expected EE&C investment is not executed for many reasons, in particular high upfront costs and financing difficulties. Reluctance may also arise from a lack of understanding of the benefits of and/or profit from EE&C investment and an insufficient knowledge of financing.

This study aims to address such hindrances to EE&C investment by presenting the available financing instruments and outlining the costs and benefits in a quantitative manner. I hope that this study can serve as a useful reference for those involved in EE&C investment and who hence facilitate it.

Ichiro Kutani

Leader of the working group

June 2019

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List of Abbreviations and Acronyms

APS	alternative policy scenario
ASEAN	Association of Southeast Asian Nations
BAU	business as usual
BDO	Banco De Oro
CCCSP	Cambodia Climate Change Strategic Plan
CFL	compact fluorescent lamp
DEDE	Department of Alternative Energy Development and Efficiency (Thailand)
DOE	Department of Energy (Philippines)
DSM	demand side management
EE&C	energy efficiency and conservation
ERIA	Economic Research Institute for ASEAN and East Asia
ESCO	energy service company
EU	European Union
FAO	Food and Agriculture Organization
GDP	gross domestic product
GHG	greenhouse gas
GTMP	Green Technology Master Plan (Malaysia)
IEA	International Energy Agency
IRR	internal rate of return
kWh	kilowatt-hour
Lao PDR	Lao People's Democratic Republic
m^2	square metres
MEPS	minimum energy performance standard
MOE	Ministry of Energy
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt-hour
NEA	National Environment Agency
NEEAP	National Energy Efficiency Action Plan

NPSAP EEC	National Policy, Strategy and Action Plan on Energy Efficiency in Cambodia
RIKEN	National Master Plan for Energy (*Rencana Induk Konservasi Energi Nasional*)
SMEs	small and medium-sized enterprises
VES	Vehicle Emissions Scheme (Singapore)

Executive Summary

The importance of energy efficiency and conservation (EE&C) is commonly discussed amongst policymakers. However, in reality, expected EE&C investment is not necessarily executed due to high upfront costs and financing difficulties. This study aims to (i) help promote EE&C investment in the Association of Southeast Asian Nations (ASEAN) region though two analyses, (ii) organise a possible financing method for EE&C investment, and (iii) analyse its costs and benefits.

It is assumed that by applying EE&C investment efficiency in Japan (measured by the necessary investment amount to reduce electricity by unit [$/kilowatt-hour]), ASEAN can expect $15.4 billion in annual net benefits and a very high (30%) internal rate of return from EE&C investment over the next 20 years. In addition, thanks to reduced electricity demand, the region can reduce investment in coal and natural gas power plants by a cumulative $136.8 billion from 2020 to 2040. Furthermore, the region can reduce carbon dioxide emissions by a cumulative 423.6 million tonnes during the same period.

The study identified the following recommended actions to materialise the potential for EE&C in a region and realise its full benefits:

- (i) re-recognise the benefit of EE&C investment;
- (ii) establish a special agency to strengthen policy implementation; and
- (iii) maximise EE&C potential by
  - (a) building up EE&C education and public relations, and
  - (b) providing low-cost and free EE&C diagnosis services.

Even if a country implements these actions, the fulfillment of EE&C investment may still encounter bottlenecks. One of these is financing, as no investment, regardless of its profitability, can be made without funds. This kind of obstacle is most evident in small and medium-sized enterprises. Therefore, financial support can play an important role in promoting EE&C investment. It is first necessary to determine which of the possible financing instruments is most effective or preferable. To this end, this study proposes four recommendations: (i) choose a method that will have a small impact on the government’s financial burden, (ii) remove any energy price subsidy to improve the EE&C investment climate, (iii) set aside a government budget through a special purpose tax, and (iv) build up financing capability.

Table 1: Annual Net Benefit and Internal Rate of Return of Energy Efficiency and Conservation Investment

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

ASEAN = Association of Southeast Asian Nations, IRR = internal rate of return, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic.

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

Source: Author.

Chapter 1

Background and Objective

1.1. Background and Objective of the Study

The importance of energy efficiency and conservation (EE&C) is commonly discussed amongst policymakers. Countries are regarding this as one of the primary principles constituting energy policy, and various types of EE&C policies have been developed and adopted. However, in reality, expected EE&C investment is not necessarily executed due to high upfront costs and financing difficulties.

The first step to overcome these challenges is to understand the potential benefits of EE&C investment and financing. One incentive to invest in EE&C is that the resulting reduction in energy bills could pay off the capital expenditure. Policymakers might also become willing to allocate a budget for an EE&C financing programme if they understand that EE&C investment can bring greater benefits to a county than investment amount. Another necessary step is to learn about possible EE&C financing methods. Eliminating knowledge gaps amongst stakeholders, particularly policymakers and financing institutions, can facilitate finance and hence EE&C investment in a country.

In this context, this study will try to identify possible financing methods for EE&C investment and will analyse their costs and benefits. By sharing this information with policymakers in Association of Southeast Asian Nations (ASEAN) member countries, this study intends to help promote EE&C investment in the region.

This study takes the following steps:

(i) provides an overview of EE&C financing methods (section 1.2),
(ii) summarises current EE&C policies and financing status in ASEAN (section 1.3),
(iii) performs a cost–benefit analysis of EE&C financing (Chapter 2), and
(iv) delivers policy recommendations (Chapter 3).

1.1. Overview of Energy Efficiency and Conservation Financing Methods

The importance of energy saving is universally acknowledged; however, given the involvement of spending and investment, it is impossible to achieve energy saving without a smooth funding process. If the companies or individuals trying to implement energy-saving measures can do so with their own funds, there is nothing to worry about. If they cannot, favourable financing programmes can help support the implementation of energy-saving measures.

Typically, such funding is provided by governments, government agencies, and financial institutions. These funds are supplied in various ways, which can be classified largely into five different types (see Table 1.1) (PricewaterhouseCoopers, 2012).

Table 1.1: Typical Financing Mechanism

Type	Example	Repayment
(i) Tax incentive	Accelerated depreciation, tax deductions, and tax credits	No
(ii) Non-tax incentive	Grants and subsidies	No
(iii) Lending programme	Bank loans, low interest lending, collateral free lending, and loan guarantees	Yes
(iv) Performance contract	Guaranteed savings Shared savings	Yes
(v) Carbon finance	Clean Development Mechanism Joint implementation	Yes

Source: Created from PricewaterhouseCoopers (2012), *Assessment of Energy Efficiency Financing Mechanism*. January, India.

Tax Incentives

Tax incentives are intended to encourage investment in energy saving by decreasing the tax burdens associated with such investment, and hence by reducing the total amount of spending, including tax. Typically, with specific energy-saving equipment and energy-saving performance subject to predetermined tax incentives, only investment recognised as satisfying these requirements is entitled to receive incentives.

Since tax incentives can be applied just by modifying the existing taxation system, they are considered easier to implement than non-tax incentives, for which a new system must be built from scratch. However, the incentive provider must set a necessary standard for the incentive system at the beginning, carry out additional work such as receiving and examining applications for the tax incentive, and bear the cost. As a natural consequence, tax revenue from the incentive receiver will decrease in any of the three following cases:

(i) Accelerated depreciation. When a company invests in energy-saving equipment, the equipment must be depreciated following certain accounting rules. Accelerated depreciation is intended to reduce taxable income by depreciating the equipment earlier in its service life, allowing the company to save on corporate income tax for the first several years after the investment.

(ii) Tax deductions. Tax deductions involve deducting the amount equivalent to the investment in energy saving from taxable income. One advantage of tax deductions is decreased tax amounts as a result of reduced taxable income. In many cases, a ceiling is set on the amount of the deduction.

(iii) Tax credits. Tax credits involve deducting the amount of tax instead of reducing taxable income.

Thus, the relationship between tax incentives and the use of related tax should be studied and coordinated.

Non-Tax Incentives

Non-tax incentives are a way to provide more direct financial support. The fixed-amount or fixed-rate funds are provided without repayment obligation to eligible equipment or investments. In some cases, payment is made depending on the amount or rate of energy actually saved. With the help of grants, activities aimed at the development and social implementation of new energy-saving technologies can be supported, including research and development and verification tests. Because there are no refunding obligations, these incentives play a significant role on the incentive receiver side.

Since there are no refunding obligations, the management of financing examination and refunding is not required for grants and subsidies. For this reason, the operation of grants and subsidies is easier than the operation of lending programmes from the viewpoint of the incentive provider. On the other hand, since the funds once supplied will not be refunded, it is important for the incentive provider to secure enough funds. At the same time, the government is typically protected from excessive financial burdens by setting a ceiling on each executed budget.

Lending Programmes

Lending programmes are a method for banks and non-banks such as leasing companies to provide charged financing. In some cases, lending programmes are implemented jointly by a financial institution and third-party entities capable of assessing and providing the energy-saving technologies involved. In addition to conventional financing methods, various types of new financing techniques are being developed, including revolving funds. It can be said that lending programmes are a sustainable financing method because the funds supplied will be refunded in all scenarios.

Potential issues with financing through lending programmes include interest and collateral. Although it encourages investment in energy saving, low interest rate financing has a disadvantage when it comes to the sustainability of financing mechanisms. The same applies to collateral conditions. Private commercial banks face limitations in reducing interest rates and easing collateral requirements. This is where the involvement of public financial institutions makes sense.

Performance Contracts

Performance contracts are a form of financing. To improve energy saving capability and reduce energy costs, energy service companies (ESCOs) are involved in revamping customers' equipment. In this case, customers choose the best contract arrangement with ESCOs from a variety of financing techniques such as guaranteed saving, in which the amount of energy to be saved is guaranteed; and shared saving, in which benefits from energy saving are equally shared between the two parties. Under performance contracts, customers will refund loans to financial institutions and will pay service charges to ESCOs using the proceeds obtained from the reduction in their energy costs.

Since ESCOs take various types of risks in performance contracts, the customer side has large benefits. For this reason, performance contracts incentivise investment in energy saving. For example, customers can avoid the risks of their investment in energy saving ending up a failure and of energy efficiency not improving as much as expected. Under performance contracts, customers do not need to make a large initial investment to revamp their equipment, and can also equalise the cost of energy saving.

Carbon Finance

The trading of carbon credits earned by greenhouse gas (GHG) reductions can provide the necessary funds for investing in energy saving in developing countries. Specifically, the Clean Development Mechanism and Joint Implementation defined in the Kyoto Protocol fall into this category. The requirements that must be met and methods for post-implementation monitoring are strictly defined in the Clean Development Mechanism and Joint Implementation, and appropriate procedures must be taken in line with a series of guidelines.

As described above, there are various types of EE&C financing. However, these financing mechanisms present several issues with respect to practical application and utilisation. These issues vary depending on the type of financing, which can be grouped largely into three types: (i) tax and non-tax incentives, (ii) lending programmes and performance contracts, and (iii) carbon finance (see Table 1.2).

Table 1.2: Types of Energy Efficiency and Conservation Financing

	Source of Funds	Repayment	Financing Method
(i)	Domestic government	No	Tax incentive Non-tax incentive
(ii)	Domestic government/private	Yes	Lending programme Performance contract
(iii)	Foreign	Yes	Carbon finance

Source: Author.

As there are no refunding obligations, this group has the following issues.

(i) There is the issue of free riders, that is, those who would have implemented investment in energy saving even without this system are subject to this financial support.

(ii) In the case of tax incentives, there is the risk of incentive receivers intentionally inflating the amount of investment for the purpose of receiving more tax deductions than necessary.

(iii) In the first place, the effects of tax deductions and tax credits are limited when tax rates are low.

(iv) The financial burden on the government budget is large, or these incentives are restricted by the government budget.

(v) Additional administrative costs will be required to build these systems and to receive and examine applications.

Due to refunding obligations, this group has the following issues:

(i) Given the lack of knowledge about energy saving on the lender side, it is difficult to assess achievements appropriately.

(ii) Since the effect of investment (energy cost reductions) is hard to recognise, it is difficult for the lender side to assess achievements appropriately.

(iii) Many loans in this group are smaller than traditional loans, making them less attractive to lenders.

(iv) The payout time of many loans in this group is longer than that of traditional loans, making them less attractive to lenders.

(v) In some cases, energy saving projects do not have enough assets (land and buildings) that can serve as loan collateral. In this case, lenders find it difficult to manage project risks.

(vi) There are only a small number of ESCOs.

(vii) The financial strength of ESCOs is low, which limits the size of investment or makes fundraising difficult in shared saving.

Due to the use of funds available overseas, this group faces the following issues:

(i) Procedures for financing are so complex and strict that it takes a long time for the project to be set up.

(ii) The amount of energy actually saved must be monitored and verified. Furthermore, the procedure for this process is complex.

1.3. Current Energy Efficiency and Conservation Policy and Financing Programme in the Association of Southeast Asian Nations

This section will examine each country's energy conservation policies and activities in ASEAN and Japan. The survey results are summarised in Table 1.3.

Table 1.3: Evaluation of Energy Conservation Policy Infrastructure in the Association of Southeast Asian Nations and Japan

	Targets	Laws and regulation	Designated energy management factories	Energy manager	Standards and labelling	Financial support	Energy price subsidy
Brunei Darussalam	Yes	No	No	No	No	Yes	Yes
Cambodia	Yes	No	No	No	No	No	No
Indonesia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lao PDR	Yes	No	No	No	No	No	No
Malaysia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Myanmar	Yes	No	No	No	No	No	No
Philippines	Yes	Yes	No	No	Yes	Yes	No
Singapore	Yes	Yes	Yes	Yes	Yes	Yes	No

Thailand	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Viet Nam	Yes	Yes	Yes	Yes	Yes	No	Yes
Japan	Yes	Yes	Yes	Yes	Yes	Yes	No

Lao PDR = Lao People's Democratic Republic.

Source: Author.

1.3.1. Brunei Darussalam

Overview

The Brunei Darussalam Energy White Paper released in March 2014, the first paper of its kind, provided a roadmap for the country's energy conservation policies (Energy Department, 2013). In this roadmap, the country set the goal of reducing energy consumption relative to gross domestic product (GDP) to 45% below 2005 levels by 2035. The roadmap also included the reduction target for each sector: 18.5% in the commercial sector, 16.2% in the housing sector, 5.9% in the transportation sector, and 4.5% in the industrial sector. As measures for achieving these goals, the country set up seven major policies to implement specific actions, as follows:

(i) Appliance energy efficiency standards and labelling

(a) Establish a legal framework for energy efficiency standards.

(b) Set up minimum energy efficiency standards for air conditioners in the first phase, followed by refrigerators, lighting, and other appliances in the subsequent phases.

(c) Design the types of energy efficiency indicators and rating scales to be adopted for each appliance.

(d) Introduce energy labelling for selected electrical appliances.

(ii) Building regulation

(a) Establish a legal framework for building energy efficiency.

(b) Introduce energy-efficient or green building labels or certificates.

(c) Demonstrate green buildings.

(iii) Energy management

(a) Introduce an energy management process that is compatible with international standards, such as ISO (International Organization for

Standardization) 50001.

(b) Introduce energy audit policy for buildings and industries.

(c) Promote ESCOs.

(iv) Fuel economy regulation

(a) Evaluate the possibility of implementing fuel economy regulations.

(b) Promote the utilisation of hybrid and electric vehicles.

(v) Electricity tariff reform

(a) Expand the current progressive electricity tariff for the residential sector to other sectors when appropriate.

(b) Evaluate the feasibility of altering tariff structures to promote desired consumption behaviour.

(c) Conduct regular surveys to understand the optimum tariff schedule through understanding the relationships between household income and electricity usage.

(vi) Financial incentives

Introduce appropriate incentives for energy-efficient appliances and vehicles.

(viii) Awareness raising

Regulations

Specifically, the following actions are currently being taken or are under consideration.

(i) The guideline for energy-saving buildings in the non-residential sector introduced in May 2015.

The Ministry of Development, jointly with the Energy Department at the Prime Minister's Office, established a guideline for buildings that meet energy performance standards in the non-residential sector. At the same time, a regulatory agency responsible for such buildings was established. While the existing guideline for energy-saving buildings is applied to all government-owned buildings, it is applied to commercial buildings only on a voluntary basis. It is expected that the guideline will be applied to all types of buildings at the time of a future revision.

(ii) The introduction of prepaid power cards and prepaid power meters in January 2012.

To reduce electricity consumption for household and commercial use, an electricity bill prepayment system using prepaid cards called 'Power-card' was introduced. In addition, all power meters were replaced with prepaid power meters free of charge. At the same time, electricity charges were reviewed to reduce electricity consumption and give preferential treatment to low-income earners. The introduction of prepaid power meters is encouraging consumers to use electricity efficiently.

(iii) Progressive electricity tariff

Unit electricity price has decreased for low usage and increased for high usage. This tariff design resulted in reducing annual electricity consumption by 12%, on average, which was cumulatively worth $20 million during 2012–2016 (Ministry of Energy, Manpower and Industry, 2018).

(iv) Energy efficiency standard and labelling system

The Energy Department at the Prime Minister's Office, jointly with the Brunei National Energy Research Institute, is involved in the development of an energy performance standard and labelling system for home appliances. This initiative is intended to prevent inefficient home appliances from being imported in the future, through education on energy saving and by encouraging the public to purchase energy-saving products.

(v) Setting a fuel economy standard

The country has set a fuel economy standard for new vehicles with the goal of achieving 17.2 kilometres per litre by 2020 (equivalent to the target identified by the European Union [EU] for 2016) and 21.3 kilometres per litre by 2025 (equivalent to the EU's target for 2020). In addition, the tax rates on electric vehicles, fuel-efficient vehicles, and small cars were reduced to facilitate the popularisation of these vehicles. For example, while hybrid vehicles receive a 5% tax reduction, diesel-powered vehicles are subject to an extra 5% tax (Ministry of Energy, Manpower and Industry, 2018).

(vi) Introduction of monetary incentives

The application of tax exemptions, tax reductions, and rebates to energy-saving equipment and products is currently under consideration. Similar preferential treatment is also under consideration in the transportation sector. Possible monetary incentives for hybrid vehicles and fuel-efficient vehicles are especially attracting attention.

Table 1.4: Evaluation of Energy Efficiency and Conservation Regulations by Sector in Brunei Darussalam

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	B: In-house measures, mainly by the oil and gas industries, to improve operational efficiency and reduce greenhouse gas emissions	N/A
Commercial and Residential	A1: Control of the use of air conditioners – temperature setting and operation hours (government buildings) A2: Energy efficiency and conservation guidelines for non-residential buildings (government buildings as of May 2015) B1: Energy efficiency and conservation guidelines for non-residential buildings (commercial buildings) A: Project-based energy efficiency measures such as the increased use of energy-efficient streetlights (government) B: Green building rating system (planned)	A: Minimum energy performance standards and energy labelling for electrical appliances (residential): 1st phase – air conditioners (awaiting endorsement) 2nd phase – refrigerators (planned) 3rd phase – lighting and water heaters (planned)

	B: Energy awards B: Energy week B: Energy club (secondary/post-tertiary schools and colleges) B: Green building design and features for public houses under the National Housing Programme	
Transport	N/A	A: Fuel economy regulations for passenger cars (planned)

Source: The Energy Research Institute Network Secretariat (2016), Energy Efficiency Policy Update, March.

Organisation

The Ministry of Energy, Manpower and Industry, which was separated from the Energy Department at the Prime Minister's Office in 2018, is responsible for general energy policies, including energy conservation.

Financing Tool

There is no EE&C financing programme at present.

1.3.2. Cambodia

Overview

In May 2013, Cambodia, with the cooperation of the EU Energy Initiative Partnership Dialogue Facility, formulated a draft of the National Policy, Strategy and Action Plan on Energy Efficiency in Cambodia (NPSAP EEC). The country set the goal of reducing energy demand by 20% and slashing emissions by 3 million tonnes of carbon dioxide (t-CO_2) compared with business as usual (BAU) by 2035. In the draft of the NPSAP EEC, the country also referred to the frameworks for its energy conservation policies, action plans, and so forth.

In November 2013, the country released the Cambodia Climate Change Strategic Plan 2014–2023 (CCCSP). The CCCSP presents the direction and strategy of the climate change countermeasures to be taken in the 10 years between 2014 and 2023. The CCCSP refers to the implementation of energy-saving measures as one of its most important strategies, along with the introduction of renewable energy.

In July 2014, the country announced its National Strategic Development Plan 2014–2018. In this plan, the main points of discussion relating to the energy field include expanded power supply capability and ensured energy security in the power sector. The plan also clearly refers to enhanced efficiency in energy consumption and the need to accomplish the CCCSP successfully.

Meanwhile, Cambodia submitted its Intended Nationally Determined Contributions in September 2015. On the condition that international support is provided, the country set the goal of reducing carbon dioxide (CO_2) emissions by 27% (3.1 million t-CO_2) compared with BAU by 2030. As specific approaches to accomplishing this goal, the country referred to the promotion of energy-saving sewing plants and buildings, and the popularisation of electric vehicles and hybrid vehicles.

Regulations

The regulations being implemented include the following:

(i) The NPSAP EEC

With the cooperation of the EU Energy Initiative Partnership Dialogue Facility, Cambodia formulated the NPSAP EEC and released it in May 2013. The NPSAP EEC consists of three parts:

(a) Energy Efficiency Policy of Cambodia (energy conservation goals, etc.);
(b) National Energy Efficiency Strategy (implementation systems and target sectors); and
(c) National Energy Efficiency Action Plan (specific action plans by sector).

As a priority target, the country set the goal of reducing CO_2 emissions by 27% (3.1 million t-CO_2) compared with BAU by 2030. The target sectors include not only typical sectors like the industrial, equipment, and building sectors, but also the power and biomass sectors operating in rural areas in the context of low electrification rates and high biomass energy consumption. The energy conservation policies by sector proposed in the NPSAP EEC include the training of qualified energy managers, the implementation of a labelling policy, database building, and consumer education, which are covered by most energy conservation policies.

(ii) The CCCSP

Cambodia formulated the CCCSP under international auspices, and the Ministry of Environment of Cambodia announced it in November 2013. The CCCSP is the strategy for climate change countermeasures approved by the Government of Cambodia. To cope with climate change, the CCCSP is designed to contribute actively to global climate change countermeasures by promoting low-carbon schemes and technologies; enhancing systems and coordination frameworks; and improving competence, knowledge, and awareness. The CCCSP refers to energy saving as a measure for accomplishing its goals.

Cambodia has implemented the following energy conservation policies in the past:

(i) An official notice from the Prime Minister on reducing electricity consumption in the public sector (2008). A guideline was presented for reducing electricity consumption in public facilities.

(ii) Reducing GHG emissions through improved energy efficiency in the industrial sector. Cambodia is currently building frameworks for energy conservation policies with assistance from the United Nations Industrial Development Organization.

(iii) Designing an energy audit system for buildings. Cambodian engineers received on the job training through partnership with other ASEAN countries. The audit system is being designed by gathering information about energy management systems, understanding the status of energy use, and training engineers through partnership with qualified energy managers from Japan. Other events include workshops for qualified energy managers and observation tours.

Table 1.5: Energy Efficiency and Conservation Regulations by Sector in Cambodia

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: Reducing greenhouse gas emissions through improved energy efficiency in the industrial sector A2: Surveying the potential for energy saving and providing help for the development of a framework for the energy saving policy with support from the United Nations Industrial Development Organization	
Commercial and Residential	A1: Designing, gathering information, and developing human resources for an energy audit system for buildings Finding a way to develop the system with support from other countries A2: Circulars from the Prime Minister to curb power consumption at public facilities The implementation of guidelines to reduce the amount of power consumed at public facilities	
Transport		

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The Ministry of Mines and Energy is responsible for the formulation of energy policies and strategies including energy saving; the development of power development plans; and the establishment of electric power technology, safety, and environmental standards.

Financing Tool

There is no EE&C financing programme at present.

1.3.3. Indonesia

Overview

In 2006, Indonesia's Minister of Energy and Mineral Resources issued a decree mandating the promotion and popularisation of energy saving based on Presidential Decree No. 5/2006. Since then, the country has reinforced actions to promote energy efficiency.

Indonesia launched the National Energy Conservation Masterplan (RIKEN) in 2005. RIKEN set the goal of improving GDP-specific energy consumption by 1% each year until 2025, and reducing energy–GDP elasticity to 1 or less by the same year. According to RIKEN, the potential for energy saving in each sector in the period from when this masterplan was formulated to 2025 is estimated at 17% in the industrial sector, 15% in business, 20% in transportation, and 15% in household.

The Energy Law No. 30/2007 is one of the most important laws related to energy conservation in Indonesia. This law is intended to devise and implement development plans with the objectives of developing and promoting renewable energy sources, improving energy use efficiency, and integrating energy conservation measures.

Regulations

The following are examples of regulations related to EE&C:

(i) Energy Conservation Regulation (2009)

   (a) This is a regulation for the implementation of specific energy conservation measures that the Energy Law calls for, including the designated energy management factory system, the qualified energy manager certification system, and the labelling system. Regarding the designated energy management factory system, one of the systems described above, its subject is factories with an annual energy consumption to 6,000 tonnes or more of crude oil equivalent. These factories are mandated to submit regular reports concerning energy conservation goal setting, planning, and energy management.

(ii) Labelling system

In addition to the items listed below, there is a plan to mandate the affixing of energy efficiency labels on home appliances such as refrigerators and television sets. Some regulations concerning labelling are:

(a) Ministry of Energy and Mineral Resources Regulation No. 06/2011 on Energy Efficiency Rating for CFL (2011). This regulation initiated energy efficiency labelling for compact fluorescent lamps (CFLs), and classified the energy performance standard for CFLs by illuminance per watt into four-level ratings (the brightest per watt is given a four-star rating).

(b) MEPS and Labelling for Air Conditioning (Ministerial Regulation No. 07/2015) (International Energy Agency, 2017). This regulation stipulates the minimum energy performance standard (MEPS) and labelling system for air conditioners.

(c) National Standard Competency for Energy Manager on Building and Industry (Ministerial Regulation No. 41/2015). This regulation stipulates the standards for competency criteria, training contents, and certification tests that are needed for training in the qualified energy manager certification system (International Energy Agency, 2016).

Table 1.6: Energy Efficiency and Conservation Regulations by Sector in Indonesia

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: Energy users that consume more than 6,000 tonnes of oil equivalent annually bear the following obligations: A2: To appoint an energy manager; A3: To formulate an energy saving programme; A4: To inspect energy regularly; A5: To put recommendations from energy inspections into practice; A6: To create an annual report on the actual situation of energy saving	A1: Standards must be in accordance with performance specifications for energy equipment and methods to carry them out. B1: The efficiency of energy equipment is labelled by their manufacturers and importers in accordance with regulations on labelling. Labelling for fluorescent lights was issued in 2014. B2: Minimum energy performance standard and labelling for air

	under the jurisdiction of the ministers and heads of states, provinces, and cities; and A7: To inspect energy.	conditioning
Commercial and Residential		(Same as above)
Transport		

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The organisation responsible for the formulation and execution of energy policies in Indonesia is the Ministry of Energy and Mineral Resources, within which the Director of General New Energy, Renewable and Energy Conservation is responsible for energy conservation policies.

Financing Tool (Ministry of Energy and Mineral Resources, 2018)

There is a tax benefit policy for equipment that contributes to energy conservation. The tax benefit will be provided after the entity has achieved energy conservation for 2 years (ex-post rather than ex-ante provision). Indonesia is planning to add a 2% surcharge on electricity bills to collect funds to support the programme.

In addition, there is a public–private partnership project for street lighting using ESCOs. Local governments will finance ESCO companies.

1.3.4. The Lao People's Democratic Republic

Overview

In the National Energy Efficiency and Conservation Policy towards 2030, the Lao People's Democratic Republic (PDR) set the goal of reducing national energy demand by 10% in 2030 compared with BAU. At the same time, the country intends to reduce GHG emissions by lowering the level of energy consumption by around 1%, on average, each year compared with BAU. As the initial phase of this initiative, the Lao People's Democratic Republic will achieve the following goals by 2020:

(i) follow up EE&C policy and develop an EE&C promotion plan, financial mechanism, rules, and principle on energy management in four main sectors (industry, residential, building and office, and transportation);
(ii) develop a database, MEPS, labelling and standards programme, capacity building, and supporting tools and guidelines; and
(iii) develop and demonstrate pilot activities in focused sectors and awareness raising.

In addition, a prime ministerial decree on EE&C was issued to define more details of the implementation rules and measures for the main designated entities.

Regulations

The Lao PDR has implemented the following energy conservation projects in the past:

(i) Demand side management and energy efficiency project by the World Bank and Global Environment Facility

Energy-saving measures for buildings of public institutions have been taken, including the replacement of 400,000 incandescent light bulbs with CFLs, the replacement of building lights at 50 government organisations, the replacement of 100 window air conditioning units with ceiling-embedded air conditioners, and the advertisement of energy saving through mass media.

(ii) Capacity building programme

To enable government officers and business executives to learn energy-saving diagnosis and management, many training programmes, workshops, and seminars are held with assistance from the ASEAN Centre for Energy, Japan, Thailand, and others.

Table 1.7: Energy Efficiency and Conservation Regulations by Sector in the Lao People's Democratic Republic

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	B1: The energy-saving diagnosis has been implemented for beer and cement plants with support from Japan and others. B2: New proposal for further improvement of energy efficiency systems for beer plants	The Electricity Act stipulates that the responsible ministries and agencies establish, approve, and test the quality of domestically produced or imported electric equipment to secure the safety and energy saving capability of electric machinery and equipment. Specific energy efficiency standards, however, have not been established. The issue is still being discussed and planned.
Commercial and Residential	A1: The Government of the Lao People's Democratic Republic promotes energy saving for lighting equipment. A2: A plan to reduce the energy consumption of government institutions by 10% between 2006 and 2007 was implemented. B1: With the support of the World Bank, energy-saving measures were implemented in the buildings of public institutions. B2: With support from Japan, including the dispatch of experts (The Energy Conservation Center, Japan), some hotels are implementing energy-saving activities.	There are fire protection standards and planning control, but no construction standard related to energy saving capability has been developed. The country once asked Japan (the Ministry of Land, Infrastructure, Transport and Tourism) for support for the establishment of a construction standards system. Energy efficiency standards and labelling systems have not yet been established for electric appliances, etc., but a plan for a labelling system is being discussed based on international cooperation.
Transport	A1: The Government of the Lao People's Democratic Republic	Details are unknown.

	announced that it would stop the import of used cars from February 2012. A2: The government encouraged the increased use of public transport financed by the Japan International Cooperation Agency, Japan.	

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The Ministry of Energy and Mines is responsible for energy policy, strategic directions, and the administration of energy and mining sections. Under this ministry, the Department of Energy Management is in charge of formulating energy conservation policies, and the Institute of Renewable Energy Promotion is responsible for implementing and promoting energy-saving measures.

Financing Tool

There is no EE&C financing policy at present.

1.3.5. Malaysia

Overview

Malaysia's energy conservation policies have been implemented under the National Energy Efficiency Programme, which was launched in 1991. As part of this master plan, the development and promotion of systems, equipment, and buildings have been pursued to improve energy efficiency. In 1998, Pusat Tenaga Malaysia was established as a nonprofit independent corporation to implement the Government of Malaysia's energy conservation policies.

The strategy for the promotion of energy-saving measures is stipulated in the 5-Year Malaysia Plans. The current 11th 5-Year Malaysia Plan, 2016–2020, set the goal of reducing CO_2 emissions relative to GDP to 40% below 2005 levels by 2020. To achieve this goal, demand side management (DSM) and the promotion of low-carbon mobility are described as necessary energy-saving measures. In addition, the following activities are described in this plan:

(i) increasing the percentage of government green procurement to 20%;
(ii) promoting the qualification of environmentally friendly buildings, and enhancing the assessment system; and
(iii) expanding the MyHIJAU labelling programme.

The National Energy Efficiency Action Plan (NEEAP) and the Green Technology Master Plan (GTMP) are implemented as longer-term strategies. The NEEAP, which was approved in a cabinet meeting in 2016, lays out energy conservation strategies for 2016–2025. The major points of the NEEAP are as follows:

(i) promotion of 5-star rated appliances,
(ii) MEPS,
(iii) energy audits and energy management in buildings and industries,
(iv) promotion of co-generation,
(v) energy audits and energy management in buildings, and
(vi) energy-efficient building design.

On the other hand, the GTMP lays out energy conservation strategies covering all energy fields for 2017–2030. Concerning energy-saving measures, the GTMP set the goal of reducing electricity intensity to 15% by 2030.

Regulations

The following regulations pertain to energy conservation:

(i) The Electricity Supply (Amendment) 2001 – Act A1116 empowers the minister to promote the efficient use of electricity (sections 23A, B, and C); determine efficiency standards; and mandate that installation and equipment meet efficiency requirements.
(ii) The Efficient Management of Electrical Energy Regulations 2008 mandate that any installations that receive electrical energy from a licensee or supply authority with a total electricity consumption equal to or exceeding 3 million kilowatt-hours (kWh) over any period of 6 consecutive months must appoint a registered electrical energy manager.

(iii) The Amendment of Electrical Supply Regulations 1994 (May 2013) enables the enforcement of the MEPS on electrical appliances and lighting equipment (incandescent, CFL, and light-emitting diode light). Because of these regulations, five new products – air conditioners, electric fans, refrigerators, television sets, and washing machines – were added in 2018 to the list of products subject to the labelling system. These products are also subject to the MEPS.

(iv) The MS1525: Code of Practice for Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (introduced in 2001 and updated in 2008) is mandatory under the Uniform Building By-Laws.

Table 1.8: Energy Efficiency and Conservation Regulations by Sector in Malaysia

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	B1: Energy efficiency rules B2: Malaysian Industry and Energy Saving Improvement Project (completed), Global Environment Facility, United Nations Development Programme Support Project B3: Energy Saving Improvement Program of Malaysia (started in 2008)	

Commercial and Residential	B1: 'ESCO' (energy service companies) business B2: Energy audit and replacement of lighting with light-emitting diode lights in government buildings B3: Energy-efficient buildings: zero-energy buildings, low-energy office buildings, Energy Committee headquarters building B4: Phase out incandescent lights by 2014. B5: National Energy Saving Consciousness Campaign – SWITCH! B6: Basic Investigation to Realize Green Township Vision in Malaysia, Japan–Malaysia Cooperation B7: Limit air conditioner temperatures in government and municipal offices to 24 degrees. B8: Energy saving programme at major government hospitals B9: Green procurement by public sector	A1: Five models are covered (voluntary) A2: Energy saving guideline for buildings (voluntary) A3: Green Buildings Index (voluntary) A4: Low-carbon city framework and assessment system (voluntary) B1: Seven products are covered (voluntary)
Transport		

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The Economic Planning Unit, one of the organisations under the direct control of the Prime Minister's Department, which is the supreme decision-making body in the country, has jurisdiction over all of Malaysia's energy policies.

Under the Economic Planning Unit, the Ministry of Energy, Science, Technology, Environment and Climate Change is responsible for developing and promoting energy conservation and renewable energy, and formulating electricity supply policies and strategies.

Financing Tool

In Malaysia, a financial support tool called the Energy Audit Conditional Grant was introduced under the 11th Malaysia Plan between 2016 and 2018. Its purpose is to provide subsidies for energy-saving diagnoses with the objective of supporting ESCOs. Its subject is the commercial and industrial sectors, and the amount of the grant is up to RM55,000 for the commercial sector, and RM95,000 for the industrial sector. As a result, the following implementation and electricity savings were achieved from July 2017 to June 2018:

(i) Industry (72 cases): electricity savings of 26,553,845 kWh, with $4.7 million financed by the government.

(ii) Commercial (50 buildings): electricity savings of 16,907,289 kWh, with $1.9 million financed by the government.

1.3.6. Myanmar

Overview

In Myanmar, the Energy Efficiency and Conservation Policy, Strategy and Roadmap was formulated in 2015 and approved in a cabinet meeting in 2016. In this roadmap, the country set the goal of reducing energy consumption by 12% by 2020, 16% by 2025, and 20% by 2030 relative to 2012 levels. The roadmap also presented energy consumption for each sector (Ministry of Industry, 2018).

Table 1.9: Energy Efficiency Policy Targets in Myanmar (%)

Sector	EE policy target by 2020	EE policy target by 2025	EE policy target by 2030
Industry	3.5	5.3	6.6
Commercial/public	2.0	3.0	4.0
Residential	5.4	6.8	7.8
Other	0.7	1.0	1.4
Total	11.7	16.1	19.8
EE policy targets	12.0	16.0	20.0

EE = energy efficiency.
Source: Ministry of Industry (2018), 'Activities and Implementations of Energy Efficiency and Conservation Activities in Myanmar', 著: *The 1st Meeting of ERIA Research Project FY2018, Working Group on 'Cost Effectiveness of EE&C Policy'*.

Specific actions to be taken for energy saving are structured on the following three pillars: (i) the application of energy management factories and buildings, (ii) the setting of efficiency standards for home appliances, and (iii) social awareness-raising campaigns on the need for energy-saving measures. At the same time, a draft of the Energy Efficiency and Conservation Law was formulated based on this roadmap.

Other than the above, Myanmar, in its Intended Nationally Determined Contributions submitted in 2015, presented the goal of reducing electricity demand to 20% below the baseline in 2030.

Regulations

According to the draft of the Energy Efficiency and Conservation Law, the following regulations are under consideration:

(i) regulation on energy management systems for factories and buildings,
(ii) regulation on energy managers and energy auditor systems,
(iii) regulation on MEPS and labelling,
(iv) regulation on transportation, and
(v) other supplementary regulations (i.e. energy conservation guidelines and financing mechanisms).

Of these regulations in the draft, the following are those whose details are known:

(i) MEPS

Based on the ASEAN-SHINE Programme, Regional Harmonised Standard, the setting of a standard for air conditioners is being studied as a first step. After the MEPS for air conditioners is stipulated, an effective compliance mechanism consisting of monitoring, verification, and enforcement will be established. It is expected that the setting of a standard for lighting systems will be studied after that for air conditioners.

(ii) Setting standards and labelling

These measures will be put in place by the following steps: (a) a tentative rating standard and MEPS values will be set, (b) these will be explained to stakeholders to see how they react, (c) a trial will be implemented, and (d) based on the trial results, these measures will be officially established. The implementation of these measures is intended to start on a voluntary basis, before shifting to implementation on a mandatory basis a few years later.

The following are a few examples of the energy-saving measures currently implemented:

(i) In Myanmar, firewood is burned in cooking furnaces, which gives rise to concerns about environmental issues such as deforestation. In response to this situation, the United Nations Development Programme and Food and Agriculture Organization have been offering high-efficiency cooking furnaces free of charge or at low prices since 2004.

(ii) Most of the streetlights in the city of Yangon have been replaced with low-voltage lights.

(iii) Energy efficiency and energy conservation are the most important points of examination for obtaining building permits.

(iv) Energy-saving diagnoses have been implemented in accordance with a request from the Ministry of Energy.

Table 1.10: Energy Efficiency and Conservation Regulations by Sector in Myanmar

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	B: Participating in the ASEAN–Japan Promotion of Energy Efficiency and Conservation	None
Commercial and Residential	B1: The Ministry of Energy implements energy-saving diagnoses upon request. B2: Promoting the widespread use of high-efficiency cooking furnaces with support from international institutions	A: Minimum energy performance standards for air conditioners are being planned.
Transport	None	None

ASEAN = Association of Southeast Asian Nations.

Source: Author.

Organisation

Within the Government of Myanmar, the Energy Efficiency and Conservation Department, which was established in the Ministry of Industry in 2014, is responsible for energy conservation.

Financing tool

There is no EE&C financing policy at present.

1.3.7. Philippines

Overview

The entire picture of the Philippines' energy policies including energy conservation is summarised in the Philippine Energy Plan formulated by the Department of Energy (Department of Energy, 2017). The latest version of this plan is the Philippine Energy Plan 2017–2040. In the Philippines, energy conservation measures are positioned as part of the policy to promote a low-carbon future.

The National Energy Efficiency and Conservation Program, which was launched in 2004, lays out the principles of the specific energy conservation policies. The programme is a comprehensive policy that covers six sectors – commercial and government buildings, industrial, household, electric power, transportation, and agricultural – and consists of the following nine programmes:

(i) the Social Mobilization and Information, Education and Communication Campaign;
(ii) the Energy Efficiency Standards and Labeling Program;
(iii) the Government Energy Management Program;
(iv) Energy Management Services and Energy Audits;
(v) the Voluntary Agreement Program;
(vi) the Recognition Award Program;
(vii) the Fuel Economy Run Program;
(viii) regional support projects to promote energy conservation, including
  (a) Road Transport Patrol (fuel conservation and efficiency in road traffic) and
  (b) Power Patrol (controlling electricity consumption and demand side management); and

(ix) foreign assistance and technical support.

Meanwhile, the Energy Efficiency and Conservation Roadmap 2017–2040 sets the goal for reducing energy consumption. While a BAU forecast predicts that energy consumption will increase by 80% between 2017 and 2040, cumulative energy consumption since 2005 will decrease by 24%. The roadmap describes the measures needed to achieve this goal separately in three timespans for the transportation, industrial, residential, commercial, and agricultural sectors: short-term (2017–2020), medium-term (2021–2030), and long-term (2031–2040).

Table 1.11: Energy Efficiency Targets in the Philippines

Sector	Annual energy saved by 2040 (kilotonnes of oil equivalent)	Implied annual savings (%)	Total savings by 2040 (%)
Transport	4,500	1.90	-25
Industry	3,000	1.30	-15
Residential	1,000	1.20	-20
Commercial	1,200	1.90	-25
Agriculture	300	0.90	-10
Total	10,000	1.60	-24

Source: Department of Energy (2017), *Energy Efficiency and Conservation Roadmap 2017–2040*. https://www.doe.gov.ph/sites/default/files/pdf/energy_efficiency/ee_roadmap_book_2017-2040.pdf (accessed 14 June 2019).

Regulations

The following are major regulations relating to energy conservation:

(i) Demand Side Management (Department Circular No. DC2014-08-0014）

To cope with a tight electric power supply and demand, this ministerial order aims to mandate all electricity consumers (especially in the household, industrial, and business sectors) – excluding socially important facilities such as hospitals, military facilities, and airports – to implement DSM and other energy-saving measures required to reduce electricity consumption. This ministerial order is also aimed at mandating electric power suppliers to provide full support to consumers in implementing DSM.

(ii) Energy Consumption Monitoring (Department of Energy [DOE] Circular No. 93-03-05)

This regulation asks all companies and facilities in the industrial, commercial, and transportation sectors to submit quarterly or annual reports on the status of their energy consumption. Those with an annual energy consumption equivalent to 1,000 kilolitres or more of fuel oil must submit quarterly reports, and those with an annual energy consumption equivalent to 2,000 kilolitres or more must also submit annual reports with more detailed descriptions.

(iii) Minimum energy efficiency

Minimum energy efficiency standards are set for eight types of equipment: CFLs, freezers, refrigerator freezers, refrigerators, electric motors, air conditioners with an outdoor unit, and window air conditioners.

(iv) Labelling system

An energy label must be affixed to the following 11 product items including those currently under consideration: electronic ballasts, fluorescent ballasts, CFLs, industrial fans, fluorescent lamps, refrigerating machines, electric motors, air conditioners with an outdoor unit, window air conditioners, refrigerators, and refrigerator freezers.

(v) Government Energy Management Program (2004)

This energy conservation programme for government-owned buildings and vehicles sets the goal of reducing electricity and fuel consumption by 10%.

(vi) Energy conservation guidelines for buildings

These guidelines are stipulated based on the Guidelines for Energy Conservation Design of Buildings and Utility Systems as a referral code to the National Building Code, which was formulated in 1994. These guidelines are applicable to the building of external walls, air conditioners, hot water supply equipment, lighting systems, power receiving and transforming facilities, and entire buildings. These specifications were prepared as guidelines and intended for use on a voluntary basis.

(vii) Certification and evaluation programme for green buildings

This is a voluntary certification and evaluation system operated by the Philippine Green Building Council. Certification under the Building for Ecologically Responsive Design Excellence system, including the processes from the planning phase to construction, requires verification by third-party institutions. In this sense, this programme is considered highly reliable amongst green building certification and evaluation programmes in the Philippines.

(viii) Energy conservation officer system

To implement the government's plans for energy conservation and energy efficiency improvements, the head of each government organisation must appoint his or her executive officers as energy conservation officers. These officers must prepare energy conservation visions, plans, and implementation plans, amongst other things; make assessment schemes for energy efficiency improvements; and manualise the results for submission to the Government of the Philippines.

Table 1.12: Energy Efficiency and Conservation Regulations by Sector in the Philippines

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: Regulation began in 2014 in accordance with the Ministerial Order about DSM Programs. A2: In accordance with the Energy Management System (DOE Circular No. 93-03-05), the following were asked to submit reports on the status of energy consumption to the DOE on a voluntary basis: (i) Companies and facilities with an annual energy consumption equivalent to 1,000 kL or more of fuel oil are asked to submit quarterly energy consumption reports. (ii) Companies and facilities with an annual energy consumption equivalent to 2,000 kL or more of fuel oil are asked to submit quarterly energy consumption reports as well as annual reports	

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
	with more detailed descriptions. B1: Energy audits and certification programmes – energy audits and energy conservation advisory services by the DOE B2: Philippine Industrial Energy Efficiency Project – energy conservation through the standardisation of energy management based on ISO50001	
Commercial and Residential	A1: Regulation began in 2014 in accordance with the Ministerial Order about DSM Programs. A2: Requests for reports on the status of energy consumption in accordance with the Energy Management System (see the description above) B1: Asian Development Bank-supported project – phase-out incandescent light bulbs by January 2010 B2: ESCO Certification Program in 2008 – four companies have been certified so far.	A1: Eight product items are subject to the minimum energy performance standard. B1: Eleven product items are subject to the energy labelling system.
Transport	B1: Various programmes intended to promote fuel efficiency are underway in accordance with the National Energy Efficiency and Conservation Program.	

DOE = Department of Energy, DSM = demand side management, ESCO = energy service company, ISO = International Organization for Standardization, kL = kilolitres.

Source: Author.

Organisation

The DOE has jurisdiction over the Philippines' overall energy policies. The Energy Efficiency and Conservation Division under the Energy Utilization Management Bureau of the DOE is responsible for overall energy conservation activities in the country.

Financing Tool

Two types of tools – lending programmes and tax incentives – are identified.

(i) Lending programmes

Since direct funding is not the role of the DOE, the following public and private banks have offered loans for energy saving investment in accordance with the DOE's policy: (a) Development Bank of the Philippines (state-owned), (b) Land Bank of the Philippines (state-owned), (c) Bank of the Philippine Islands (private), and (d) Banco De Oro (private). Competition amongst financing institutions is believed to provide better loan conditions for borrowers.

Although the difference is small, state-owned banks lend at a lower interest rate than private banks. Although the screening of state bank loans is stricter than that implemented by private banks, state banks' collateral requirements are less strict than those of private banks to help finance EE&C investment in the public sector where the timing of repayment (budget execution is rigid in the public sector) and available assets as collateral are unfavourable for private banks in general.

Besides the above-mentioned banks, the Philippine National Oil Company-Renewable Corporation provides a benefit-sharing type ESCO service to public buildings.

(ii) Tax incentives

Climate action incentives are provided to the manufacturing industry (steel, cement, and paper) by the Board of Investment. Eligible investments include the replacement of air conditioners, motors, fans, and pumps with more efficient equipment.

1.3.8. Singapore

After ratifying the Kyoto Protocol in 2006, in March 2008 Singapore announced the National Climate Change Strategy to take various countermeasures against the issue of global warming, including energy conservation on its land. In accordance with the energy conservation strategies presented in the National Climate Change Strategy, the country set up the Energy Efficient Singapore Program to implement a series of energy conservation measures, in which multiple relevant ministries and agencies participate under the initiative of the National Environmental Agency.

In 2012, the Energy Conservation Act was enforced. Under this act, large companies stepped up the level of energy management, strategies for promoting energy conservation in individual industrial fields were formulated, and responsible ministries and agencies were named.

Regulations

In Singapore, a number of energy conservation-related regulations, initiatives, and measures have been implemented, as shown below.

(i) Energy Conservation Act (June 2012)

This act is aimed at implementing the energy conservation measures, which would have involved multiple laws and government offices, under a single law and in a more collaborative and cross-sectional manner. Details of some major regulations are as follows:

(a) Regular reporting system: Companies in the industrial and transportation sectors that consume 15 gigawatt-hours per year or more of electric power or 54 terajoules per year or more of fuel and steam are mandated to report the amounts of energy consumed and GHGs emitted, and to prepare their energy efficiency improvement plans.

(b) Certified energy manager system: Companies are mandated to appoint certified energy managers from their employees, and the number of such managers must be proportional to the scale of their business. The certified energy managers must be certified through the energy manager qualification system, and receive appropriate job performance training. The Singapore Certified Energy Manager Programme is implemented as an energy manager qualification system.

Apart from the responsibilities that large companies must fulfill, the Energy Efficiency National Partnership was established so that companies will participate voluntarily. This programme was launched in April 2010 by the National Environment Agency (NEA), in which companies interested in energy efficiency participate on a voluntary basis.

(ii) Labelling system

In 2008, the NEA stipulated the Environmental Protection and Management (Energy Conservation) Regulations, mandating that home appliances conform to the labelling system. In 2011, a MEPS was defined for air conditioners and electric refrigerators; and electric clothes dryers, television sets, and lighting equipment were later added to the list one after another. In 1992, the Singapore Green Labeling Scheme was initiated as a voluntary environmental labelling system, and the energy efficiency certification standard was applied to some of the products subject to the scheme.

(iii) Regulations on buildings

The Green Mark, a rating certification system for environment-conscious buildings, was introduced in 2005. The assessment criteria for the Green Mark include energy use efficiency, water use efficiency, site and project development and management, indoor environment quality and environmental protection, and creativity. Since 2008, new buildings and large-scale renovation of existing buildings with a total floor area of 2,000 square metres (m^2) or more are required to meet the Green Mark certification standard.

The following are recent energy conservation-related developments:

(i) Public Sector Sustainability Plan 2017–2020 (June 2017)

Under this initiative, the public sector will take the lead in implementing various energy-saving measures. Government green procurement of electronic equipment and paper products, food waste recycling on the part of the public sector, and the like are subject to this initiative.

(iii) Carbon tax (February 2018)

The Government of Singapore announced a carbon tax of S$5 per tonne of GHG, with collection slated to start in 2020. The government set a fixed carbon tax without introducing a different tax basis for each industrial sector. The tax amount will be kept unchanged until 2023 when it will be increased to S$10, reaching S$15 per tonne of GHG by 2030. The carbon tax will apply to 30–40 business locations, such as electric power plants, refineries, and petrochemical plants, which emit GHGs at a rate of 25,000 tonnes of CO_2 equivalent per year or more. Total GHG emissions from these operations account for 80% of the country's total GHG emissions.

(iv) Super low energy programme (September 2019)

This programme is a certification system intended for non-residential buildings with high energy efficiency. To achieve certification through this system a building must improve energy efficiency by at least 60% compared with the green building criteria established in 2005.

Table 1.13: Energy Efficiency and Conservation Regulations by Sector in Singapore

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: As an effort to put in place mandatory energy management practices, the Energy Conservation Act came into effect in April 2013. Energy-intensive companies (those consuming at least 15 gigawatt-hours of electricity or 54 terajoules of fuel or steam per year) are required to appoint an energy manager, submit an annual report stating their energy usage and greenhouse gas emissions, and develop an energy efficiency improvement plan. Currently, 170 companies are subject to this regulation. B1: Promotion of cogeneration and tri-generation (the integrated production of electricity, heat, and chilled water) in the power generation sector B2: Implementation of the Energy Efficiency National Partnership	A: Minimum energy performance standards for home electric appliances B) Mandatory energy labelling schemes for home electric appliances

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
	Program, a voluntary partnership programme to support companies in their energy efficiency efforts through learning activities, energy efficiency-related resources, incentives, and recognition. B3: Industry-led initiatives – a collective target to improve the energy intensity of the biomedical manufacturing industry by an annual average of 6% amongst the energy workgroup B4: Encourage energy efficiency in industries through energy performance contracting under the ESCO model.	
Commercial, Institutional, and Residential	A1: The Green Building Master Plan, 3rd Phase – with a broad vision of greening 80% of buildings, this phase of the master plan focuses on accelerating the green building agenda with three broader strategic goals: continued leadership, wider collaboration and engagement, and proven sustainability performance in buildings. Three major initiatives include a $52 million fund for the Green Buildings Innovation Cluster, a $50 million Green Mark Incentive Scheme for Existing Buildings and Premises, and a new award, the Green Mark Pearl Award for developers.	A1: Minimum Green Mark standards for new buildings – enables 28% greater energy efficiency relative to the 2005 codes. A2: Minimum energy performance standards for home electric appliances A3: Green Data Centre Standard – as data centres are extremely energy-intensive facilities, the Infocomm Development Authority of Singapore is working with other agencies to develop a Singapore Standard for Green Data Centres. B1: Mandatory energy labelling schemes for home electric appliances B2: Green Mark ratings for existing

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
	A2: Mandatory energy auditing of building cooling systems every 3 years B1: ESCOs Accreditation Scheme – encourages the growth of ESCOs and enhances the quality of services. B2: Save Energy Save Money Initiative – encourages households to reduce their energy consumption by practicing simple energy-saving habits. B3: Online Life Cycle Cost Calculator for electrical appliances, Tips on Home Energy Audit B4: Public Sector Taking the Lead in Environmental Sustainability Initiative – encourages energy efficiency in public sector agencies. B5: Guaranteed Energy Savings Performance contracting model – promotes liaising with ESCOs to enjoy guaranteed energy performance and savings during the contract period.	and new buildings B3: The Energy Smart label for offices – encourages offices to perform in the top quartile in terms of energy efficiency and indoor air quality.
Transport	A1: Carbon Emissions-Based Vehicle Scheme – encourages the purchase of low-carbon emission vehicles. A2: Target to achieve 75% modal share of journeys made via public transport during peak hours A3: Continuous expansion and improvement of train infrastructure and bus networks – double the length of the train network by 2030	A: Higher emissions standards for vehicles – Euro V for diesel vehicles, and Euro IV for petrol vehicles B: Fuel economy labelling scheme for cars and light goods vehicles – helps consumers choose greener vehicles.

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
	A4: New regulations on the composition of petrol and diesel fuel supplied in Singapore from 2017 onwards A5: Vehicle quota system to limit the vehicle population; Certificate of Entitlement calculated based on the sustainable vehicle population in the long term A6: Electronic road pricing to manage vehicle usage – levies a charge (on the basis of fuel grade) on vehicles using congested portions of roads during peak hours. B1: Walk2Ride programme: Safe and Pleasant Walking for Everyone – connected shelters and walkways B2: National Cycling Plan – expand island-wide cycling paths from 230 km today to a network stretching over 700 km by 2030. B3: Testing of clean vehicle technologies	
Others	A2: Waste-to-energy plants – four waste-to-energy plants in operation, contributing 2%–3% of the electricity generated in Singapore, with more plants planned.	

ESCO = energy service company, km = kilometre.
Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

In Singapore, the Ministry of Trade and Industry formulates and implements energy policies. Energy conservation measures are implemented by Energy Efficient Singapore, in which multiple relevant ministries and agencies participate under the initiative of the NEA.

Financing tool

The following tax incentives are intended for motor vehicles.

(i) Vehicle Emissions Scheme (VES) (July 2018)

The VES is an energy conservation measure that replaced the previous measure called the Carbon Emissions-Based Vehicle Scheme. Under this scheme, new vehicles are subject to tax refunds or surcharges calculated based on their CO_2 emissions. The VES is also based on the measurement of four other gases and substances (carbon monoxide, hydrocarbons, nitrous oxide, and particulate matter) contained in exhaust gas. In this case, tax refunds and surcharges are calculated based on the substance with the highest content of the five pollutants.

1.3.9. Thailand

Overview

Thailand has been working on energy conservation since the 1980s. In 1992, the Energy Conservation Promotion Act (B.E. 2535) was enacted to promote energy conservation (particularly in factories and buildings). The act was revised in 1998, 2003, and 2007. The 2007 revision focused not only technical initiatives (such as equipment and systems) but also on various measures, including system management (human resources). The expanded authority of the Ministry of Energy (MOE) as the supervisory organisation was also defined in this revision.

Under the Energy Conservation Promotion Act, a subsidy system was introduced through the Energy Conservation Fund. This fund is intended to support investment in energy conservation mainly at designated factories and buildings, but is also used for energy-related research and development and human resource development.

In Thailand's 20-Year Energy Efficiency Development Plan: 2015–2036, which was released in 2015, the country presented its energy conservation goal of reducing energy consumption relative to GDP by 30% from 2010 levels. As a result, a reduction in energy consumption of 51.7 million tonnes of oil equivalent is expected in 2036 compared to 2010. Specific energy conservation measures to be taken are as follows:

(i) designate factories and buildings,

(ii) implement a building energy code,

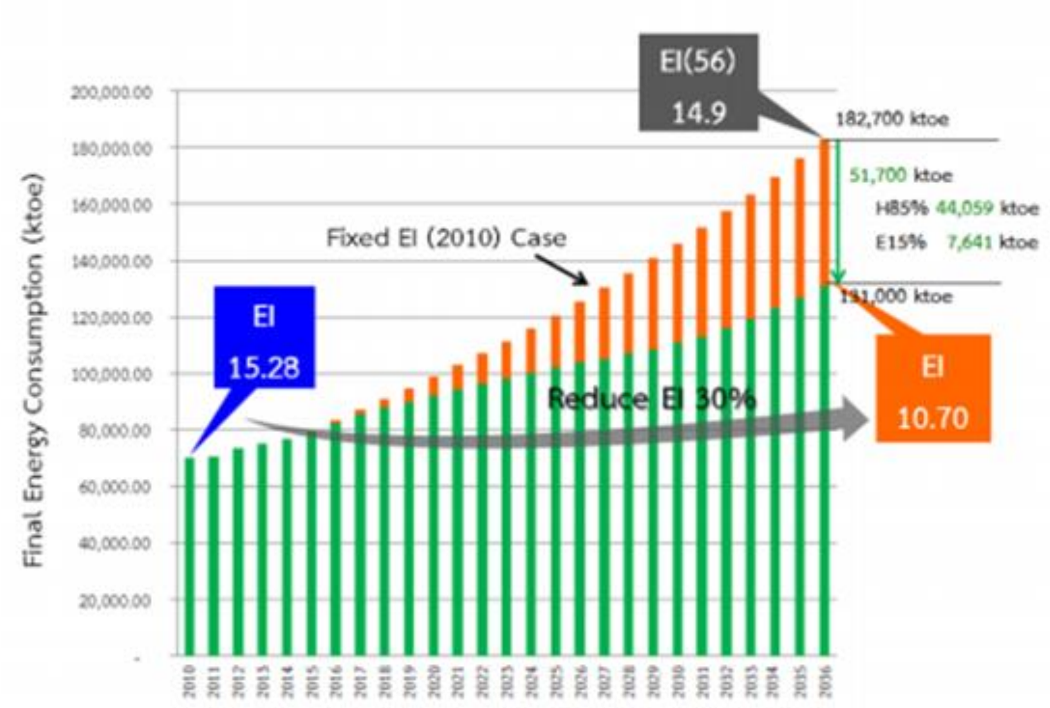
(iii) establish advanced and minimum energy performance standards for equipment,

(iv) provide financial support,

(v) encourage the widespread use of light-emitting diode lights, and

(vi) increase energy saving in the transportation sector, and elsewhere.

Figure 1.1: Energy Efficiency Target During 2010–2036 in Thailand



E = electricity, EI = energy intensity, H = heat, ktoe = kilotonne of oil equivalent.

Source: Energy Policy and Planning Office home page: Thailand Power Development Plan 2015–2036 http://www.eppo.go.th/images/POLICY/ENG/PDP2015_Eng.pdf (accessed 14 June 2019).

Regulations

The regulations being implemented include the following:

(i) The appointment of energy managers at designated factories and buildings

In accordance with the Energy Conservation Promotion Act, designated factories or buildings must appoint an energy manager, establish an energy management system, and report the result annually. Facilities subject to this requirement include those whose contract power demand is 1,000 kW or more, whose total installed capacity of power transformers is 1,175 kilovolt-amperes or more, or whose annual demand for electricity and steam is 20 million megajoules or more.

(ii) Energy efficiency standard

The labelling system is operated based on an energy performance standard. Energy efficiency ratings are indicated according to five levels – Level 1 (low performance) through Level 5 (high performance). The need to indicate these ratings should be determined on a voluntary basis. MEPS are set for fluorescent lamps, CFLs, electric motors, air conditioners, liquefied petroleum gas stoves, and refrigerators, amongst others. There are two types of MEPS: mandatory and voluntary. As for high energy performance standards, voluntary standards of excellence are set for air conditioners, refrigerators, air conditioner electric fans, rice cookers, cooling systems, windowpanes, electric water heaters, and kitchen water heaters, amongst others.

(iii) Building energy code

This code sets standards for energy-saving building designs, although use of this code is not mandatory. The code is applied to new construction and renovation of buildings with a total floor area of 2,000 m^2 or more. The code stipulates standards for curtain walls, lighting equipment, air conditioners, hot water systems, renewable energy utilisation, and overall building energy performance.

Table 1.14: Energy Efficiency and Conservation Regulations by Sector in Thailand

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards, and Labelling A: Standard, B: Labelling
Industrial	A1: Designated factories or buildings – facilities whose contract power demand is 1,000 kilowatts or more, whose total installed capacity of power transformers is 1,175 kilovolt-amperes or more, or whose annual demand for electricity and steam is 20 million megajoules or more. A2: The appointment of managers to promote energy-saving activities	A1: MEPS for six product items A2: HEPS for eight product items

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards, and Labelling A: Standard, B: Labelling
	based on laws and regulations. The submission of annual energy management reports on the implementation of an energy management system for each facility. A3: Energy management system B1: Transforming industrial parks into eco-towns	
Commercial and Residential	A1: The appointment of at least one energy manager in a designated building or factory (with an energy consumption of 3 megawatts or less), or at least two energy managers in a designated building or factory (with an energy consumption of more than 3 megawatts), and providing education and training to these energy managers A2: Energy service companies (introduced in March 1999) A3: Building Energy Awards of Thailand, 2010 (implemented in 2010) A4: Energy conservation measures at government organizations and government-owned companies A5: Green procurement by public institutions B1: Promotion of the labelling of energy-saving buildings, which began in 2007. B2: Implementation of programmes to replace conventional lighting	A1: MEPS for six product items, HEPS for eight product items. A2: Building energy code B1: Energy-saving air conditioner programme B2: Green labels B3: MEPS labels for 18 product items B4: HEPS labels for 27 product items

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards, and Labelling A: Standard, B: Labelling
	systems with high-efficiency lighting systems B3: Implementation of programmes to apply energy efficiency labels to home appliances B4: Green building certification system	
Transport		B1: Eco-labels (started in October 2015)

HEPS = high energy performance standard, MEPS = minimum energy performance standard.

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The MOE is responsible for energy policies in Thailand. The Department of Alternative Energy Development and Efficiency (DEDE) under the MOE is tasked with energy conservation. In 1985, the Energy Conservation Center of Thailand was established jointly by the DEDE and the Federation of Thai Industries. The centre is responsible mainly for providing energy consulting, energy diagnosis, technical assistance, training, and education, amongst other things.

Financing Tools

The following EE&C financing instruments are being implemented in Thailand (DEDE, 2019).

(i) Revolving fund

Requests for revolving funds are possible at the time of the development of the factory or building. The application must be made through a bank that then evaluates the financial aspect of the project, and the DEDE will carry out the technical review of the project. The loan limit is B50 million, with an interest rate of 3.5% or less, and a repayment period of not more than 5 years.

(ii) Direct subsidies for small and medium-sized enterprises (SMEs)

Factories and buildings of SMEs can apply. The subsidy ratio is 20–30% of equipment and installation costs, the maximum subsidy amount is B1.5 million per corporation or business owner, and the payback period is less than 7 years.

(iii) Performance-based subsidy for demand side management (DSM)

This subsidy will be given only when the energy saving target is achieved. Equipment eligible for this subsidy is large (50 megawatt-hours per year or more) cooling and air conditioning systems. The subsidy amounts to B2.00/kWh if the payback period is more than 3 years and B1.00/kWh if the payback period is 3 years or less.

1.3.10. Viet Nam

Overview

In Viet Nam, the Law on Energy Efficiency and Conservation was enforced in 2010. As a result of the enforcement of this law, energy conservation-related measures such as energy management and reporting systems, energy conservation standard and labelling systems, and measures for promoting the installation of energy-saving equipment that had been stipulated via government decisions and notices are now organised in the form of bills. At the same time, a shift from voluntary initiatives to mandatory systems is currently being promoted.

The National Green Growth Strategy formulated in 2014 is the latest guideline related to energy conservation policies in Viet Nam. This guideline includes descriptions of action plans for 2014 through 2020. The following are four major action plan items, including a total of 66 activities.

(i) action plan at the local level,

(ii) reduction of GHG emission intensity and promotion of clean and renewable energy,

(iii) greening, and

(iv) promoting green life and sustainable consumption.

Regulations

The following regulations are being implemented:

(i) Regulations intended for the industrial sector

Pursuant to Article 9 of the Law on Energy Efficiency and Conservation, the following energy conservation obligations are stipulated:

(a) formulate annual energy conservation plans,

(b) install highly energy-efficient equipment,

(c) make maximum use of natural lighting and ventilation,

(d) follow maintenance procedures for production lines to prevent possible energy loss, and

(e) remove outdated equipment consuming a large amount of energy one after another.

(ii) Regulations intended for the consumer sector

Article 15 of the Law on Energy Efficiency and Conservation recommends the introduction of building designs utilising the natural environment with the aim of reducing the amount of energy consumed for space heating and cooling. Article 18 recommends the use of high-efficiency heat-insulating materials and mechanical equipment specified by the government when constructing new buildings. Article 26 recommends that heat and electricity supply management systems be adopted. Article 27 requires commercial building owners to implement energy saving management and limit the use of high-capacity power equipment during peak hours.

(iii) Energy management officer system

Companies designated pursuant to the Law on Energy Efficiency and Conservation are mandated to deploy energy conservation officers, prepare and submit plans for the efficient use of energy each year and every 5 years, and implement energy conservation diagnoses every 3 years. Meanwhile, the details of qualification requirements for energy conservation officers are stipulated in Article 35 of the Law on Energy Efficiency and Conservation (including an energy engineering degree, technical skills obtained through field experience, or attendance at training courses offered by the Ministry of Industry and Trade).

(iv) Labelling system

Article 39 of the Law on Energy Efficiency and Conservation stipulates the use of a labelling system. There are two types of labels: certification labels and comparative labels. A certification label is affixed to a product that has passed the energy performance standard stipulated by the Ministry of Industry and Trade, indicating whether or not the product satisfies the standard. On the other hand, a comparative label uses five stars to indicate how well the product satisfies the energy performance standard. A comparative label allows a consumer to choose the product he/she wants by comparing the energy performance of multiple products. Equipment is subject to two types of labelling: mandatory labelling and voluntary labelling. The number of equipment categories subject to mandatory labelling is increasing gradually – these include straight-tube fluorescent lamps, fluorescent bulbs, magnetic ballasts and electronic ballasts for fluorescent lamps, air conditioners, vertical washing machines, rice cookers, electric fans, refrigerators, drum washing machines, television sets, office equipment, and commercial use equipment (e.g. commercial-use refrigerators, copying machines, computer monitors, and printers).

Equipment subject to voluntary labelling includes commercial-use refrigerated warehouses, distribution transformers, electric motors, and passenger vehicles (seven seats or less).

Table 1.15: Energy Efficiency and Conservation Regulations by Sector in Viet Nam

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: Formulation of an annual energy saving plan A2: Introduction of highly energy-efficient facilities A3: Maximum use of daylight and ventilation A4: Implementation of regulations on the maintenance of production lines aimed at the prevention of energy loss A5: Sequential dismantlement of energy-consuming facilities with old technologies	B1: Industrial equipment including three-phase distribution transformers, electric motors, and industrial boilers

Commercial and Residential	A1: Building designs that harness nature to reduce energy consumed by lighting, ventilation, and air conditioners A2: Use of heat insulators produced based on national or international specifications A3: Establishment of monitoring systems for the supply of electric power and heat B1: Preferential installment of highly efficient facilities using renewable energy in lighting equipment for public use B2: Encouraging homes to use natural light, ventilation, heat insulators, and energy-saving electric equipment B3: Encouraging the restrained use of large-capacity facilities during peak hour(s)	B: Applied to various lighting equipment, air conditioners, refrigerators, washing machines, electric cookers, electric fans, televisions, copy machines, monitors, printers, and others.
Transport	A1: Use of liquefied petroleum gas, natural gas, electric power, hybrid fuels, and biogas as oil alternatives A2: Selection of routes and transport methods that optimise the use of fuel, and establishment and adoption of regulations on maintenance and repair from the perspective of fuel reduction A3: Adoption of advanced technologies, including research into low fuel-consumption facilities, and use of clean fuel, renewable energies, and other alternative fuels	B1: Passenger cars with fewer than seven seats

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

Under the Ministry of Industry and Trade, the General Energy Office is responsible for energy conservation in Viet Nam.

Financing Tool

There is no EE&C financing programme at present. However, there was a financing programme until 2016, and plans are being made to establish a new programme after 2019. Under the project Low Carbon Transition in the Energy Efficiency Sector, bank guarantees were provided for SMEs in the brick, ceramic, and food-processing sectors, which invest in energy-efficiency equipment. The guarantee could not exceed 50% of the initial loan, ranging from D200 million to D4 billion. After energy saving is achieved, beneficiaries can enjoy an investment rebate of 10–30% of the initial loan, up to a maximum of D2.4 billion.

1.3.11. Japan

Overview

Japan began to formulate energy conservation policies after the oil crises, and enacted the Act on the Rational Use of Energy (Energy Conservation Act) in 1979. Since its enforcement, the Energy Conservation Act has undergone many revisions in response to changes in the energy situation at home and abroad. The act requires companies using more than a certain amount of energy to take measures to ensure the rational use of energy, appoint energy managers, and prepare and submit regular reports and energy saving plans.

In the 1998 revision to the Energy Saving Act, the Top Runner Program was introduced for the first time. Because of this revision, the energy efficiency of specified equipment has improved significantly. At the same time, the Energy Saving Act emphasised providing information to consumers to promote energy-saving equipment. For this reason, the act mandates manufacturing companies to fulfill their labelling obligation by providing information about energy consumption efficiency. The act also stipulates the need for an energy efficiency labelling system.

In 2008, the Benchmark System by Sector intended for the industrial sector began, although it was non-binding. This system is intended to encourage energy saving initiatives further by setting a specific energy consumption target (benchmark index) for each industry or sector to enable companies to check their positions in the race to save energy.

In 2015, the Act for the Improvement of the Energy Saving Performance of Buildings (Building Energy Efficiency Act) was established. In 2017, the energy-saving performance of houses and buildings was mandated to conform to that of new non-residential buildings with a total floor area of over 2,000 m^2 (this had previously been a best effort obligation).

In April 2016, the Ministry of Economy, Trade and Industry announced the Innovative Energy Strategy, which referred to the following matters as major energy-saving measures in the future:

(i) To promote each company's voluntary initiatives, energy saving incentives for companies will be reinforced.

(ii) As actual energy management is changing along with the introduction of new production and distribution processes, an appropriate system will be built so that companies can implement energy-saving measures in line with their management policies.

(iii) To create an environment in which it is possible to determine the potential of energy saving efforts at the level of small and medium-sized companies and households, which lack energy saving know-how, the utilisation of private-sector companies that have sufficient energy saving know-how will be promoted.

Regulations

The following are major regulations relating to energy efficiency and conservation:

(i) Act on the Rational Use of Energy (Energy Conservation Act)

This act was established in 1979, and has undergone many revisions since then. The act is a fundamental law by which Japan's energy conservation measures will be vigorously promoted depending on the characteristics of each sector: industrial, consumer, and transportation.

(ii) Top Runner Program

This programme was introduced in the 1998 revision to the Energy Conservation Act. Intended mainly for automobiles and electric appliances, this system asks manufacturers and importers to achieve a certain standard by a target date 3–10 years in the future. In this case, the energy consumption efficiency goal is set by taking into account the advancement of technology based on the performance of the most energy-efficient equipment of all currently commercialised products in the same group. Those companies that continue to produce and sell products that fail to meet the targeted standard after the target date will be advised by the competent minister to improve the situation. In some cases the situation will be made public or the company will face a potential penalty. The product items subject to this programme are being expanded from home appliances such as air conditioners, television sets, machinery, and appliances such as automobiles to building materials like heat-insulating materials. There are currently 32 product items on this list.

(iii) Benchmark System by Sector (2008)

In this system, appropriate indexes (benchmark indexes) are set so that the energy efficiency levels of companies belonging to the same specific industry or sector can be compared. By making clear a company's status in energy saving initiatives in comparison with other companies, this system is intended to determine which companies are well ahead of others and urge those who are behind others to make a greater effort (best effort obligation). By analysing the specific energy consumption of companies whose consumption is above a certain level in each industry or sector, this system sets benchmark indexes at the specific energy consumption level of the top 10–20% of companies. To date, benchmark indexes have been set for nine industries and 13 sectors, including the blast furnace iron industry, the cement manufacturing industry, the cardboard industry, the oil refining industry, the basic petrochemical products manufacturing industry, and the soda industry.

(iv) Act for the Improvement of the Energy Saving Performance of Buildings (Building Energy Efficiency Act) (2015)

This act applies to the following types of buildings:

(a) Large-scale buildings (with a total floor area of more than 2,000 m^2), both residential and non-residential, are mandated to conform to the energy performance standard.

(b) Medium-scale buildings (with a total floor area of at least 300 m^2 and less than 2,000 m^2) are mandated to report conformance to the energy performance standard.

(c) For small-scale buildings (with a total floor area less than 300 m^2), conformance to the energy performance standard is a best effort obligation.

In addition to the above regulations, a number of energy-saving measures are being implemented and studied. Recent energy saving initiatives, such as zero-emission buildings and houses, are intended to reduce the amount of operational energy consumed in buildings and houses to as close to zero as possible through energy-saving measures and the use of renewable energy. One way to achieve these initiatives is the building of energy management systems or home energy management systems. These systems are designed to reduce the amount of energy consumed through the operational management of equipment and facilities in buildings and houses. These systems consist of technology to 'visualise' the consumption of electricity and gas on a monitor and technology to 'automatically control' electric equipment.

Table 1.16: Energy Efficiency and Conservation Regulations by Sector in Japan

	Management of Energy Saving A: Regulatory, B: Voluntary	Standards and Labelling A: Standard, B: Labelling
Industrial	A1: 1% per year reduction for large energy consumers (> 1500 kilolitres of crude oil equivalent) A2: Specifically targets very large energy-consuming sectors A3: Reporting obligation for designated consumers B1: Voluntary commitment by business associations to reduce greenhouse gasses and hence improve energy efficiency	A1: Specific target for very large energy-consuming sectors (e.g. iron and steel, power generation, cement, paper and pulp, oil refinery, petrochemical, and soda chemical [7 sectors in total])
Commercial and Residential	A1: Reporting obligation for designated consumers (building owners with more than 300 m^2 of floor space)	A1: Require designated building owners to implement energy efficiency measures. A2: Top Runner system is applied to 32 appliances and building insulation materials.

Transport	A1: Reporting obligation for designated consumers. Fleet operator: Rail: > 300 cars Truck: > 200 trucks Bus: > 200 buses Taxi: > 350 cars Seaborne: > 20,000 tonnes Airborne: > 9,000 tonnes Cargo owner: > 30 million tonne-kilometres	A1: Require designated fleet operators and cargo owners to implement energy efficiency measures.

Source: The Energy Research Institute Network Secretariat (2016), 'Energy Efficiency Policy Update', March.

Organisation

The Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry is responsible for energy policies.

Financing Tool

In 1975, Japan launched an energy conservation subsidy programme to support the introduction of energy-saving equipment, mainly in the industrial sector. While room for energy conservation in the industrial sector gradually decreased, support measures for the transportation and building sectors have been strengthened since the 1990s from the viewpoint of global warming countermeasures.

There are three types of financial support for energy conservation: (i) tax incentives, (ii) subsidies, and (iii) a loan programme.

(i) Tax incentives

This is one of the main measures to promote corporate investment in energy conservation. In 2000, a reduction in taxes on the purchase of fuel-efficient vehicles and energy-saving home renovations was introduced. These incentives target large enterprises, SMEs, or individuals. The available incentives can be applied to taxes on corporations (national tax), income (national tax), property (local tax), automobiles (local tax), and automobile acquisition (local tax).

A recent example is the tax reduction for eco-friendly vehicles. This incentive reduces taxes on high-environmental-performance vehicles that meet the criteria for exhaust emissions and fuel efficiency set by the Ministry of Land, Infrastructure and Transport. While the tax reduction amount for gasoline-engine vehicles and hybrid vehicles is becoming smaller, 'next-generation vehicles' such as electric, fuel cell, plug-in hybrid, natural gas, and clean diesel vehicles enjoy tax exemptions or reductions. The criteria for this incentive include the achievement of fuel-efficiency standards, which vary depending on the vehicle. Eligible vehicles include electric, fuel cell, plug-in hybrid, natural gas, clean diesel, gasoline engine, and liquefied petroleum gas vehicles.

Tax reductions can be applied to the automobile acquisition tax imposed when you buy a car (a 20%–100% reduction), the weight tax imposed at the time of vehicle inspection (a 25%–100% reduction), and the automobile tax or light vehicle tax imposed every year on car owners (a 25%–75% reduction for the second year after purchase).

(ii) Subsidies

Through the New Energy and Industrial Technology Development Organization and the Energy Conservation Center Japan, the Government of Japan provides energy conservation subsidies to companies, local governments, individuals, and nonprofit organisations. The programme covers a wide range of activities, including the introduction of energy-saving equipment, the construction and renovation of energy-saving buildings and houses, public relations activities, and educational activities to promote energy conservation.

The programme targets large enterprises investing in energy conservation, SMEs, individuals, public organisations, and nonprofit organisations. It involves a fixed amount or fixed-rate subsidy for energy-saving activity.

A recent example is the subsidies to promote energy conservation investment. These subsidies promote energy conservation by supporting the introduction of large-scale energy-saving facilities and technologies or the renewal of existing facilities. The subsidy budget was ¥60.04 billion in fiscal year 2019, and the criteria include improving the energy-conservation rate (standards vary by category), and replacing existing facilities with those that exceed the efficiency threshold, amongst other things. The subsidy can be applied to factories or business sites based on the cost of design, equipment, and construction (¥1 million–¥1.5 billion), at a subsidy rate of one-fourth to one-half.

It can also be applied to equipment, including air conditioners, industrial heat pumps, commercial water heaters, boilers, combined heat and power, industrial furnaces, refrigerators, and industrial motors (¥300,000–¥30 million), at a subsidy rate lower than one-third[1].

(iii) Loan programme

A loan programme was established for large companies to invest in energy conservation, such as the use of waste heat recovery, and its scope was later expanded to include SMEs. Since then, facilities, buildings, and energy-efficient housing have also been eligible for loans. The programme targets large enterprises, SMEs, or individuals; and it encompasses special loans, low-interest rate loans, and interest subsidies.

A recent example of such a loan programme is the 'Flat 35 S', which provides low interest rate home loans (with a duration of 35 years) for energy-efficient or safe houses. The programme budget was ¥25.31 billion for part of fiscal year 2017, and the criteria included being a certified low-carbon house that satisfied primary energy consumption standards. The interest rate was lowered by 0.25% per year for the first 5–10 years.

Furthermore, in Japan, subsidies have been provided not only for the dissemination and promotion of energy-saving equipment but also for research and development of energy-saving technologies. Such grants are provided mainly by the following organisations and measures:

(a) research and development by government-affiliated research institutes,
(b) a tax incentive for promoting research and development, and
(c) the New Energy and Industrial Technology Development Organization.

Funds for the financing programmes mentioned above are provided from a special national account, the Energy Measures Special Account. The purpose of the special account is to increase the transparency of the accounting involved in energy-related policy measures, stabilise the fuel supply, improve the energy supply–demand structure, and promote power development. The special account is financed by the oil and coal tax and the power development promotion tax.

[1] The result is used to calculate the necessary investment amount to reduce unit electricity demand in Chapter 2, section 2.1.3 ($301 million per terawatt-hour).

Chapter 2

Cost and Benefit of Energy Efficiency and Conservation Financing

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

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

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

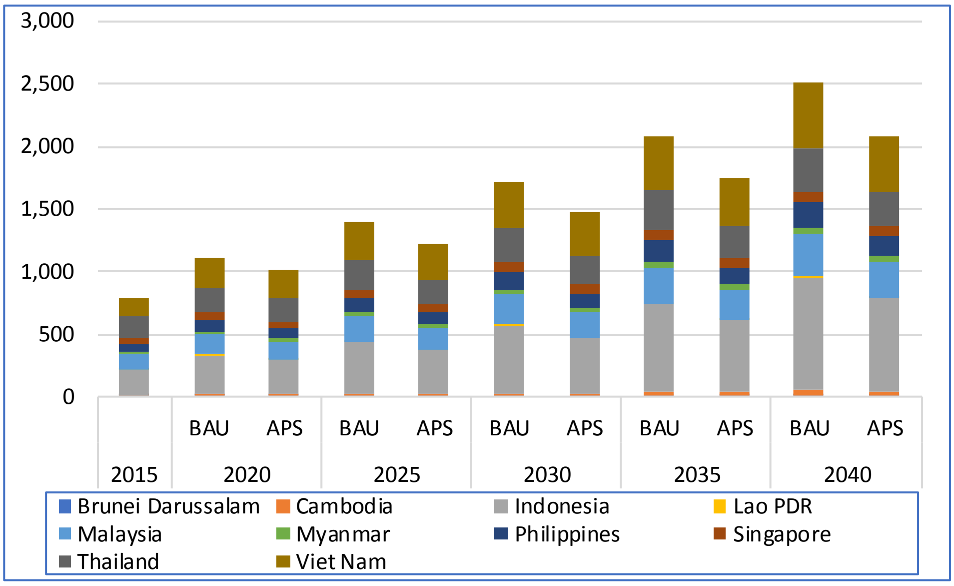
2.1.1. Electricity Saving Potential

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

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

Figure 2.1: Comparison of Electricity Demand Outlook by Scenario

(terawatt-hour)

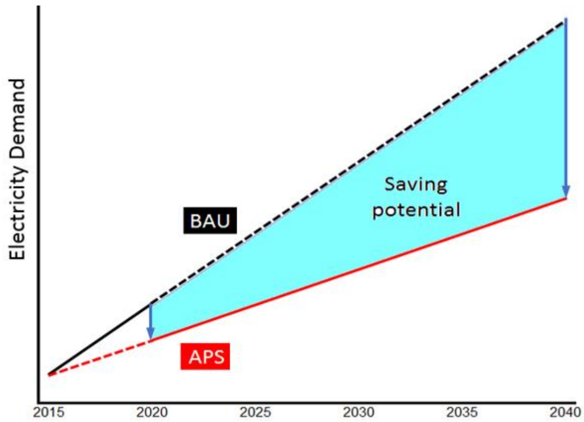


APS = alternative policy scenario, BAU = business as usual, Lao PDR = Lao People's Democratic Republic.

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

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

Figure 2.2: Electricity Saving Potential



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

Source: Author.

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

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

(terawatt-hour)

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

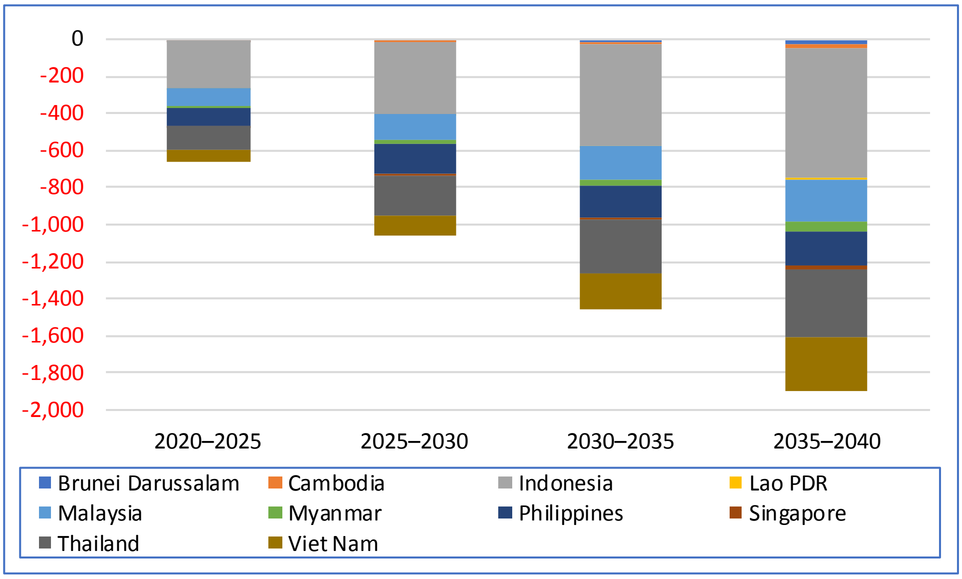
ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

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

Figure 2.3 shows the electricity saving potential by periods.

Figure 2.3: Electricity Saving Potential by Periods

(terawatt-hour)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

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

Formula

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

Gross benefit [$] = saved electricity amount [(kilowatt-hour) kWh]

* Unit electricity price [$/kWh]

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

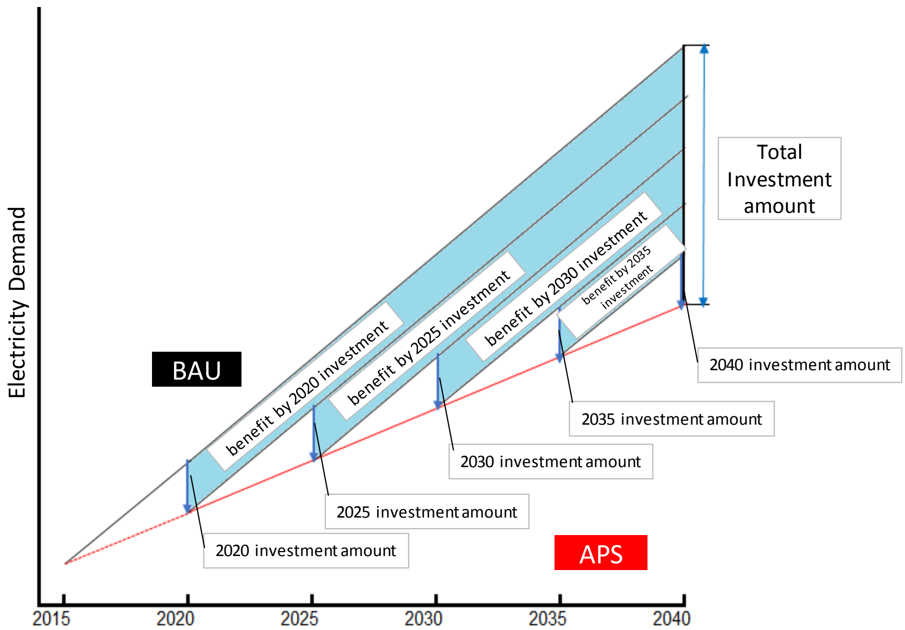
Saved Electricity Amount

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

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

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

Figure 2.4: Image of Gross Benefits



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

Source: Author.

Unit Electricity Price

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

Table 2.2: Electricity Price by Country

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

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

Source: See Appendix 2.

Calculated Result

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

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

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

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

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

Source: Author.

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

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

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

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

Source: Author.

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

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

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

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

Source: Author.

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

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

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

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

Source: Author.

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

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

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

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

Source: Author.

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

Table 2.8: Cumulative Gross Benefit by Country

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

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

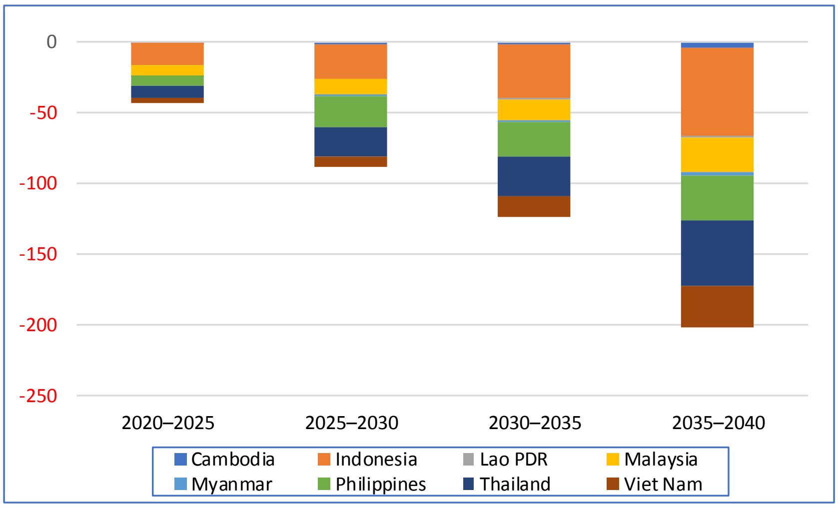
Note: Brunei Darussalam and Singapore are not included in ASEAN.

Source: Author.

Figure 2.5 shows cumulative gross benefit by periods.

Figure 2.5: Cumulative Gross Benefit by Periods

($ billion)



Lao PDR = Lao People's Democratic Republic.

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

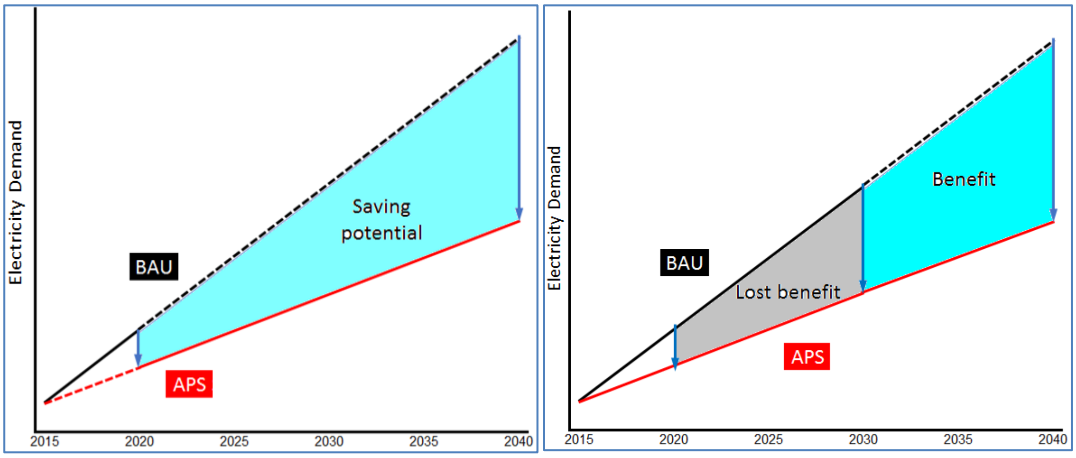
Source: Author.

Box 2.1 Relationship between Benefit and Investment

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

Figure 2.6: Investment and Benefit

Investment from 2020 Investment from 2030



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

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

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

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

Source: Author.

2.1.3. Required Investment in Electricity Saving Potential

Average Unit Cost of Electricity Saving

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

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

Required Investment Amount

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

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

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

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

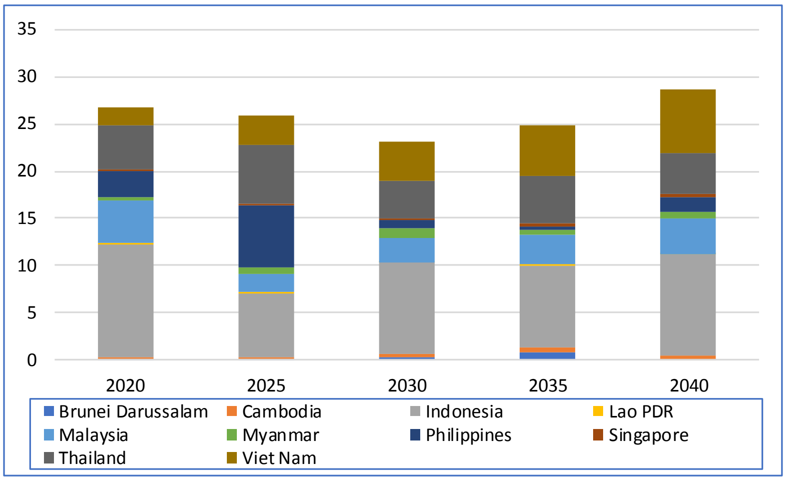
Country	Initial investment	Additional investment -1	Additional investment -2	Additional investment -3	Additional investment -4	**Total ($ billion)**
	2020	2025	2030	2035	2040	
Brunei Darussalam	0.2	0.1	0.3	0.8	0.0	**1.3**
Cambodia	0.1	0.2	0.3	0.5	0.5	**1.7**
Indonesia	11.9	6.8	9.7	8.7	10.7	**47.7**
Lao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

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

Figure 2.7 shows the required investment by investment timing.

Figure 2.7: Required Investment

($ billion)



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

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

Table 2.11: Net Benefit by Country

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

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

Source: Author.

2.2. Estimation of Indirect Benefits

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

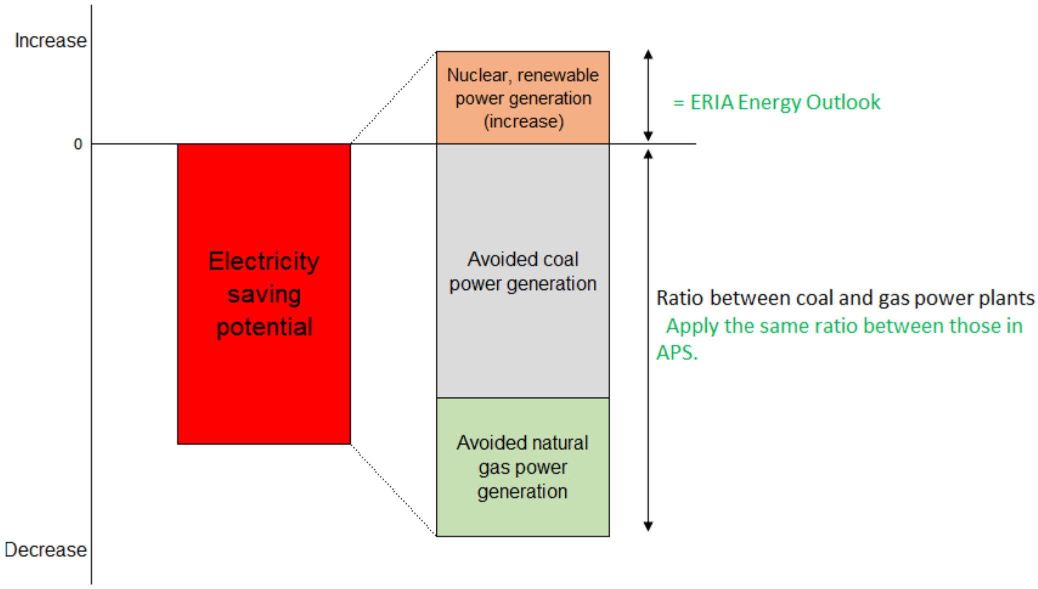
2.2.1. Avoided Investment in Power Generation Capacity

Method and Assumption

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

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

Figure 2.8: Image of Avoided Power Generation



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

Source: Author.

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

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

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

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

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

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

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

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

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

Estimation of Avoided Coal and Natural Gas Power Plant Costs

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

Table 2.13: Avoided Electricity Generation (2040)

(terawatt-hour)

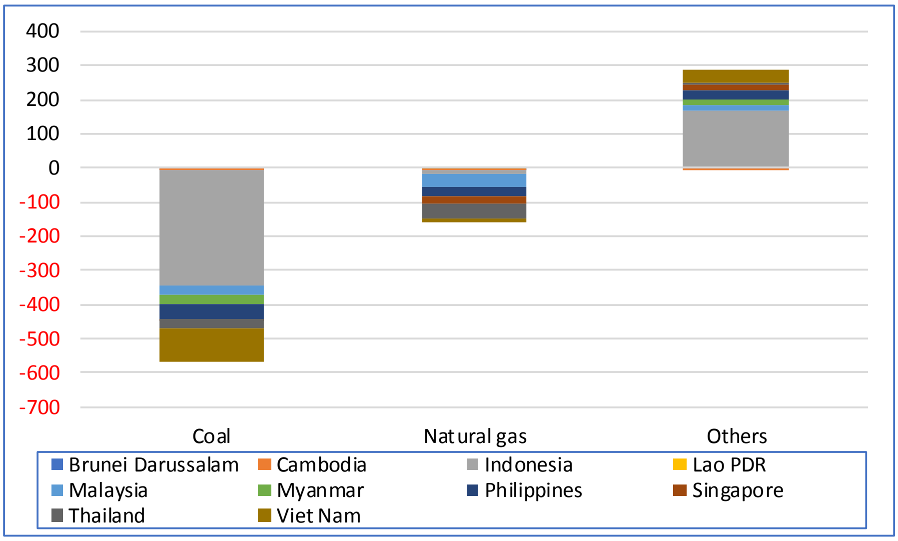
Country	APS–BAU					Avoided electricity generation
	Electricity saving potential	Electricity generation by fuel				
		Total	Coal	Natural gas	Others	
Brunei Darussalam	-4	-5	-3	-3	1	-5
Cambodia	-6	-12	-2	-6	-5	-1
Indonesia	-158	-176	-337	-9	170	-329
Lao PDR	-1	0	0	0	0	-1
Malaysia	-53	-56	-32	-39	15	-68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

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

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

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

(terawatt-hour)



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

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

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

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

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

Source: Author.

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

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

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

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

Note: Land cost is excluded.

Source: Author.

Estimation of Increasing Nuclear and Renewable Power Plant Cost

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

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

(terawatt-hour)

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

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

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

Source: Author.

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

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

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

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

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

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

($ billion)

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

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

Estimation of Net Avoided Power Plant Cost

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

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

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

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

Table 2.19: Net Electricity Generation Capacity Construction Cost, 2040

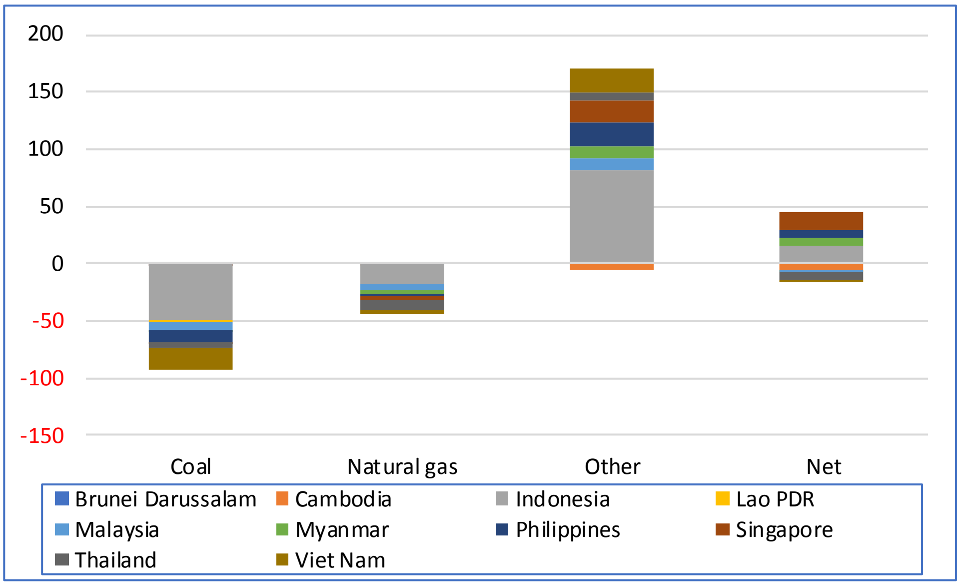
($ billion)

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

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

Figure 2.10: Net Generation Capacity Construction Cost

($ billion)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.2.2. Avoided Carbon Dioxide Emissions

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

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

(ii) Thermal efficiency[2]

Coal power plant: 43%

Natural gas power plant: 55%

(iii) Net calorific value of coal

0.6138 toe/tonne (IEA, 2018d)

(iv) Conversion factor for natural gas

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

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

(v) Carbon content (IEA, 2018a)

Coal: 3.961 tonnes of CO_2/toe-input

Natural gas: 2.349 tonnes of CO_2/toe-input

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

Table 2.20: Avoided Carbon Dioxide Emissions by Electricity Demand Decrease

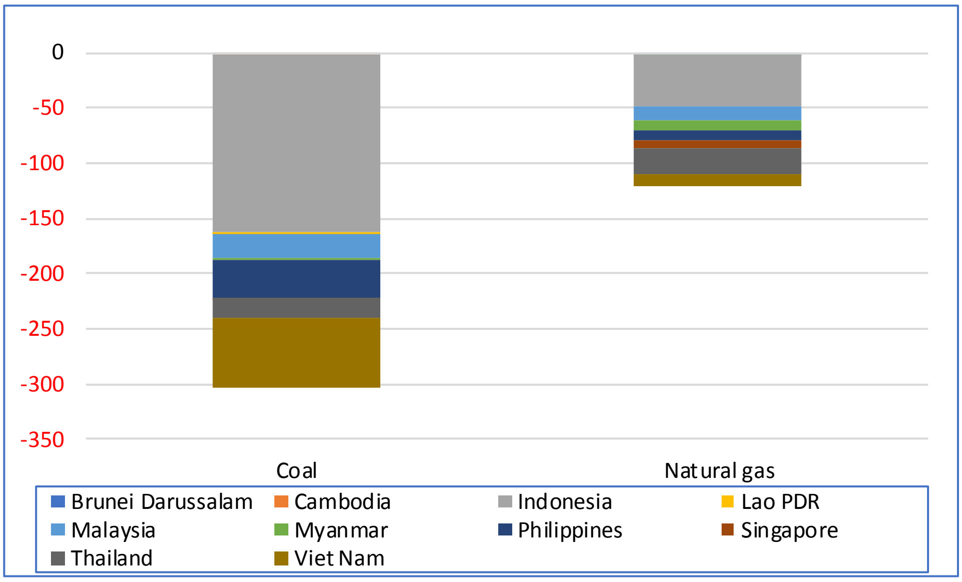
Country	Avoided electricity generation (terawatt-hour)		Avoided input energy (million tonnes of oil equivalent)		Avoided CO_2 emission (million tonnes)		
	Coal	Natural gas	Coal	Natural gas	Coal	Natural gas	Total
Brunei Darussalam	-0	-5	-0.1	-0.7	-0.3	-1.8	-2.0
Cambodia	-1	-0	-0.2	-0.0	-0.7	-0.0	-0.7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

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

Source: Author.

Figure 2.11: Avoided Carbon Dioxide Emissions

(million tonnes of carbon dioxide)



Lao PDR = Lao People's Democratic Republic.

Source: Author.

2.3. Evaluation of the Significance of the Benefits

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

2.3.1. Electricity Bill Savings

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

Internal Rate of Return of Electricity Saving Investment

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

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

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

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

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

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

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

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

Comparison of the Effect of Money for Other Purposes

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

Subsidy = (reference price - end-user price) × consumed amount (7)

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

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

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

($ billion)

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

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

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

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

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

Table 2.23: Tentative Calculation of Gasoline and Diesel Price Reductions

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

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

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

2.3.2. Net Electricity Generation Capacity Construction Cost

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

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

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

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

Source: Author.

2.3.3. Avoided Carbon Dioxide Emissions

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

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

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

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

Source: Author.

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

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

Table 2.26: Estimated Value of Avoided Carbon Dioxide Emissions

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

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

Source: Author.

Chapter 3

Policy Recommendations

This study surveyed the methods of financing energy efficiency and conservation (EE&C) investment and quantitatively analysed the economic efficiency of EE&C financing. This chapter will outline the policy implications based on this analysis.

3.1. How to Materialise Energy Efficiency and Conservation Potential

Chapter 2 indicated that a country can expect large benefits from EE&C investment. This raises the question of what is needed to enjoy these benefits fully. To this end, this study makes three policy recommendations, as follows:

(i) re-recognise the benefit of EE&C investment;
(ii) establish a special agency to strengthen policy implementation; and
(iii) maximise EE&C potential by
  (a) building up EE&C education and public relations, and
  (b) providing low-cost or free EE&C diagnoses.

3.1.1. Re-Recognise the Benefits of Energy Efficiency and Conservation Investment

According to the estimate in Chapter 2, the internal rate of rerun (IRR) of EE&C investment can be as high as 30%. Although the results may differ by country and/or project-specific conditions, this clearly indicates that EE&C investment is a profitable business in general. Recognition of the profitability of EE&C investment may not be as high as is recognition of the importance of EE&C. Re-recognition of the high profitability of EE&C investment is a necessary first step to materialise EE&C potential. In addition, the results of this estimation also indicated that earlier investment can give larger benefits. Thus, governments are urged to promote and eventually materialise EE&C investment as early as possible.

3.1.2. Establish a Special Agency to Strengthen Policy Implementation

When implementing EE&C policy into a market, professional knowledge, such as practical knowledge on available technologies and energy management, is required. The role of the policy execution body grows larger when a country is at an early stage of implementing EE&C, and private businesses or the general public lack sufficient knowledge of EE&C. At such times, it may be better to consolidate existing knowledge and know-how in a country to make EE&C implementation more efficient. One way to do this is to acquire and educate personnel within the government. Another way is to establish a specialised agency outside of the government. The advantages of such an agency include the following:

(i) An agency can enhance its expertise through specialised daily work experiences.
(ii) An agency can efficiently execute policies thanks to their accumulated expertise.
(iii) An agency can reduce government costs if it can leverage human resources and funds in the private sector.

3.1.3. Excavation of Energy Efficiency and Conservation Potential

Some examples of actions required to materialise EE&C potential include the following:

(i) Build up EE&C education and public relations

Although this is an unspectacular area that does not easily yield instant and visible results, countries must build up EE&C education and public relations, because no EE&C investment will be made if there is a lack of knowledge thereof. In the medium to long term, education in schools is the most important action. Countries should offer classes on energy and the environment, including EE&C, as part of compulsory education. As a first step, a country may be required to develop teaching guidelines on energy and the environment to help teachers who may not necessarily be well educated about it. A country can refer to the example of some developed countries that have already implemented such education.

In the short term, particularly for private businesses, raising awareness of energy costs and presenting the amounts of possible cost reductions can be an effective incentive. Private businesses would start taking EE&C actions autonomously when they recognise that energy saving equals cost saving.

For the general public, the organisation of a special event, such as a 'no-light night to enjoy the starry sky,' can be useful. People may be willing to join and enjoy the event, and eventually they can incidentally contribute to and raise awareness of energy saving. Countries can raise public awareness though this and other ways. In any case, a long-term approach is necessary as it takes time to see the results of education.

(ii) Provide low-cost or free EE&C diagnoses

Countries can incentivise EE&C investment, particularly amongst private businesses, by showing the potential of energy saving and corresponding cost savings. However, businesses may be deterred from ordering a diagnosis of their factories by the expense of hiring an expert. Thus, the provision of low-cost or free diagnosis services may help businesses understand their opportunities to reduce costs and thus encourage them to invest in EE&C. If such services are provided to energy-consuming industries and buildings, country could tap a large EE&C potential.

If a government wants to reduce the cost of diagnosis as much as possible, they could make the initial diagnosis free of charge, with repayment tendered after the materialisation of an EE&C investment as a result of the diagnosis.

3.2. Seeking a Better Way to Finance Energy Efficiency and Conservation

Even if a country applies the various actions identified in section 3.1, the fulfillment of EE&C investment still faces bottlenecks. One of the most critical of these is financing. No one can invest without funds, regardless of the expected profitability. This kind of obstacle becomes more evident in small and medium-sized enterprises. Therefore, financial support can play an important role in promoting EE&C investment.

It is next necessary to determine which of the possible financing instruments is more effective or preferable. To this end, this study proposes the following four recommendations:

(i) choose a method with a small impact on a government's financial burden,
(ii) remove any energy price subsidies to improve the EE&C investment climate,
(iii) set aside a government budget through a special purpose tax, and
(iv) build up financing capability.

3.2.1. Choose a Method with a Small Impact on the Government's Financial Burden

There are multiple financing method options as indicated in section 1.2. Amongst those, tax and non-tax incentives will not be repaid, and thus consume the national budget. These methods are less financially sustainable as they contain the risk of harming the national budget or restricting financial support due to future budgetary constraints. In addition, they are high-cost methods from the government's point of view. On the other hand, lending programmes and performance contracts are sustainable methods that are repayable, and thus do not consume the government's budget. Thus, a comparison of the available methods makes it clear which are more preferable.

Of the other elements that should be considered when choosing a financing method, one basis for selection is financial sustainability. For instance, it may be difficult to adopt a loan programme when the technology being used is advanced and its effect is being tested. Adoption of a lending programme can also be difficult when energy prices are low, as this makes the investment's payback period very long. In the case of a high-risk investment, the provision of a grant or subsidy is more appropriate, as this allows the government to take the risk on the company's behalf.

3.2.2. Remove the Energy Price Subsidy to Improve the Energy Efficiency and Conservation Investment Climate

The price of energy is a critical component of a sustainable financing method such as a lending programme or performance contract. This is because under these methods, the reduction in energy bills achieved as a result of improved efficiency is the source of the funds used for repayment. The financial feasibility of EE&C investment is higher in countries where the price of energy (i.e. the expected profit from EE&C investment) is high. In this sense, countries are encouraged to remove energy price subsidies, which pose an obstacle to EE&C investment, as soon as possible.

The profitability of EE&C investment in countries where the price of energy is (artificially) low is likewise naturally low; hence, such countries have no choice but to implement tax or non-tax incentives. This means that if a country provides an energy price subsidy, they must also bear the outflow of government money to support EE&C investment. Such a double burden is clearly unsustainable for a country.

3.2.3. Set Aside a Government Budget through a Special Purpose Tax

Governments must set aside a budget to adopt tax or non-tax incentives. One way to secure such a budget is to implement a special purpose tax. When designing such a tax, taxpayers (the sources of a fund) and beneficiaries (the recipients of a fund) should be consistent. For instance, if a special purpose tax on the electricity charges of industrial consumers is used to build a fund, tax incentives financed by this fund should be given to the industry in question. This will help minimise any feelings of unfairness on the part of the taxpayers. This can also become an incentive for EE&C investment because those who invest can gain larger benefits than those who are taxed.

Meanwhile, the operation of funds can sometimes become problematic if the funds are used for any other purpose than that initially intended. As this may lead a loss of taxpayer trust, and social problems in the future, the government must maintain tight control of the funds.

3.2.4. Build up Financing Capability

Building up the capability of bank institutions is another important measure to promote EE&C investment.

Energy Efficiency and Conservation Education for Bank Institutions

The barriers to EE&C finance include a lack of knowledge on the part of bank institutions. Since banks cannot evaluate and thereby finance an EE&C project without appropriate knowledge, education for bank institutions, ranging from the importance of EE&C to major technology and its effects, is suggested to improve their financing capability.

Develop Energy Efficiency and Conservation Financing Guidelines for Bank Institutions

Education for bank institutions must cover the methods of evaluating EE&C projects. EE&C investment sometimes cannot provide traditional collateral (e.g. fixed assets). In this case, a bank is able to request holding knowledge to evaluate the project’s profitability and risk, as in the case of project finance. The only way to achieve such capability is through the accumulation of experience, which takes time. Developing a guideline for EE&C financing is just one of several ways that a government can provide support. Countries can also refer to and cooperate with bank institutions in developed countries that have more experience in this field.

3.3. Conclusion

ASEAN is diverse and the state of EE&C policy implementation differs significantly from country to country. Thus, the region is expected to raise the overall level of such policy implementation though either multilateral or bilateral cooperation. Multilateral cooperation would enable the region to share best practices of financing in each country, while bilateral cooperation would enable receiving countries to ask providing countries for specific types of support, including that relating to the financing of policy design and facility diagnoses.

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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		BAU					APS				
	2015	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 ($0.01/kWh)	Reduced electricity bill ($ million)				
	2020–2024	2025–2029	2030–2034	2035–2039	2040		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)

	Initial investment	**Additional investment-1**
Country	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)

	Initial investment	Additional investment-1	Additional investment-2	**Additional investment-3**
Country	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 (TWh)	Electricity generation (TWh)		
	Biomass	Solar	wind	Biomass	Solar	wind		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.

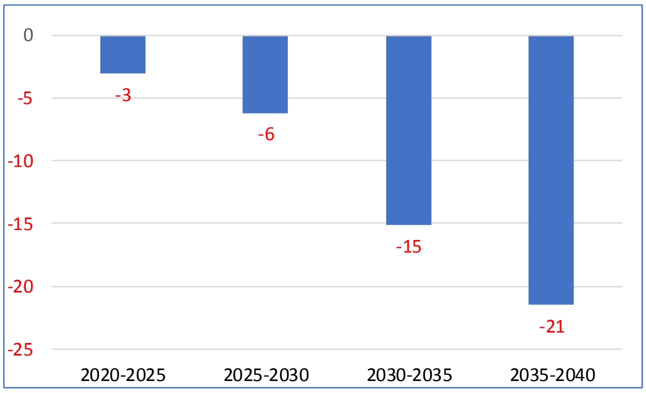
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

(terawatt-hour)



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

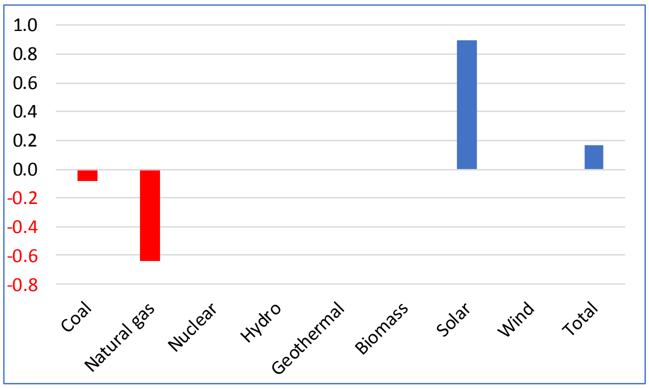
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.
Source: Author.

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

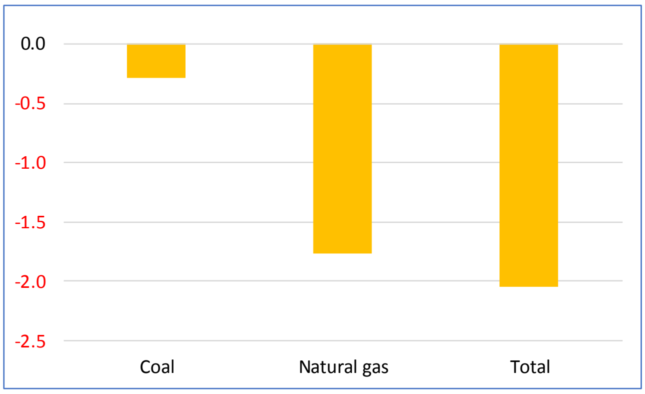
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

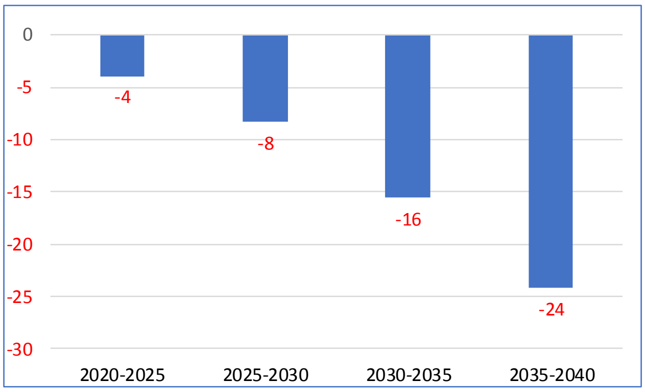
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

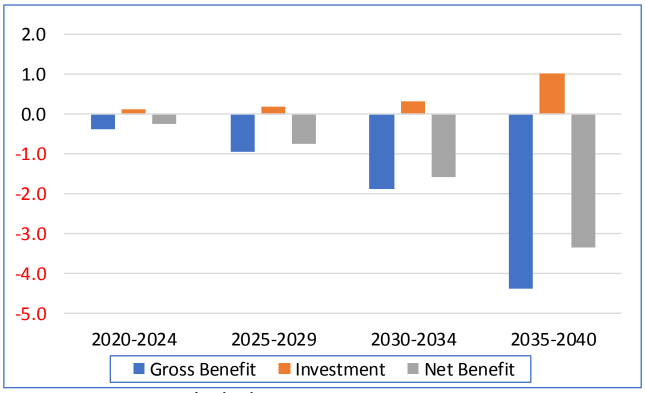
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(Annual)
-0.2	-0.8	-1.6	-2.9	-0.5	-5.9	-0.3
IRR						57%
Electricity price (2017, $0.01/kWh)						17.1

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

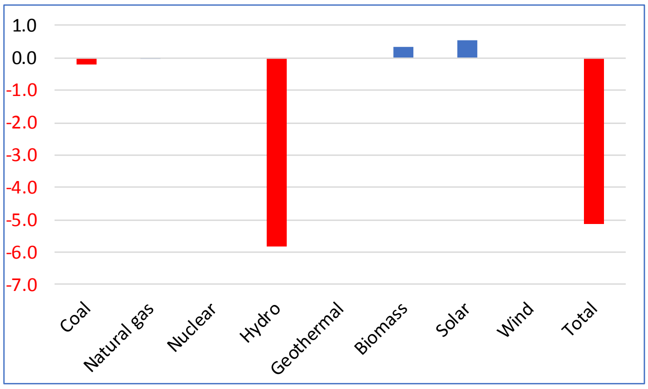
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

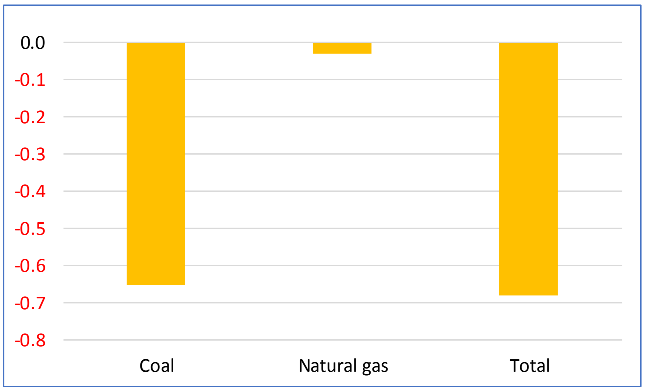
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

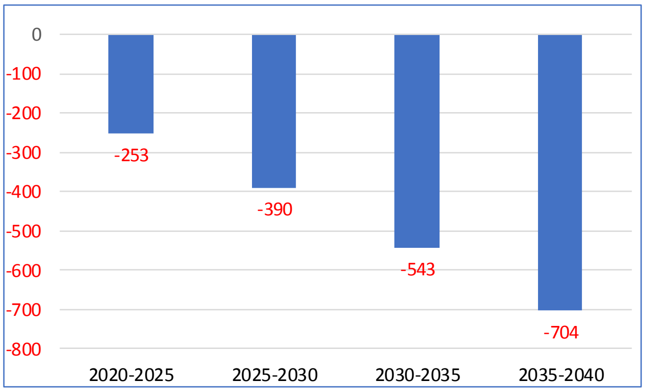
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

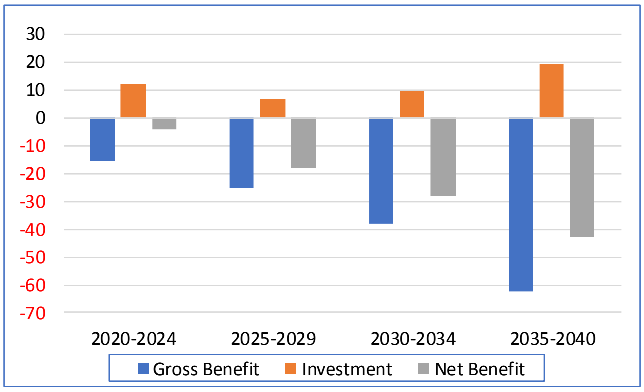
kWh = kilowatt-hour, IRR = internal rate of return.

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

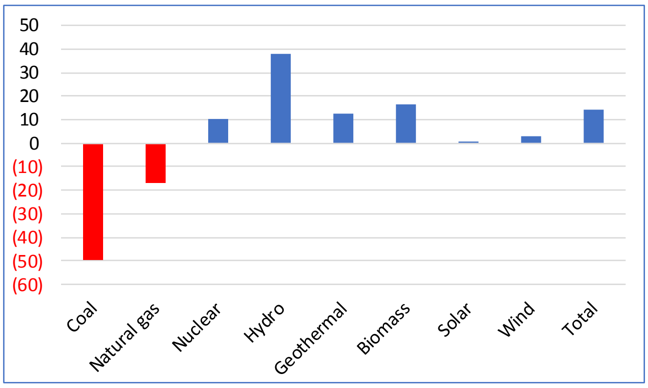
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

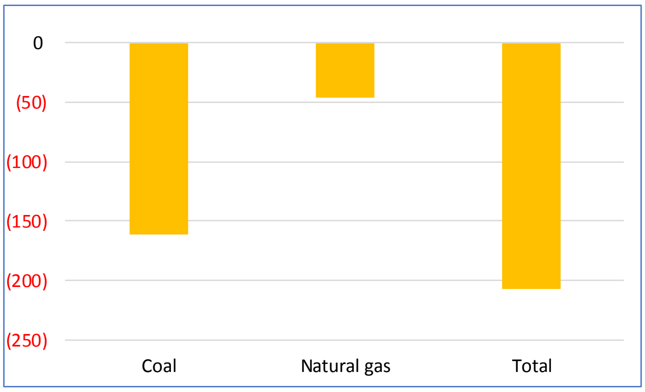
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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											

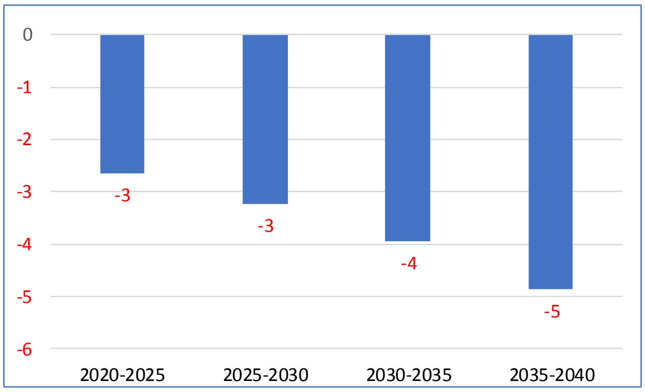
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower.
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

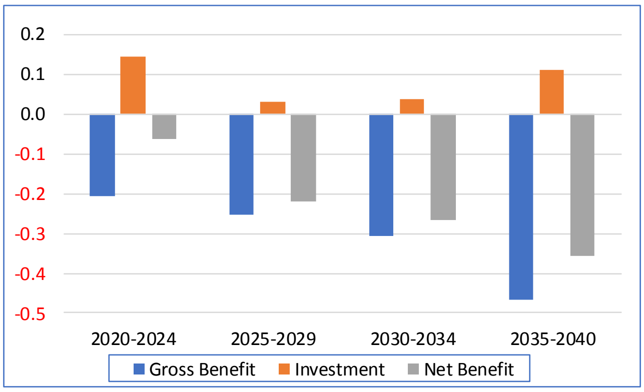
IRR = internal rate of return.

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

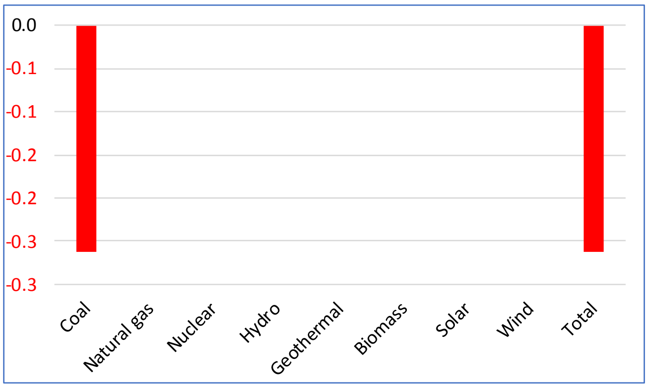
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

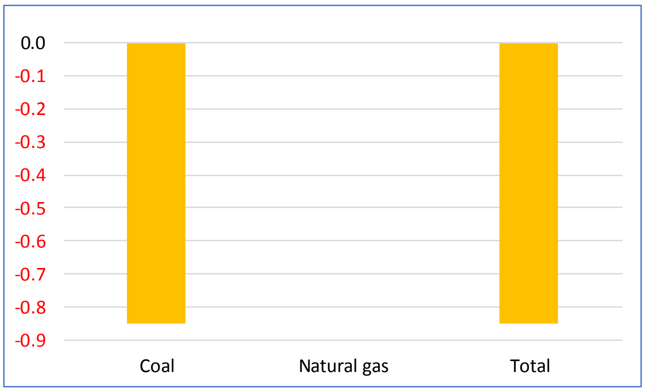
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

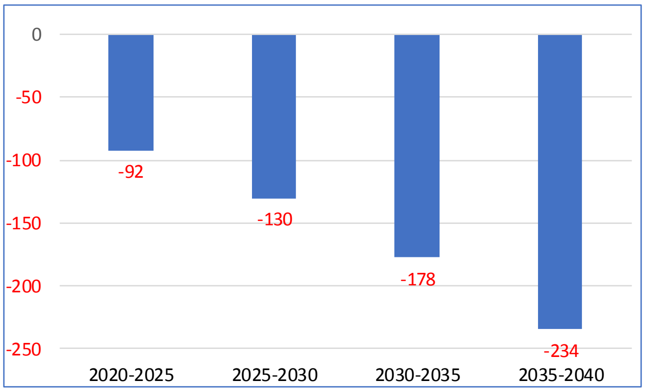
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

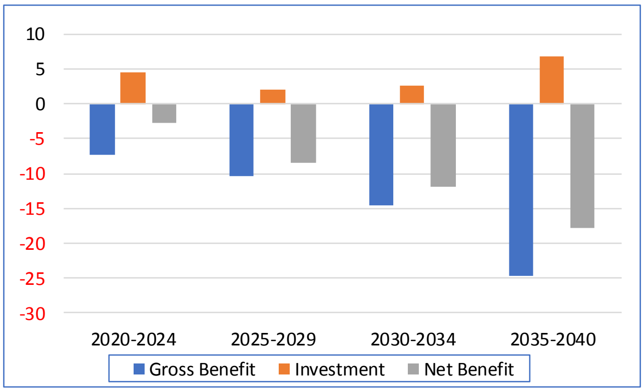
IRR = internal rate of return.

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

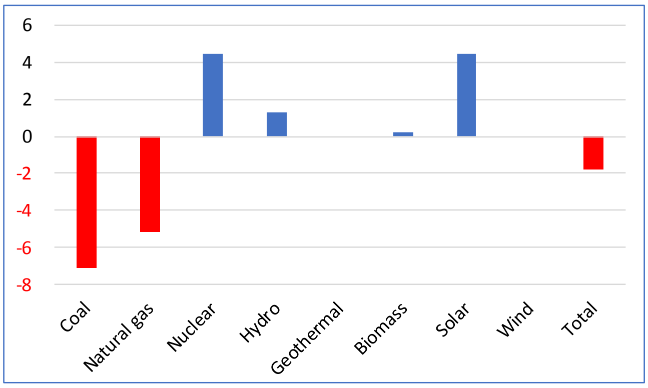
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

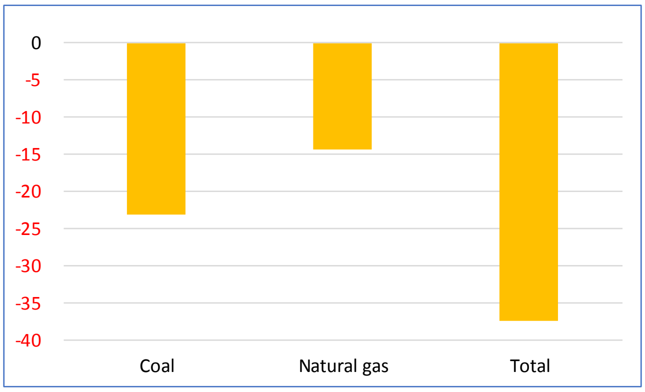
Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-29.1	43%	-5.8	-23.1
Natural gas	-38.9	55%	-6.1	-14.3
Total	-68.1	-	-11.9	-37.4

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

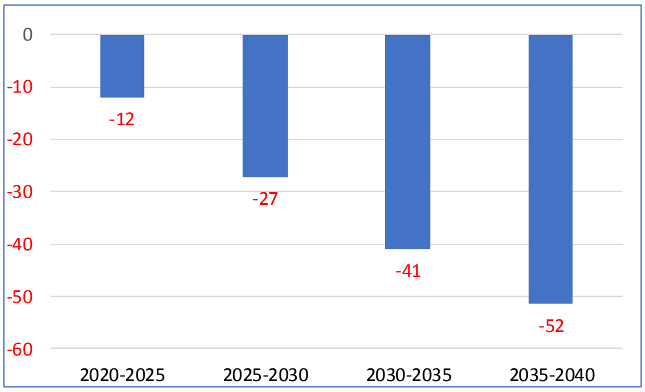
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

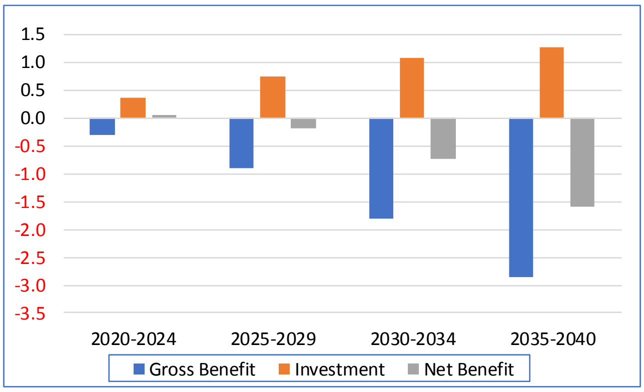
IRR = internal rate of return.

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

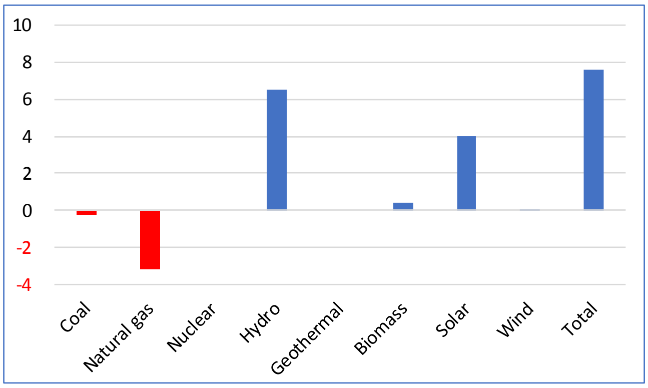
Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-0.9	75.0	-136	1,600	-0.2
Natural gas	-23.9	60.0	-4,540	700	-3.2
(Sub-total)	(-24.8)		(-4,677)		(-3.4)
Nuclear	-	70.0	-	3,298	-
Hydro	7.5	33.0	2,605	2,500	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

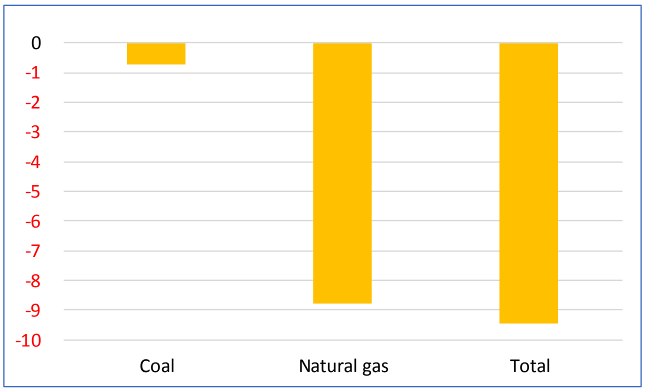
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

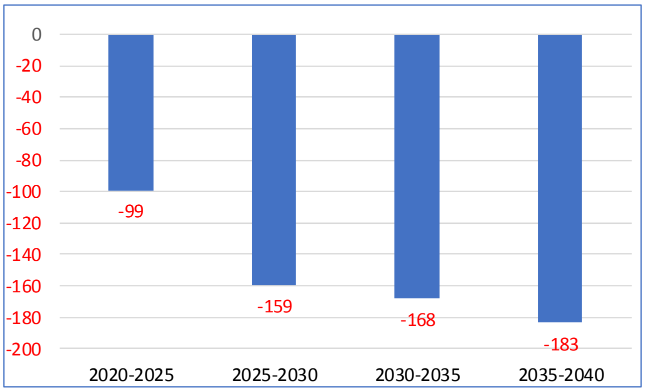
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

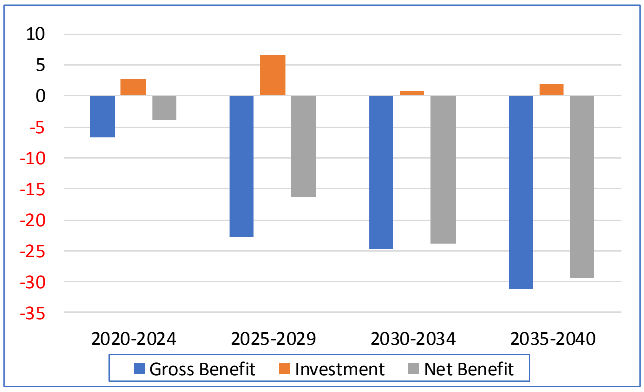
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-4.0	-16.3	-23.9	-25.1	-4.3	-73.5	-3.5
IRR						49%
Electricity price (2016, $0.01 per kilowatt-hour)						14.9

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

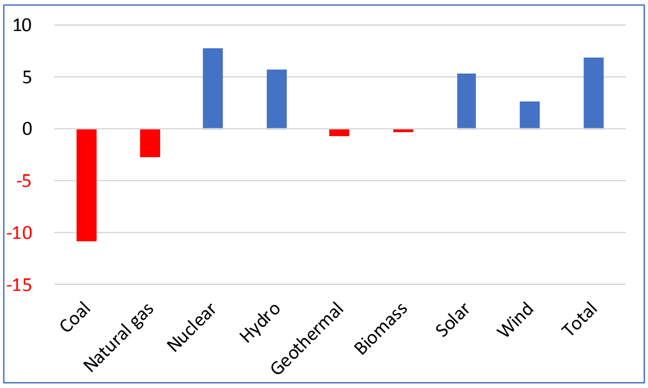
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

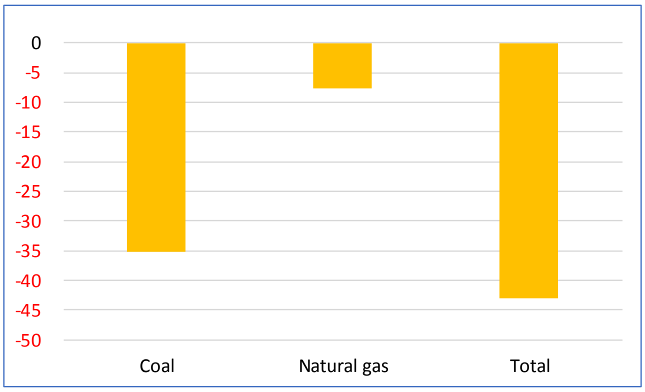
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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.

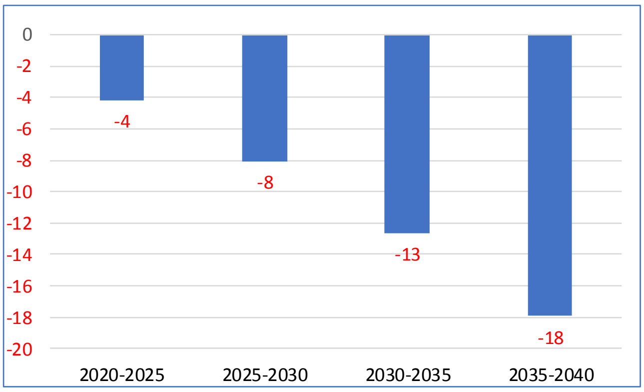
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

(terawatt-hour)



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

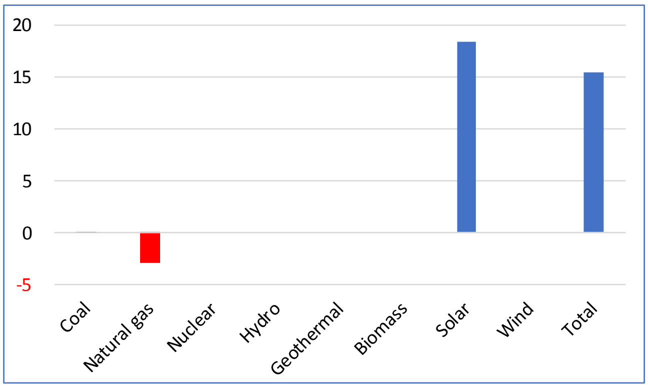
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, kW = kilowatt, MW = megawatt, TWh = terawatt-hour.

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

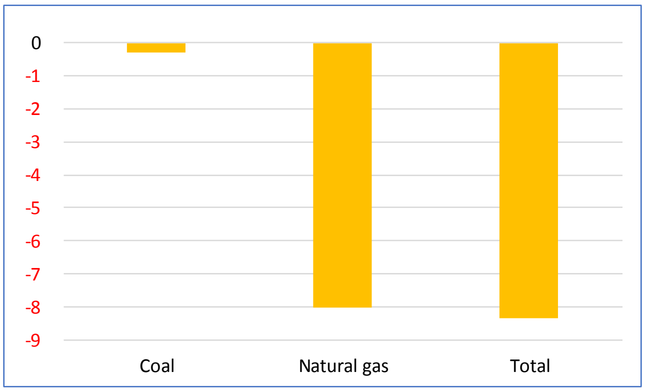
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU					APS				
		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.

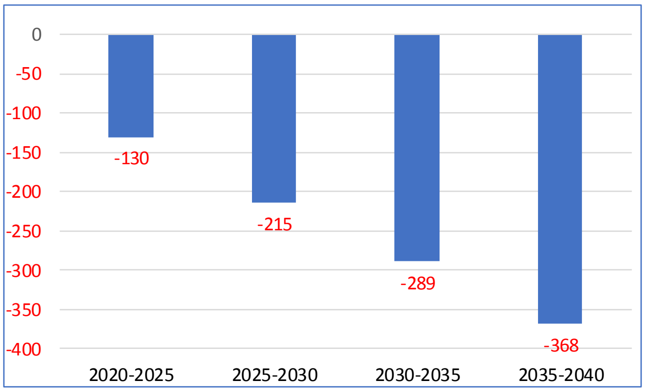
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

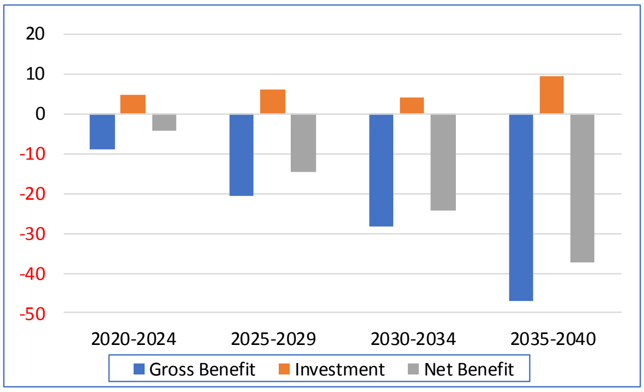
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-4.2	-14.5	-24.2	-32.7	-4.8	-80.5	-3.8
IRR						49%
Electricity price (2018, $0.01 per kilowatt-hour)						11.4

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.

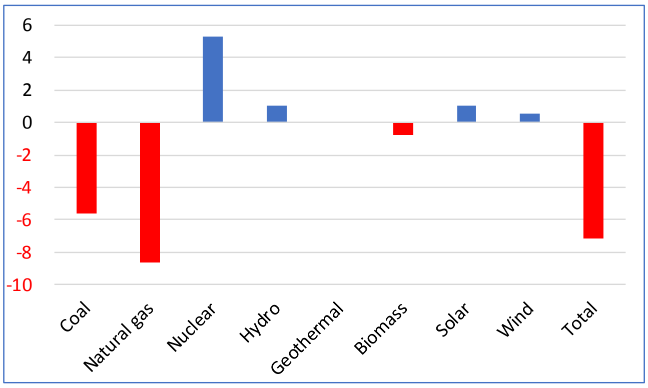
Source: Author.

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

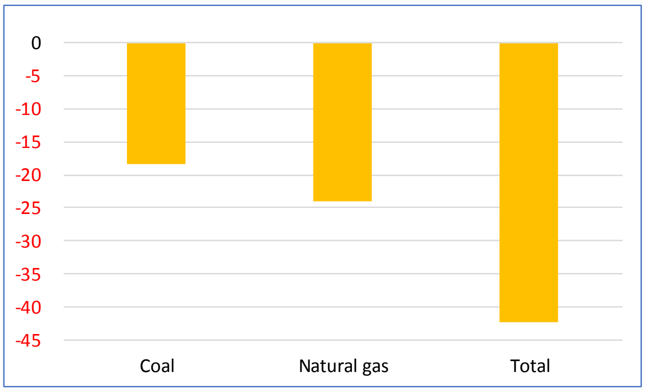
CO_2 = carbon dioxide, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

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)

Fuel	2015	BAU 2020	BAU 2025	BAU 2030	BAU 2035	BAU 2040	APS 2020	APS 2025	APS 2030	APS 2035	APS 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.

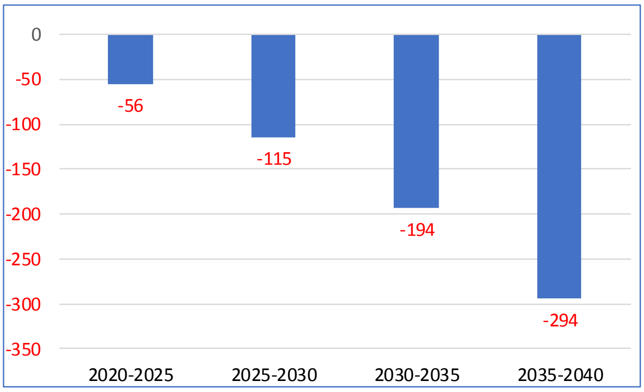
Source: Kimura, S. and H. Phoumin (eds.) (2019), *Energy Outlook and Energy Saving Potential in East Asia 2019*. Jakarta: Economic Research Institute for ASEAN and East Asia.

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

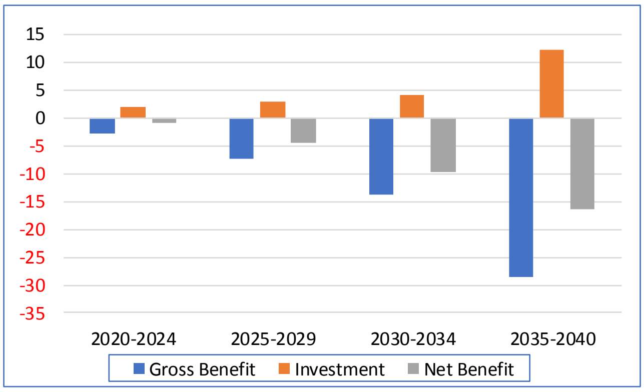
2020–2024	2025–2029	2030–2034	2035–2039	2040	Total	(annual)
-1.0	-4.4	-9.7	-16.7	0.3	-31.5	-1.5
IRR						37%
Electricity price (2017, $0.01 per kilowatt-hour)						9.3

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

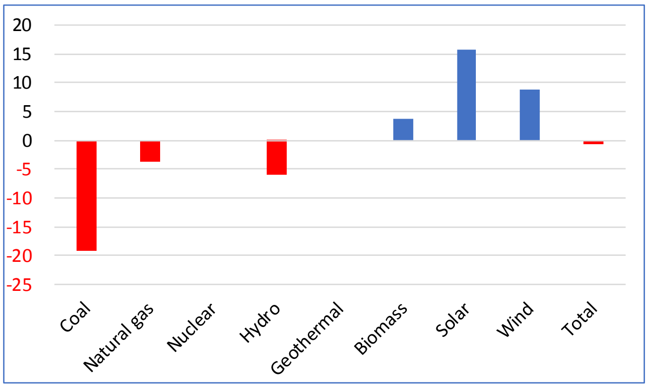
Fuel	Avoided generation (2040 APS–BAU)	Avoided capacity		Avoided construction cost	
	(TWh)	Capacity factor (%)	(MW)	Unit cost ($/kw)	($ billion)
Coal	-78.9	75.0	-12,003	1,600	-19.2
Natural gas	-26.5	60.0	-5,050	700	-3.5
(Sub-total)	(-105.4)		(-17,053)		(-22.7)
Nuclear	-	70.0	-	3,298	-
Hydro	-7.0	33.0	-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)

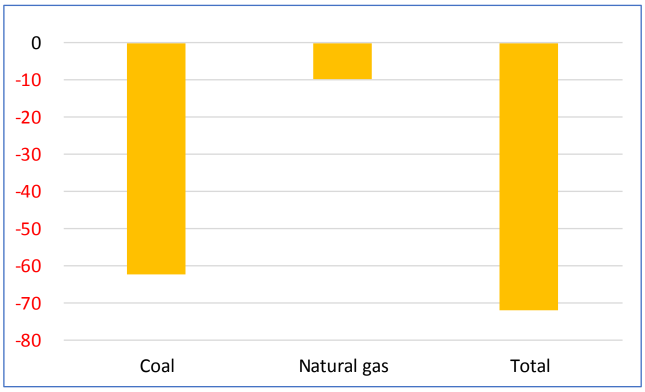
Fuel	Avoided generation (TWh)	Avoided energy input		Avoided CO2 Emission (million tonnes-CO_2)
		Thermal efficiency	(Mtoe)	
Coal	-78.9	43%	-15.8	-62.5
Natural gas	-26.5	55%	-4.2	-9.8
Total	-105.4	-	-19.9	-72.2

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.