Cambodia Basic Energy Plan

Prepared by
The General Department of Energy with input from the General Department of Petroleum, Ministry of Mines and Energy of Cambodia

Supported by
The Economic Research Institute for ASEAN and East Asia

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The Cambodia Basic Energy Plan was prepared by the General Department of Energy (GDE) with input from the General Department of Petroleum (GDP) of the Ministry of Mines and Energy and technical support from the Economic Research Institute for ASEAN and East Asia (ERIA). The data and information expressed herein help to facilitate the Ministry's energy planning processes and policy formulation. However, the views and judgements expressed in this plan are of technical experts.

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FOREWORD

Cambodia has experienced high economic growth over the past 5 years and, according to the economic experts, this trend will continue at least to 2020 and beyond. In this regard, Cambodia's energy consumption could increase significantly. Following the publication of *Cambodia National Energy Statistics 2016* with technical support from the Economic Research Institute for ASEAN and East Asia (ERIA), the Ministry of Mines and Energy (MEE) has benefitted greatly from the energy data and statistics as a foundation for its energy policy planning and policies. However, the MEE needs further support from ERIA to formulate policy targets with regard to energy use in all sectors and to improve energy security in the country. Thus, the Ministry identifies the urgent need for the Cambodia Basic Energy Plan as it will lay out targets and policy recommendations on oil and petroleum production and consumption, electricity demand, renewable energy, energy efficiency, energy security, and predicted future energy demand and supply. To achieve energy policy targets in the medium term as well as understand the policy implications for energy security in the long term, there is a need for concrete programmes and action plans for energy use and supply. Thus, the MME needs an appropriate and comprehensive basic energy plan to achieve its energy policy targets and planning.

The Cambodia Basic Energy Plan aims to set numerical targets for each energy issue covered by the plan, and the targets should be achievable. The basic objective of the plan is to seek an energy supply for Cambodia with the following conditions: affordability, accessibility, security (sustainable security), safety, and transparency in the energy market.

The Ministry made a request to ERIA to support the MME in setting up the basic energy plan. In response, ERIA kindly accepted the offer and in March 2018, formed a project team consisting of international experts to work in collaboration with staff from the General Department of Energy and General Department of Petroleum. During the project period, ERIA also conducted capacity-building training, such as on building a basic understanding of energy data and statistics.

Lastly, the MME would like to express its appreciation to ERIA for its technical and financial support for publishing the Cambodia Basic Energy Plan.

Suy Sem
Minister of Mines and Energy, Cambodia
March 2019

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The Cambodia Basic Energy Plan was developed by a working group consisting of the Cambodian team and the Economic Research Institute for ASEAN and East Asia (ERIA) team. The Cambodian team consists of staff from the General Department of Energy (GDE) and the General Department of Petroleum (GDP) of the Ministry of Mines and Energy (MME). The ERIA team consists of experts on oil, electricity, renewable energy, energy efficiency and conservation, energy security, and energy outlook modelling. We would like to acknowledge the members of the working group for their excellent work. We would also like to especially take this opportunity to express our gratitude to the staff of the GDE, GDP, and Electricité Du Cambodge (EDC) for their cooperation on this project through their data and knowledge inputs.

Special acknowledgement is also given to Mr Shigeru Kimura, Special Adviser on Energy Affairs to the President of ERIA, for his excellent leadership of this project.

Victor Jona
Director General
General Department of Energy
Ministry of Mines and Energy
Cambodia

Cheap Sour
Director General
General Department of Petroleum
Ministry of Mines and Energy
Cambodia

March 2019

PROJECT MEMBERS

Ministry of Mines and Energy

HE Mr Victor Jona	Director General, General Department of Energy, Ministry of Mines and Energy, Cambodia
HE Mr Cheap Sour	Director General, General Department of Petroleum, Ministry of Mines and Energy, Cambodia
Mr Heng Kunleang	Deputy Director General, Ministry of Mines and Energy, Cambodia
Mr Chea Socheat	Deputy Director General, General Department of Petroleum, Ministry of Mines and Energy, Cambodia
Mr Tan Sokun	Director of Department of Energy Development, Ministry of Mines and Energy, Cambodia
Mr Kin Sothea	Deputy Director of Department of Energy Development, Ministry of Mines and Energy, Cambodia
Mr Chhim Bora	Deputy Director of Department of Petroleum Technology, Operation Supporting and Energy Security
Mr Sok Chandareth	Chief of Statistics Office, Ministry of Mines and Energy, Cambodia
Mr Heang Theangseng	Officer of Energy Planning Office, Department of Energy Development
Mr Chea Channara	Director of Department of Petroleum Technology, Operation Supporting and Energy Security

Economic Research Institute for ASEAN and East Asia (ERIA)

Mr Shigeru Kimura	Special Advisor to the President for Energy Affairs, Energy Unit, Research Department, ERIA
Dr Han Phoumin	Energy Economist, Energy Unit, Research Department, ERIA
Mr Junichi Wada	Senior Policy Advisor, Energy Unit, Research Department, ERIA
Mr Takahisa Hiruma	Executive Vice President and Director, Asiam Research Institute, Inc.
Ms Cecilya Malik	ASEAN Energy Policy Planning Expert, Indonesia
Ir Leong Siew Meng	Managing Consultant, Green Tech Solutions, Malaysia.
Ms Maritje Hutapea	Renewable Energy Expert, Indonesia

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AFD	Agence Française de Développement
AGTP	APG generation and transmission system planning
APG	ASEAN Power Grid
APS	alternative policy scenario
ATSO	APG transmission system operator
BAU	business as usual
BEPC	Basic Energy Plan for Cambodia
BOT	build, operate, and transfer
BT	build and transfer
CCS	carbon capture and storage
CNG	compressed natural gas
CNMC	Cambodian National Mekong Committee
CO_2	carbon dioxide
EAS	East Asia Summit
EB	electric bike
EDC	Electricité Du Cambodge
EE	energy efficiency
EEC	energy efficiency and conservation
EEF	energy efficiency framework
EPR	emergency preparedness and response
ESCO	energy services company
EV	electric vehicle
FIT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
GMS	Greater Mekong Subregion
HFO	heavy fuel oil
HV	high voltage
IEA	International Energy Agency

IGCC	integrated gasification combined cycle
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPP	independent power producer
JICA	Japan International Cooperation Agency
kl	kilolitre
ktoe	kilotonnes of oil equivalent
kv	kilovolt
kWh	kilowatt hour
LCOE	levelised cost of electricity
LPG	liquefied petroleum gas
LV	low voltage
MEPS	minimum energy performance standards
MME	Ministry of Mines and Energy of Cambodia
Mtoe	million tonnes of oil equivalent
MV	megavolt
MW	megawatt
NESO	National Emergency Supply Organization
NLS	New Lao Stove
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
PDP	Power Development Plan
PV	photovoltaic
RE	renewable energy
REE	rural electricity enterprise
REF	Rural Electrification Fund
RPS	Renewable Portfolio Standards
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
TFEC	total final energy consumption
TFES	total final energy supply
TOU	time of use
TPES	total primary energy supply
TWh	terawatt hours
USC	ultra-supercritical

EXECUTIVE SUMMARY

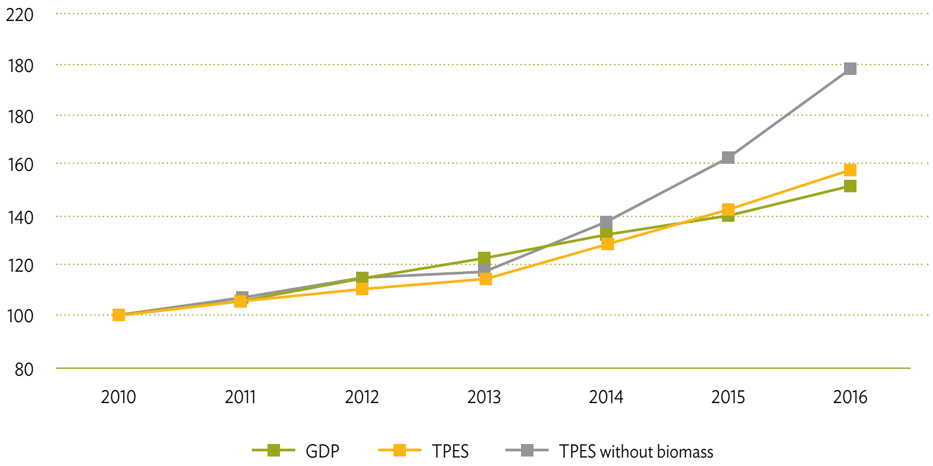
Background

During 2010–2016, the total primary energy supply (TPES) saw an increase similar to that of gross domestic product (GDP) in Cambodia, but the TPES without biomass increased by 2.0 times and was much higher than GDP (1.5 times) in the same period (Figure 1). Curbing coal, oil, and electricity demand to the GDP level is crucial (Figure 2). Cambodia has increased its imports of coal and petroleum from other ASEAN countries such as Indonesia and Singapore and this has affected Cambodian economic growth due to the following defined formula of GDP:

GDP = C + I + J + E – M
C: Private consumption + government consumption
I: Private capital formation + government capital formation
J: Stock change
E: Export
M: Import

Consequently, the Ministry of Mines and Energy (MME) needs an appropriate and comprehensive basic energy plan, and the Economic Research Institute for ASEAN and East Asia (ERIA) is supporting the MME to set up this plan. The basic energy plan should contribute two points: (a) saving conventional energy consumption, such as oil and electricity; and (b) utilising domestic energy, such as hydropower and biomass.

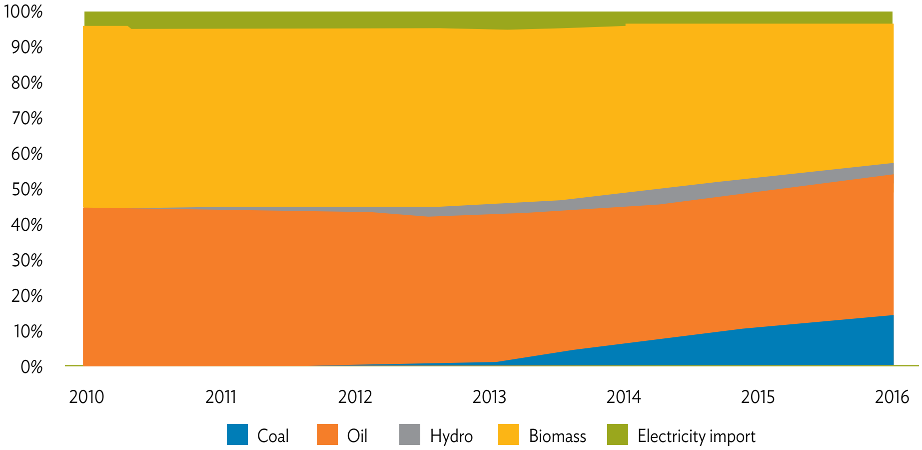
Figure 1. Historical Trend of GDP and TPES
(2010=100)



GDP = gross domestic product, TPES = total primary energy supply.

Source: Ministry of Mines and Energy, 2018.

Figure 2. Primary Energy Consumption Share by Fuel



Source: Ministry of Mines and Energy, 2018.

Objective

ERIA and the MME will prepare a Basic Energy Plan for Cambodia (BEPC) that is appropriate, comprehensive, feasible, and effective. In addition, the basic plan should have numerical targets for each energy issue covered by the plan, and the targets should be achievable.

Basic principle

The basic principle of the plan aims for an energy supply for Cambodia with the following conditions:

- Affordability
- Accessibility
- Security (sustainable security)
- Safety
- Transparency of the market

The catchphrase of the plan is 2A2S+T. In other words, the Cambodian energy policies described in the BEPC would contribute to an energy supply in the Cambodian market with affordability, accessibility, security, and safety + transparency. The target year of the plan is 2030, and the plan applies a rolling-plan method that will be reviewed every five years.

Energy issues covered by the BEPC

Recognising the current energy issues in Cambodia, the basic plan covers the following six energy fields: (i) oil, (ii) electricity supply, (iii) renewable energy, (iv) energy efficiency, (v) energy security, and (vi) the energy outlook brought by the BEPC.

Methodology

Each energy field applies a common approach:

(1) Extract the current issues.
(2) Set the appropriate targets for solving the issues.
(3) List the necessary action plans, polices, and roadmaps for achieving the targets.

Oil supply

In Cambodia, gasoline, diesel oil, and liquefied petroleum gas (LPG) demand has been increasing rapidly, and the demand has depended on imports. Also, according to Cambodia's energy outlook, which is a part of the East Asia Summit (EAS) energy outlook prepared by ERIA, these petroleum products will increase their demand continuously up to 2040. In this regard, the following countermeasures are recommended:

(1) The major use of gasoline and diesel oil as well as LPG is transportation (vehicle), so that Cambodia can shift to highly efficient vehicles under the appropriate regulations (reduction by **10%** from the business-as-usual [BAU] scenario).

(2) Petroleum products are convenient and useful, and they are used across the industry, transport, residential, and commercial sectors. If a petroleum supply disruption occurs, Cambodia will face serious damage on both the economic and social aspects. Therefore, appropriate stockpiling volumes, including commercial stocks, will be needed (at least **30 days** until 2030).

(3) Biofuel, especially bioethanol, is one of the options for reducing imports of gasoline. In addition, biofuel affects the economic growth of Cambodia, such as through agriculture and industry activities and reductions in CO_2 emissions. The General Department of Petroleum is seeking business opportunities for biofuel (**E3 gasoline** will be possible by 2025).

(4) The BEPC also states that the petroleum supply chain will be resilient through business activities under the appropriate petroleum policies and regulations.

Electricity supply

Electricity demand increased significantly by 18% per year during 2010–2016, and, in parallel, power generation increased by 19% per year in the same period. Previously, Cambodia fully depended on oil power generation and imports from neighbouring countries, but since coal and hydropower generation has increased rapidly, imports of electricity have largely decreased compared to 2010. The Cambodia energy outlook also reports that its electricity demand will increase by 7.5 times from 2015 to 2040. Based on this situation, the BEPC recommends the following countermeasures:

(1) The power generation mix in 2030 will be **coal (35%), hydro (55%), and renewable energy (10%)**, consisting of biomass and solar/photovoltaics (PV). This mix will maintain affordability and security.

(2) Resilience of the transmission and distribution networks will bring improvement of transmission and distribution losses (13% in 2016 to **8%** in 2030), decrease the System Average Interruption Duration Index and System Average Interruption

Frequency Index to less than **620** minutes and **7.3** times, respectively, and increase the household electrification ratio from the current 70% to **95%** in 2030 through connecting to the national grid. This will contribute to accessibility, security, and safety.

(3) Reforms of electricity tariffs, such as time-of-use and cross-subsidy systems, have to contribute to the levelisation of electricity demand and elimination of the price gap between urban and rural areas and maintain affordability and transparency.

Renewable energy

Renewable energy consists of hydro, biomass, and solar/PV in Cambodia. Wind is very hard to install due to insufficient wind conditions in Cambodia. Hydro will increase continuously as a major power source based on its affordability and security. Biomass and solar/PV are treated here.

(1) Traditional biomass will be phased out and replaced by LPG for its use for cooking in rural areas. However, highly efficient biomass cooking stoves are recommended. A biomass supply chain might be established to supply fabricated biomass such as wood chips to final users in rural areas.

(2) Another biomass use will be power generation to be applied in isolated areas (with no national grid). Its target will be 6.5% of total power generation in 2030.

(3) There are several policies to promote solar/PV systems, such as feed-in tariffs, Renewable Portfolio Standards, and net metering. However, the BEPC recommends not to apply these policies for the penetration of solar/PV. The MME will open the power generation market to local and foreign entities such as the Asian Development Bank and private companies to install solar/PV in Cambodia for supplying electricity to subscribers. Its target will be 3.5% in 2030.

Energy efficiency

Energy efficiency is crucial for Cambodia because the TPES without biomass has increased much more than GDP growth, as mentioned before. On the other hand, energy prices in Cambodia, such as for electricity and LPG, are fully marketed (no subsidies) and this brings incentives for energy consumers, such as saving energy costs through applying energy efficiency and conservation (EEC) activities. Thus, the necessary EEC policies, action plans, and targets of the industry, commercial, and residential sectors are specified here, especially for saving electricity consumption. The BEPC recommends the following:

(1) Apply the same energy saving target, a 10% reduction from the BAU, across sectors until 2030.
(2) Apply a standards and labelling system to appliances used by households. An inspection laboratory will need to be set up in Cambodia.
(3) The MME has to grow local energy managers and invite energy service companies, both local and foreign companies, for engaging in engineering EEC activities in the industry (factories) and commercial (buildings) sectors. In this regard, an association of energy managers or energy service companies, such as the Cambodia Chapter of the American Society of Heating, Refrigerating and Air-conditioning Engineers, will be established.
(4) Education and campaigns on EEC are important and will contribute to making Cambodian people aware of EEC.
(5) When EEC becomes popular in Cambodia, the MME will have to set up an EEC regulation under the electricity law. The regulation will support the EEC action plans mentioned above.

Energy security

There are many energy security issues, such as the diversity of energy supply sources outside Cambodia, the increase of domestic energy such as hydro and biomass, emergency preparedness and response (EPR), stockpiling, the resilience of the energy supply chain, and power grid interconnection in the Greater Mekong Subregion. Here, we introduce only EPR and grid interconnection.

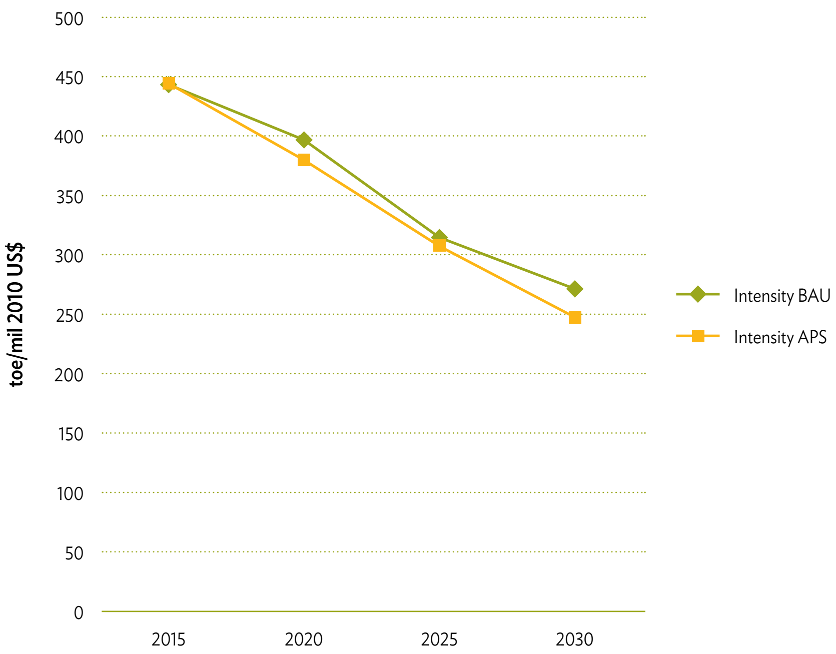
(1) EPR is a plan or procedure for when Cambodia faces an emergency. EPR clearly specifies three measures: short term, medium term, and long term. The short-term measure emphasises how to reduce energy consumption quickly, while the medium and long-term measures mention the diversity of energy supply sources, promotion of EEC, and stockpiling. The establishment of the National Emergency Supply Organization (NESO) is also very important. NESO consists of several ministries (energy, industry, commerce, transport) and large energy supply and consumption companies, and is headed by the prime minister. NESO works on the coordination, harmonisation, and prioritisation of a limited energy supply to final users under an emergency.
(2) Cambodia has imported electricity from Viet Nam and Thailand historically and will import it from Lao PDR soon. As such, Cambodia has already joined a grid interconnection network amongst the countries, but this is on a bilateral basis. According to the BEPC, 60% of power generation will come from hydropower plants, and this will depend on the volume of water flow, which is usually affected

by climate conditions. In order to secure electricity supply in Cambodia, a power trade system on a multilateral basis is recommended.

Energy outlook

Two energy outlooks, business as usual and the alternative policy scenario (applying targets specified by the BEPC), are projected up to 2030. Both outlooks show the trends of total final energy consumption (TFEC) and TPES up to 2030. Thus, the MME will surely monitor the actual TFEC and TPES from Cambodia's energy balance tables to be produced continuously after 2017 and compare them with the projected trends in the BEPC. If the actual TFEC or TPES differs from the trends, the MME will make checks (regarding why the difference is generated) and take action (revise action plans and policies) by applying a Plan-Do-Check-Action cycle. However, the TFEC and TPES can become volatile depending on the economic conditions, such as GDP, so that the intensity defined as TFEC/GDP and TPES/GDP is better than the TFEC and TPES themselves. The intensity of the TFEC is shown in Figure 3.

Figure 3. TFEC Intensity under the BAU and APS Outlooks



BAU = business as usual, APS = alternative policy scenario, TFEC = total final energy consumption.

Source: Author's calculation.

CHAPTER 1

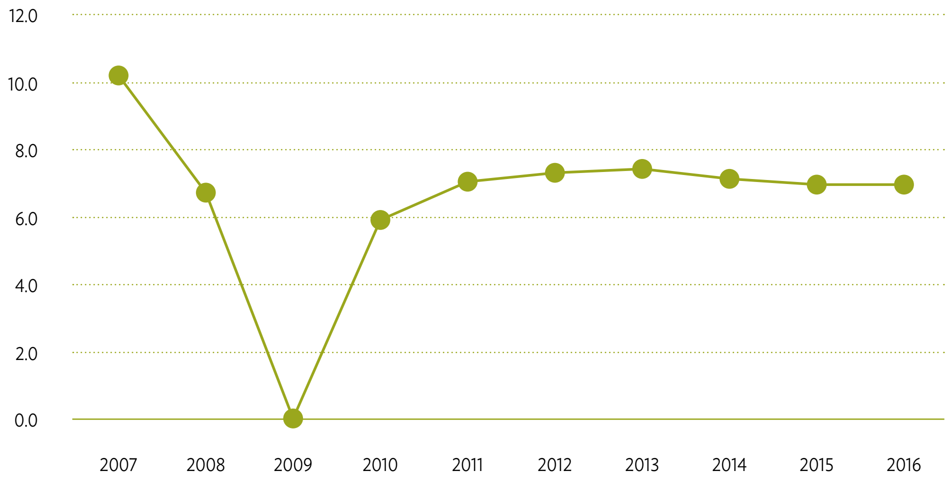
OIL

1.1 Issues and required policies for petroleum products on the demand side

1.1.1 The demand trend

Cambodia has attained high economic growth since 1999. Although growth was temporarily stagnant due to the global financial crisis in 2009, it continued to increase by 7% from 2011 onwards. According to the International Monetary Fund and the Asian Development Bank, the Cambodian economy is expected to continue growing steadily, supported by strong domestic demand.

Figure 1.1 **Real GDP Growth Rate of Cambodia**



GDP = gross domestic product.

Source: International Monetary Fund.

Economic growth has increased demand for petroleum products, and petroleum product imports have continued to increase. From 2012 to 2016, the demand for petroleum products increased by 7.2% per year. Amongst them, gasoline, diesel oil, and liquefied petroleum gas (LPG), which are the main products, showed high growth rates of 6.1%, 8.4%, and 23.0%, respectively.

Furthermore, according to the demand forecast by the Economic Research Institute for ASEAN and East Asia (ERIA), the total demand for petroleum products in the year 2040 is expected to be 4,650 kilotonnes of oil equivalent (ktoe) (3.8% growth per year) under the assumption of stable economic growth.

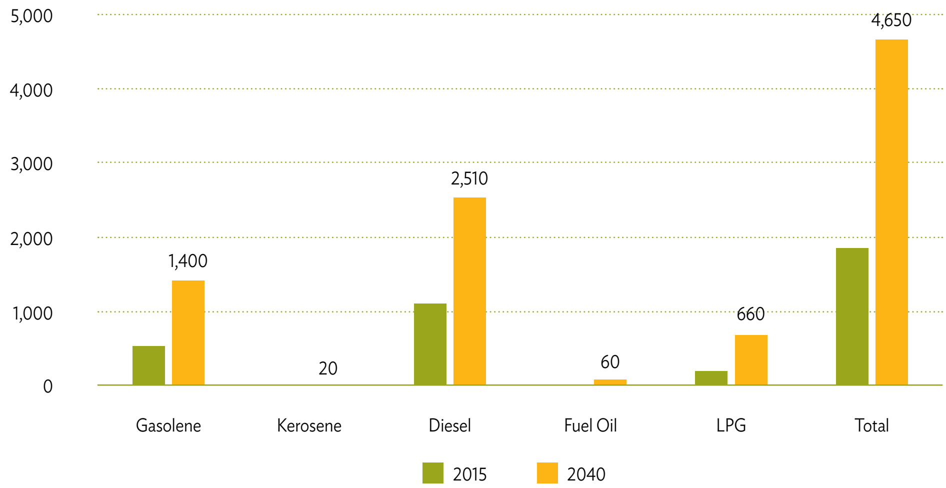
Table 1.1 Annual Imports of Main Petroleum Products
(tonnes)

	2012	2013	2014	2015	2016
Gasoline	387,729	392,011	426,830	481,671	490,898
Diesel	897,641	918,437	1,005,484	1,073,248	1,240,184
LPG	84,678	98,692	112,120	162,332	193,595

LPG = liquefied petroleum gas.
Source: Customs Statistics.

Additionally, in the future, gasoline and diesel oil demand for the transportation sector, LPG demand for households, and fuel oil and LPG demand for the industry sector will increase until 2040.

Figure 1.2 Demand Forecast by ERIA
(1,000 ktoe)



ERIA = Economic Research Institute for ASEAN and East Asia, ktoe = kilotonnes of oil equivalent, LPG = liquefied petroleum gas.
Source: ERIA Outlook 2018.

Because Cambodia is in the development stage, it is expected that oil demand may increase more than the economic growth rate at times. Therefore, it is important to consider how to respond to increasing oil demand.

With the expansion of demand, we have to consider the following issues:
- Environmental burden
- Accidents in each field
- Deterioration of the trade balance

There is concern that the environmental burden, such as air pollution, will become worse, and the number of accidents will increase. The trade balance will also worsen due to an increase in imports of oil. Therefore, it is necessary to improve the quality of petroleum products to prevent air pollution and to strengthen the regulations for fire prevention in oil storage, transportation, and sales. In Asia, the environmental burden has increased due to the rapidly rising oil demand in some countries, but measures have been taken when the problem has become serious. It is necessary to implement countermeasures at the appropriate time, taking this as a lesson. It is also important to promote energy saving and alternative energy and take measures to prevent international oil supply disruptions and oil supply shortages due to natural disasters.

1.1.2 Action plans and necessary policies on the demand side

(1) Energy saving in the transport sector

Energy saving not only improves the international balance of payments by reducing the imports of fossil fuels but also contributes to reducing the environmental burden.

The following are effective examples of action plans in the medium-to-long term:
- Import restrictions on old cars (medium or long-term policy)
- Preferred tax system for fuel-efficient cars (medium-term policy)
- Fuel consumption regulation by type of vehicle (long-term policy)

Figure 1.3 Example of a Promotion Method for Fuel Efficiency

Understanding the current situation	Average car age
Improvement target	15 years in 2030
Promotion measures - Import regulation - Inspection regulation - Vehicle tax	Car import ban for 15 years or more Cars over 12 years are inspected every year New-car tax reduction
Annual grasp	Register and discard

Source: Asiam.

Consultation and cooperation with the relevant ministries and agencies, such as the Ministry of Transportation and the Ministry of Economy and Finance, are necessary to implement these action plans.

(2) State of demand for petroleum products

In order to extract the issues and formulate policies, it is important to grasp the actual state of the consumption of petroleum products and recognise the products that are being rapidly expanded. It is necessary to have a system for periodically collecting the required data from oil companies and conducting market research. Also, in future, if we can clarify the data on petroleum consumption intensity for each sector, the targets for fuel efficiency and alternative energy will be clearer.

(3) Promotion of alternative energy

Biogasoline, electric vehicles (EV), electric bikes (EB), and compressed natural gas (CNG) have the effect of decreasing oil demand. The balance between the benefits of reducing oil imports and the costs of introducing alternative energy should be studied, and, in order to assess the benefits, a pilot project should be considered.

(4) Establishment of the quality specifications for petroleum products

The quality of petroleum products is also an issue on the supply side, but quality assurance is an effective policy for reducing the environmental burden, such as air pollution associated with the expansion of demand. Quality should be gradually improved while looking at the circumstances of neighbouring countries.

(5) Strengthening of regulations aimed at preventing accidents

There is a risk that accidents will increase due to the expansion of oil demand. Regulations are required to prevent accidents in the fields of oil storage, transportation, sales, and consumption. Especially for LPG, since accidents at the consumption stage have been increasing, consumer awareness is important.

1.2 Issues and required policies for petroleum products on the supply side

1.2.1 The supply situation

Cambodia currently imports 100% of its petroleum products. The import sources are mainly Thailand, Viet Nam, and Singapore. Quality specifications of petroleum products have not been established, so there are variations in the quality of imported goods.

Meanwhile, the construction of a domestic refinery is planned by a private enterprise. Because this refinery is small in size, there is a possibility that it will be subject to severe competition from imported goods. Having refineries in the country is important for energy security, but it is necessary for the refineries to be competitive with refineries in the Association of Southeast Asian Nations (ASEAN) region. There are large refineries in Asia, as shown in Table 1.2.

Table 1.2 Asia's Large Refineries

Country	Company	Location	Cap. 1,000b/d
Korea	SK energy	Ulsan	840
Korea	GS caltex	Yeosu	785
Korea	S-OIL	Onsan	669
Korea	Hyundai	Daesan	390
Singapore	Exxon Mobil	Jurong	593
Singapore	Shell	Bucom	462
Singapore	SPC	Merlimau	290
Taiwan	FPCC	Unrin	540
Taiwan	CPC	Darin	300
Taiwan	CPC	Takao	220
Taiwan	CPC	Toen	200
Thailand	Esso	Sriracha	177
Thailand	BCP	Bangchak	120
Thailand	TOC	Sriracha	275
Thailand	PTT	Map ta Phut	280
Thailand	IRPC	Rayong	215

B/d = barrels per day.

Source: Ministry of Economy, Trade and Industry, Japan.

1.2.2 Action plans and necessary policies on the supply side

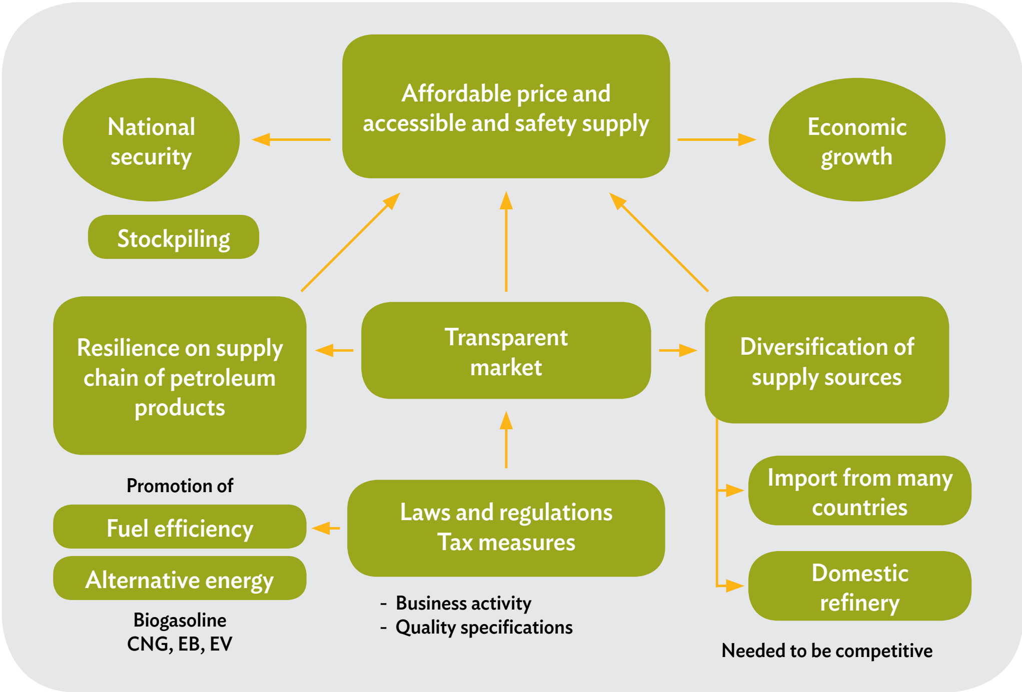
The most important objectives are affordable prices and an accessible and safe supply of oil. This will contribute to national security and economic growth and will be achieved through a transparent market. The relevant agencies and companies can contribute to the petroleum market data on supply and demand and prices.

A transparent market will promote the following:

- The diversification of supply sources
- Resilience in the supply chain of petroleum products

Laws and regulations and a preferential tax system are the platform of a transparent market and also contribute to ensuring safety and the promotion of fuel efficiency and alternative energy. In order to advance these policies, cooperation with the related ministries and agencies is necessary.

Figure 1.4 Summary of the Issues and Policies on the Supply Side



CNG = compressed natural gas, EB = electric bikes, EV = electric vehicles.

Source: Author.

(1) Early promulgation and the implementation of laws and regulations

Laws and regulations are the platform of a transparent market and contribute to ensuring safety. The following laws and regulations are ready, and early promulgation and implementation are expected:

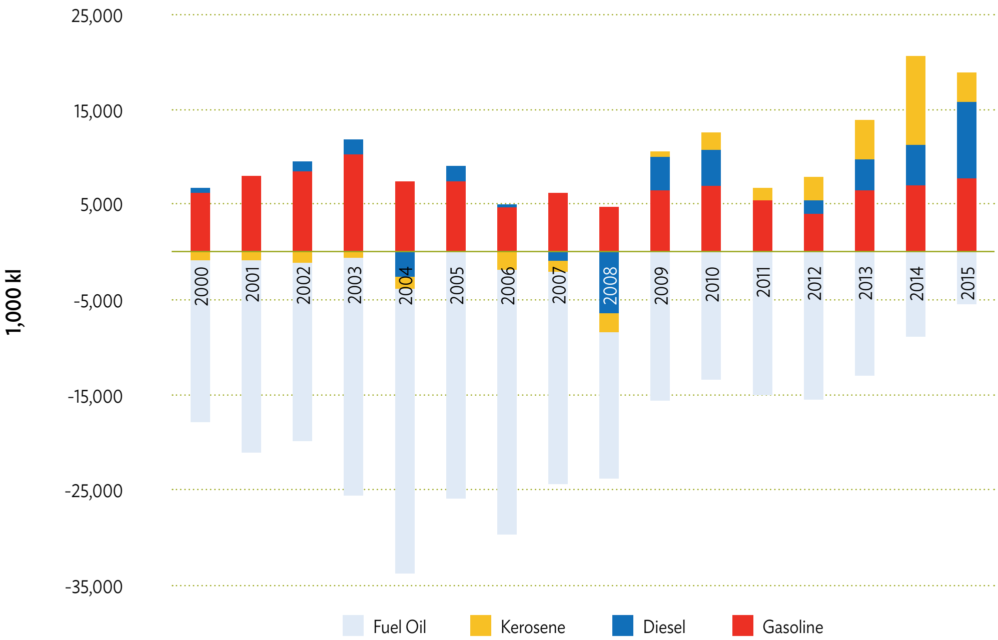
- Petroleum Law
- Sub-decree on Licenses and Permit Letters
- Specifications of petroleum products
- Assurance of quality of petroleum products
- Technical Regulation on Storage Tanks
- Technical Regulation on Petroleum Service Stations
- Technical Regulation on Bottling Stations of LPG
- Technical Regulation on Storage of LPG

(2) Diversification of supply sources

The oversupply of petroleum products in China, the Republic of Korea (hereafter, Korea), Taiwan, India, and the Middle East is expected to continue in the medium term, and Cambodia should seek cheap procurement sources. The diversification of supply sources also contributes to energy security. Understanding the price formulas of importing petroleum products is important. In an oversupply environment, it is encouraged that importing companies look for the appropriate procurement sources.

→ China's export volume of petroleum products is over 15 million kilolitres (kl) per year.

Figure 1.5 China's Net Exports of Petroleum Products

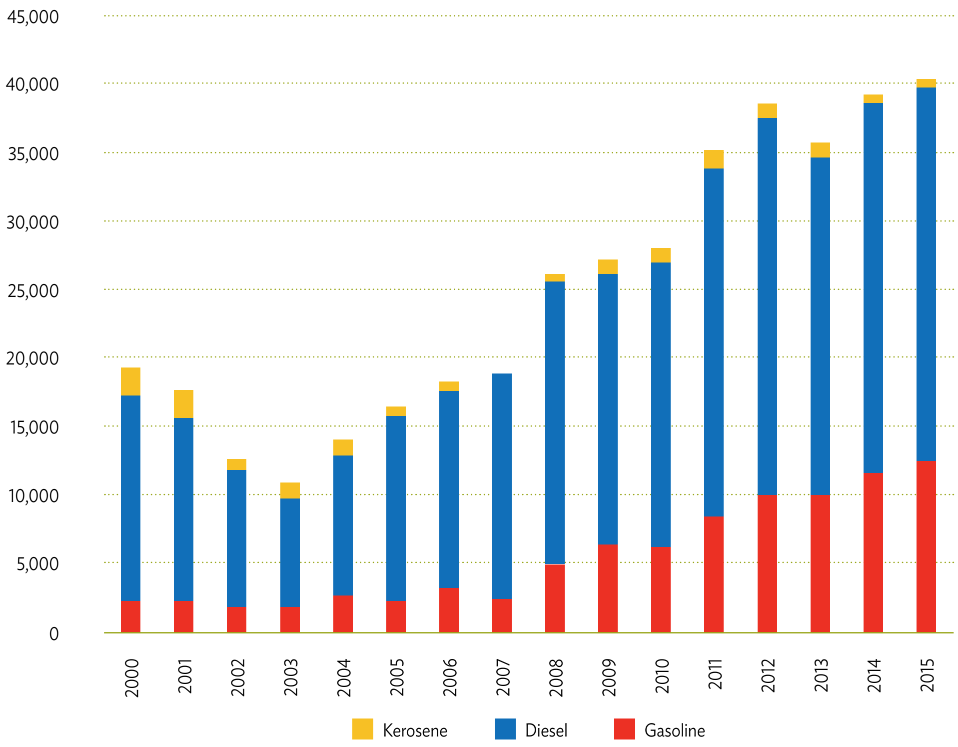


kl = kilolitres.

Source: Asiam.

→ Korea's export volume of petroleum products is over 40 million kl per year.

Figure 1.6 **The Republic of Korea's Net Exports of Petroleum Products** (1,000 kl)



kl = kilolitres.

Source: Asiam.

(3) Promotion of a transparent market

Currently, Cambodia lacks statistical data on the oil market. For statistical data on supply and demand, although the energy balance table has been developed, it must be continuously updated and further improved in its level of detail, such as for petroleum demand and supply data on both a yearly and monthly basis. It is also necessary to further improve the data, such as on the number, size, and location of oil terminals, LPG bottling stations, gas stations, and petroleum service stations, etc. Increasing market transparency will lead to the following:

- Resilience of the supply chain of petroleum products
- Investment opportunities for market participants
- The fostering of a strong and active oil industry

Such a market environment will contribute to affordable prices and an accessible and safe supply.

(4) Quality assurance of petroleum products

→ **Establishment of quality specifications**
Currently, since Cambodia imports all its petroleum products, it is necessary to check the specifications of the exporting countries and determine the specifications for Cambodia, taking into consideration the balance between the purchase price and the environmental burden, as high-quality products have high prices.

→ **Promulgation of the *prakas* (regulations)**
Based on the Petroleum Law, restrictions on quality assurance at the time of storage, transfer, and sale of petroleum products should be conducted.

In the prakas, the following shall be stipulated.

Clarification of who is obligated
The refinery (petroleum products producer), oil terminal, petroleum service station, gas station, or LPG bottling station should be obligated to ensure quality.

Designation of inspection centres
The Ministry of Mines and Energy (MME) should designate inspection centres with capacity and experience. Those obligated to ensure quality must periodically undergo inspection by the MME. The inspection centre performs quality inspection practices by receiving consignments from the MME. Refineries, oil terminals, petroleum service stations, gas stations, and LPG bottling stations can also ask for inspections from inspection centres.

Inspection items
In order to shorten the time required for inspection and to reduce the inspection costs, inspection items should be set and be subject to inspection.

(5) Stockpiling of petroleum products (including crude oil)

Currently, importing companies are carrying out commercial stockpiling for 30 days according to the prakas by the Ministry of Commerce. This should be executed reliably by the Petroleum Law to ensure industry stock (strategic petroleum reserves by private companies). Oil stockpiles are an effective means of countering the risk of disruptions in international markets, such as sudden crude oil supply shortages due to accidents and natural disasters, and it is necessary to gradually strengthen oil stockpiles. Also, the national stock (strategic petroleum reserves by the government) should be considered in the medium or long term. There are also low-cost methods, such as ticket stockpiling in foreign countries, and various options that should be considered.

(6) Introduction of biogasoline (E3)

Cambodia has crude oil resources, but their development will take time. There are no oil-refining facilities in the country at the present time, and all petroleum products depend on imports, which is a critical issue for the national trade balance.

Because of this situation, biogasoline, as a domestically produced liquid fuel, is important for the improvement of the national trade balance and energy supply security. The development of biogasoline can form an industry chain of cassava cultivation, bioethanol manufacturing, and biogasoline production. The promotion of biogasoline contributes to improving farmers' incomes, reducing gasoline imports, and reducing greenhouse gases.

The key to successfully introducing biogasoline into Cambodia is to reduce the production cost of cassava as a raw material, reduce bioethanol production costs, and promote the consumption of biogasoline. Establishing bioethanol policies and related regulations, such as biogasoline specifications, safety regulations, and roadmaps, is also required. To achieve these policy objectives, cooperation between the related ministries and agencies is indispensable.

Regarding the quality specification of biogasoline, it is preferable to upgrade step by step to ethanol protection engines, such as from E3 to E5 and E10, according to vehicle speed. E3, which is blended ethanol 3%, should be the first step because E3 has no effect on old cars. In order to introduce biogasoline into Cambodia, it is necessary for the government to encourage it by providing some incentives, and the promotion of a pilot project would also be effective. The primary goal of the pilot project would be to catch the issues that may occur during the initial deployment and promptly take effective countermeasures.

→ Targets of the pilot project:
- Catch issues and consider countermeasures
- Secure the ethanol supply chain
- Improve public consciousness

→ Benefits of the introduction of biogasoline:
- Agricultural industry development
  - Increase in cassava demand → increase in farmer income
- Improvement of the trade balance
  - Reduction in the outflow of Cambodian monetary assets
- Improvement of energy security
  - Reduction in reliance on imported fossil fuels
- Greenhouse gas reduction
  - Bioethanol can replace gasoline consumption and reduce CO_2

(7) Resilience of the supply chain of petroleum products

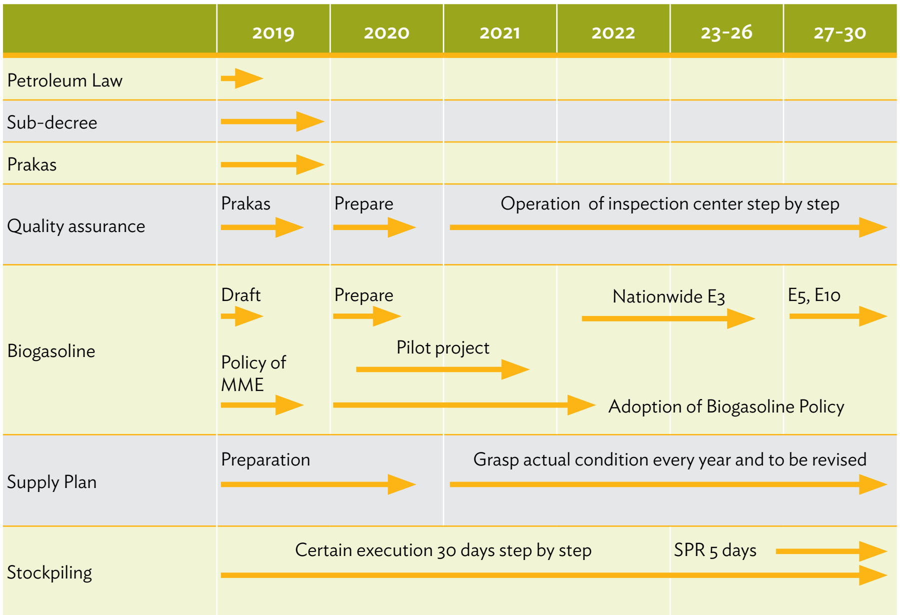
Based on the medium-to-long–term forecast for the demand for petroleum products, the government needs to prepare a petroleum supply plan.

The objective of the petroleum supply plan is to consider optimal logistics measures, assuming the scale, location, and timing of the new expansion of the oil supply base. This will lead to resilience of the supply chain of petroleum products.

- A reasonable supply plan should be considered based on the demand assumptions by province.
- The supply plan should include new or expansion plans for refineries, import terminals, and secondary terminals and their locations, sizes, and timing.
- The optimal means of transportation should be studied, such as tank trucks, ships, railroad, and pipelines.

The above are the optimal logistics based on the supply plan.

Figure 1.7 Roadmap



Source: Author.

1.3 Conclusion

Oil demand in Cambodia has increased rapidly in recent years, and it is expected that it will continue to increase with economic growth in the future. With the expansion of demand, we have to consider the environmental burden, the accidents in each field, and the deterioration of the trade balance. It is necessary to take countermeasures at an appropriate time before problems become serious. It is also important to promote energy saving and alternative energy sources and take measures against international oil supply disruptions and shortages due to natural disasters.

The action plans and necessary policies on the demand side are as follows:

(1) Energy savings in the transport sector through the promotion of eco cars
(2) Grasping of the actual state of demand for petroleum products
(3) Promotion of alternative energy
(4) Establishment of quality specifications to prevent air pollution
(5) Strengthening regulations aimed at preventing accidents, including on the supply side

On the other hand, the most important objectives of the supply side are affordable prices and an accessible and safe supply. This will be achieved through a transparent market. This means that the data on supply and demand and prices should be maintained so anyone can access the data on the petroleum market. In addition, laws and regulations and a preferential tax system are the platforms for a transparent market and also contribute to ensuring safety and the promotion of fuel efficiency and alternative energy. Collaboration with the related ministries and agencies is necessary to advance them.

The action plans and necessary policies on the supply side are as follows:
(1) Early promulgation and implementation of laws and regulations
(2) Diversification of supply sources
(3) Promotion of a transparent market
(4) Quality assurance of petroleum products
(5) Stockpiling of petroleum products (including crude oil)
(6) Introduction of biogasoline (E3)
(7) Resilience of the supply chain for petroleum products

CHAPTER 2

ELECTRICITY

2.1 Review of the current situation and selected major issues

This chapter focuses on Cambodia's basic electricity plan. The electricity plan of Cambodia has been conducted based on the National Strategic Development Plan (NSDP) 2014–2018.[1] The government focuses on (i) ensuring supply capacity, (ii) improving electrification, and (iii) reducing tariffs. The content has been concluded as follows.

2.1.1 Ensuring supply for the best energy mix

- Reduce reliance on petroleum fuels for electricity generation so supply capacity and diversified energy sources such as hydropower, natural gas, and coal are expanded.
- Hydropower and coal-fired power plants are broadly preferred along with the import of electricity from neighbouring countries.
- Invest in electricity generation infrastructure focusing on technical and economic efficiency and minimising the environmental and social impacts by the private sector, such as independent power producers (IPPs).
- Encourage the efficient use of energy and mitigate the adverse effects on the environment resulting from energy supply and use.

Outstanding issues

- The maximum electricity production from hydropower plants occurred only in the rainy season. In the dry season, the power production generated was only 25%.

[1] http://cdc-crdb.gov.kh/cdc/documents/NSDP_2014-2018.pdf

2.1.2 Improving electrification by expanding transmission and distribution networks

- To reduce electricity losses, transmission and distribution networks are expanded.
- To regionally expand economic cooperation, which maximises the use of resources in the region to achieve the most benefit, Cambodia has been participating in the implementation of a Greater Mekong Subregion (GMS) power trade plan and the ASEAN Power Grid plan.
- To strengthen energy security and ensure an efficient, safe, high-quality, reliable, and affordable electricity supply, all levels of the transmission and distribution networks are developed.
- Invest in transmission and distribution infrastructure focusing on technical and economic efficiency and minimising the environmental and social impacts by the private sector.

To realise the goal that 'by 2020, all villages in the Kingdom of Cambodia will have access to electricity supplied by the national grid and other sources', implementation of the electrification strategy is accelerated.

- Promote regional electricity trade through bilateral and multilateral cooperation.

Outstanding issues

- Due to the high costs required to build electricity infrastructure in numerous rural areas in Cambodia, the electricity supply in rural areas is limited as most areas are not yet connected to the grid.
- The expansion of distribution lines to rural areas is limited, and the unit cost remains relatively high compared to the unit cost in neighbouring countries.

2.1.3 Reducing tariffs to make them more affordable

- Further support the rural electrification fund aimed at acquiring equitable electricity access for all citizens through government funding and social funding by Electricite Du Cambodge (EDC), and seek funding support from other development partners.
- Pursue rational measures for electricity consumption by reducing power tariffs during off-peak hours to serve production and irrigation systems aimed at improving agricultural productivity and accelerating the development of industry and handicraft sectors.

- Maximise revenue inflows through multi-layered revenues such as royalties, production sharing, and income tax to increase the government's financial capacity.
- Reduce tariffs to an appropriate level in the whole country.

Outstanding issues

- Electricity tariffs in rural areas are higher than in urban areas.
- The tariff cost is relatively high compared to the tariff cost in neighbouring countries.

To solve the above outstanding issues, this chapter reviews the current situation, describes the targets for 2030, and considers the necessary policies with a roadmap.

2.2 Generation

2.2.1 Targets by 2030

According to the Ministry of Mines and Energy's (MME) generation development plan for 2017–2030 (Table 2.1) and the forecasted demand by the Economic Research Institute for ASEAN and East Asia's (ERIA) outlook in Chapters 1 and 6, this section describes two cases, Case 1 (Power Development Plan [PDP]) and Case 2 (ERIA_BAU), for the targets by 2030 in regard to power generation calculated using the power generation capacity and several conditions, such as the capacity factor and the loss of transmission and distribution lines.

Case 1 focuses on the relationship between the existing PDP of the MME and forecasted demand (outlook by ERIA). Case 2 is an aggressive pattern that includes the maximal use of solar/wind and biomass power and mainly hydro potential, which is estimated at about 10,000 megawatts (MW) by the hydroelectricity department of the MME.

Table 2.2 presents the revised capacity in the aggressive case (Case 2). In this case, hydro, biomass, and solar/wind capacity will increase by approximately 350 MW/year (3,526 MW/10 years), 30 MW/year (301 MW/10 years), and 36 MW/year (368 MW/10 years), respectively, compared with Case 1 from 2021 to 2030. In order to achieve the best mix in 2030, the coal/gas capacity will decrease by approximately 130 MW/year (–1,317 MW) compared to Case 1 from 2021 to 2030.

Table 2.1 Power Generation Development Plan

No.	Project name	Type	Capacity (MW)	Year	Company
1	Coal Power Plant I-2	Coal	135	2017	CIIDG ERDOS HONGJUN Electric Power Co., Ltd.
2	Sesan II lower	Hydro	400	2018	Hydro Power Lower Se San 2 Co., Ltd.
3	Coal Power Plant	Coal	135	2019	Cambodia Energy Limited (CEL II)
4	Coal Power Plant II-2	Coal	200-250	2020	Cambodia International Investment Development Group (CIIDG)
5	Coal Power Plant II-3	Coal	200-250	2021	Cambodia International Investment Development Group (CIIDG)
6	Coal Power Plant IIII-1	Coal	350	2022	Royal Group Co., Ltd.
7	Stung Sala mum Thun	Hydro	70	2022	
8	Middle Stung Russey Chrum	Hydro	70	2022	China Huadian Lower Stung Russey Chrum Hydro-Electric Project (Cambodia) Co., Ltd.
9	Veal thmor kambot	Hydro	100	2022	
10	Prek Liang	Hydro	120	2022	Asia Ecoenergy Development Ltd.
11	Coal Power Plant IIII-2	Coal	350	2023	Royal Group Co., Ltd.
12	Stung Battambang II	Hydro	36	2023	Stung Battambang II Hydro Power Plant
13	Stung Pursat I	Hydro	40	2023	Stung Pursat I Hydro Power Plant
14	Sambor (Step 1)	Hydro	600	2025	Sambor Hydro Power Plant
15	Sambor (Step 2)	Hydro	600	2026	Sambor Hydro Power Plant
16	Coal Power Plant V	Coal	300	2026	
17	Sambor (Step 3)	Hydro	600	2027	Sambor Hydro Power Plant
18	Coal Power Plant VI	Coal	300	2027	
19	Coal Power Plant VII	Coal	300	2028	
20	Coal Power Plant VIII	Coal	300	2029	
21	Lower Sesan I	Hydro	96	2029	
22	Coal Power Plant VIIII	Coal	300	2030	

Total Capacity in 2030
- Coal/gas: 2,373 MW - Oil: 251 MW
- Hydro: 1,602 MW - Biomass: 185 MW - Solar/wind: 305 MW

Source: Electricite Du Cambodge (2016).

Table 2.2 Aggressive Generation Development Plan (revised existing plan)

No.	Type	Capacity (MW)	Year	Total in 2030 (MW)
1	Coal/gas	-1,317	2021–2030: /10 years	1,056
2	Hydro	+3,526	2021–2030: /10 years	5,127
3	Biomass	+301	2031–2030: /10 years	486
4	Solar/wind	+368	2031–2030: /10 years	673

Source: Author (outcome of the dialogue with the Ministry of Mines and Energy).

Case descriptions

Common condition: Case 1 and Case 2

- Demand is the same as in the outlook by ERIA (Table 2.5)
- Supply (including loss) + import = demand (outlook by ERIA)
- Import: The constant amount of electricity imported from 2020 to 2030 (Table 2.5) Demand = national capacity + electricity imported
- Oil: Gradually reduced high cost as an impact of no oil use from 2020

Case 1: Existing PDP (2017–2030)

- Capacity: Planned capacity mentioned in the power generation development plan, covering the years from 2017 to 2030 (Table 2.1)
- Loss: 10% of the total national power supply is transmission and distribution losses.
- Capacity factor: Coal/gas (85%), oil (85%), hydro (35%), biomass (40%), solar (15%), wind (20%). The capacity factor of hydro plants in the dry season is 35%. In order to ensure essential power generation, the percentage is completely used in the whole year.
- Required import supply: Calculated according to demand – supply. A negative value for imports reflects an excess of electricity power supply in a year and encourages electricity exports or a reduction of electricity generation, while a positive value of imports reflects the need for imported electricity.

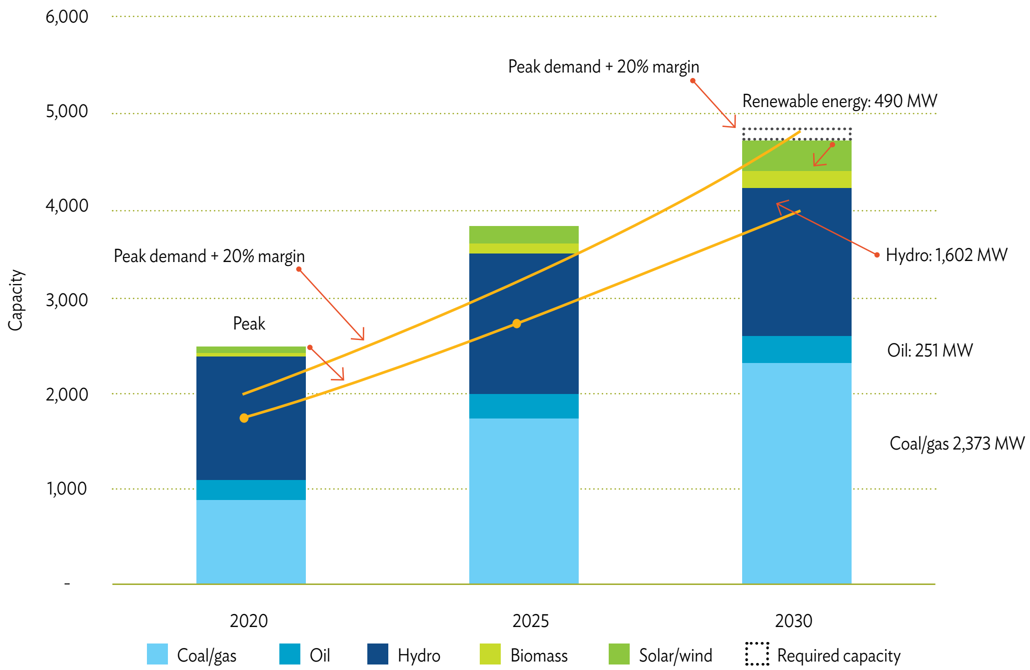
Table 2.3 and Figure 2.1 show the power generation capacity in Case 1. Referring to the existing plan by 2030, a lack of peak capacity will occur in 2030 and peak with a +20% margin in 2030 using estimated data on 2020 and 2025 using the linear extrapolation method. Therefore, this case roughly indicates the capacity needed by 2030 if the current plan is implemented by 2030. Imported electricity is not included in this data, but it is surely an aspect to be considered in the power supply calculation.

Table 2.3 Power Generation Capacity in Case 1

Capacity (MW)\year	2020	2025	2030
Coal/gas	873	1,773	2,373
Oil	251	251	251
Hydro	1,330	1,506	1,602
Renewable energy (biomass, solar, wind)	72	281	490
Total capacity	2,526	3,811	4,716
Peak demand +20% margin	2,017	3,214	4,776
Required capacity	0	0	60

Source: Electricite Du Cambodge (2016).

Figure 2.1 **Power Generation Capacity in Case 1**



Source: Electricite Du Cambodge (2016).

Case 2: Recommended pattern

- Power supply: The total amount of the power supply is the same as in the current generation development plan from 2017 to 2030.
- Additional capacity (2021 to 2030): Consider only hydro and renewable energy (RE) (biomass, solar/wind) in terms of reducing the use of fossil fuels.
- Loss: 10% of the total national power supply is transmission and distribution losses.
- Capacity factor: Coal/gas (85%), oil (85%), hydro (35%), biomass (40%), solar (15%), wind (20%). The capacity factor of hydro plants in the dry season is 35%. In order to ensure essential power generation, the percentage is completely used in a whole year.
- Required import supply: Calculated according to demand – supply. A negative value for imports reflects an excess of electricity power supply in a year and encourages electricity exports or a reduction of electricity generation, while a positive value of imports reflects the need for imported electricity.
- Oil: Gradually reduced as an impact of no oil use from 2020.
- Import: Gradually reduced as an impact of no imports from 2022.

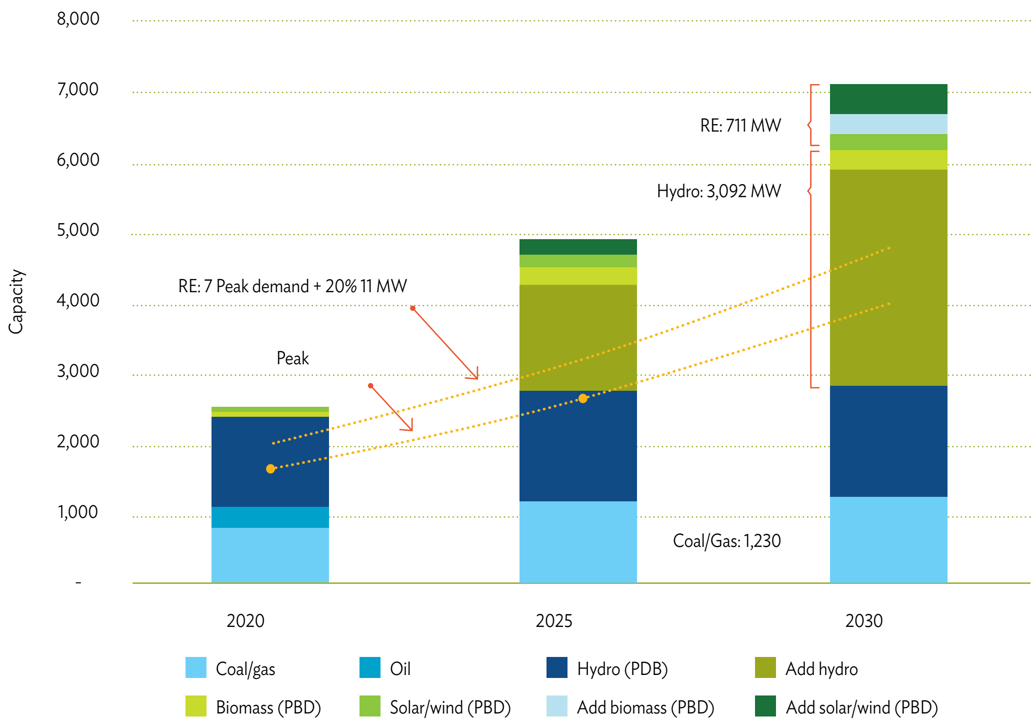
Table 2.4 and Figure 2.2 show the power generation capacity in Case 2. Since constructing new generation capacity requires time, this case only considers additional hydro and RE capacity from 2021 and 2030, respectively. These capacities are also presented in Table 2.2. The total capacity of the current PDP is 4,716 MW in 2030, but the total capacity of the revised plan is 7,081 MW due to a difference in the capacity factor between coal/gas (85%) and hydro (35%). Therefore, if the energy mix is prioritised towards hydro and RE, increased total capacity will be required. In this case, the total capacity is over the peak demand with a +20% margin each year without electricity imports. The figure shows there will be capacity access shown above the dotted line for peak demand with a +20% margin, which benefits operators by having the best-chosen electricity resource, resulting in some long-term economic advantages such as affordable electricity prices, sustainable supply, and high security. To attain these advantages, Cambodia must consider not only power capacity planning but also transmission and distribution planning throughout the country. In the case of electricity exports, enhancement of the interconnection plan is needed.

Table 2.4 Generation Capacity in Case 2

Capacity (MW)\year	2020	2025	2030
Coal/gas	873	1,230	1,230
Oil	251	0	0
Hydro	1,330	3,012	4,694
Renewable energy (biomass)	0	243	485
Renewable energy (solar/wind)	72	372	672
Total capacity	2,526	4,856	7,081
Peak demand +20% margin	2,017	3,214	4,776
Required capacity	0	0	0

Source: Author (outcome of the dialogue with the Ministry of Mines and Energy).

Figure 2.2 Power Generation Capacity in Case 2



RE = renewable energy.

Source: Author (outcome of the dialogue with the Ministry of Mines and Energy).

We consider the energy mix based on the above conditions. Table 2.5 shows the summarised pattern of the power generation plan by 2030. Demand uses the basic plan from the outlook by ERIA as a reference.

Figure 2.3(a) shows the power supply mix and electricity demand in Case 1 for the current existing plan. The dependency on fossil fuels will increase towards 2030 due to the massive use of coal/gas power plants. The percentage in the energy mix will be 68% in 2030. To reach the power demand of 19.7 terawatt hours (TWh) using a controllable supply consisting of coal/gas, hydro, and RE, this percentage will increase to a minimum of 70%, which is also a high percentage for fossil fuel dependency. Therefore, the current plan by 2030 has high potential fossil fuel dependency as fossil fuels are a major energy source in the world today. On the other hand, the overconsumption of fossil fuels can lead to serious environmental issues such as air pollution and global warming. What is more, as this resource is limited, prices will possibly change drastically. Hence, the higher dependency on fossil fuels will result in higher potential risk.

Based on Case 1, we consider a recommended Basic Energy Plan for Cambodia (BEPC) pattern for Case 2. Figure 2.3(b) shows the power supply mix in Case 2. The total supply is the same as in Case 1 (26.2 TWh). In order to reduce fossil fuel dependency, hydro and RE capacity are increased. In 2030, the energy mix of fossil fuels will be 35%.

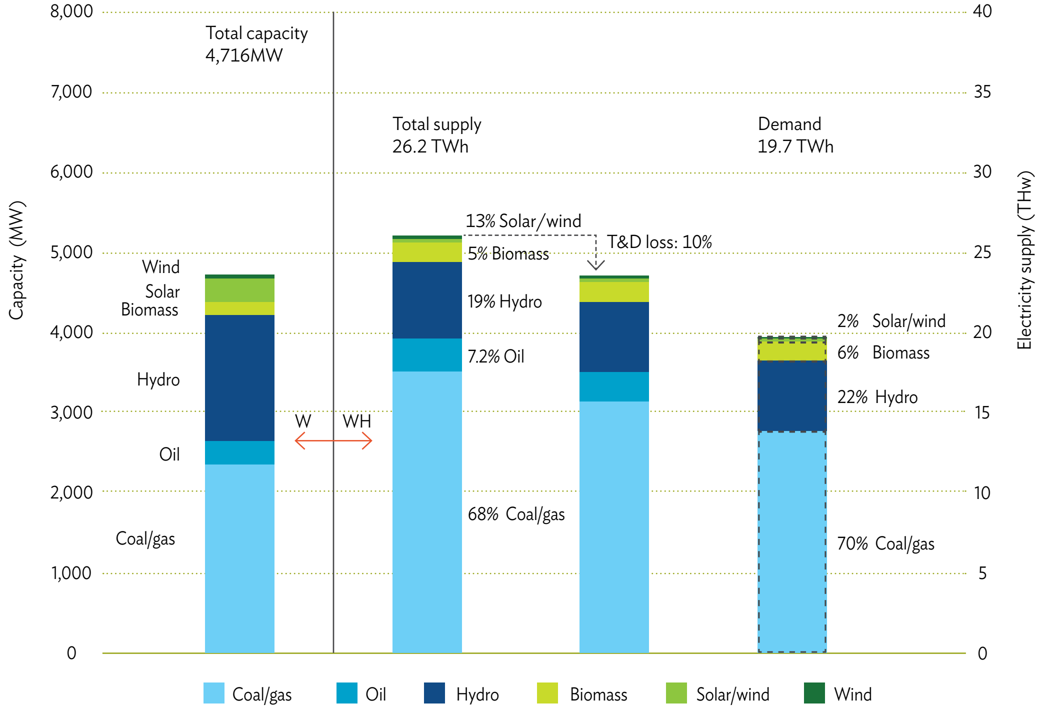
Table 2.5 Summarised Pattern of the Power Generation Plan

Case	Year	2020	2025	2030
	Demand (TWh), BAU outlook by ERIA	**11.8**	**15.0**	**19.7**
Case1 Existing plan (2017–2030)	Planned power supply (TWh)	12.5	20.4	26.2
	T&D loss (10%) (TWh)	-1.2	-2.0	-2.6
	Available power supply (TWh)	11.2	18.3	23.6
	Required import supply (TWh) (demand – available supply)	0.6	-3.3	-3.8
	Energy mix (%) at a maximum			
	- Coal/gas	52.2	64.8	67.5
	- Oil	15.0	9.2	7.2
	- Hydro	32.7	22.7	18.8
	- RE (biomass)	0.0	3.2	5.0
	- RE (solar, wind)	0.1	0.1	1.6
Case 2 Aggressive pattern (reduce imports, improve hydro and RE)	Estimated power supply (TWh)	11.6	19.1	26.2
	T&D loss (10%) (TWh)	1.2	-1.9	-2.6
	Available power supply (TWh)	10.5	17.2	23.6
	Required import supply (TWh) (demand – supply)	1.3	-2.2	-3.8
	Energy mix (%) at a maximum			
	- Coal/gas	56.0	46.4	35.0
	- Oil	8.1	0.0	0.0
	- Hydro	35.1	46.8	55.0
	- RE (biomass)	0.0	4.3	6.5
	- RE (solar, wind)	0.7	2.2	3.5

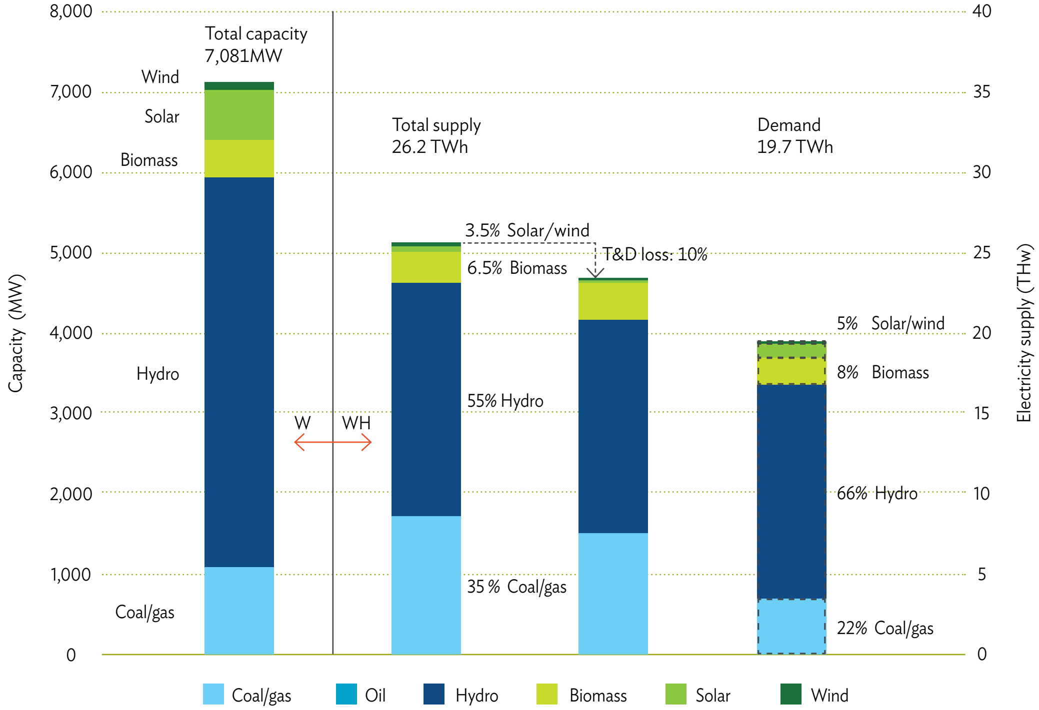
BAU = business as usual, RE = renewable energy, T&D = transmission and distribution, TWh = terrawatt hour.

Source: Electricite Du Cambodge (2016).

Figure 2.3 Power Development Plan and Basic Energy Plan for Cambodia in 2030



(a) Case 1: Power Development Plan in 2030



(b) Case 2: Basic Energy Plan for Cambodia in 2030

MW = megawatt, T&D = transmission and distribution, TWh = terrawatt hour.

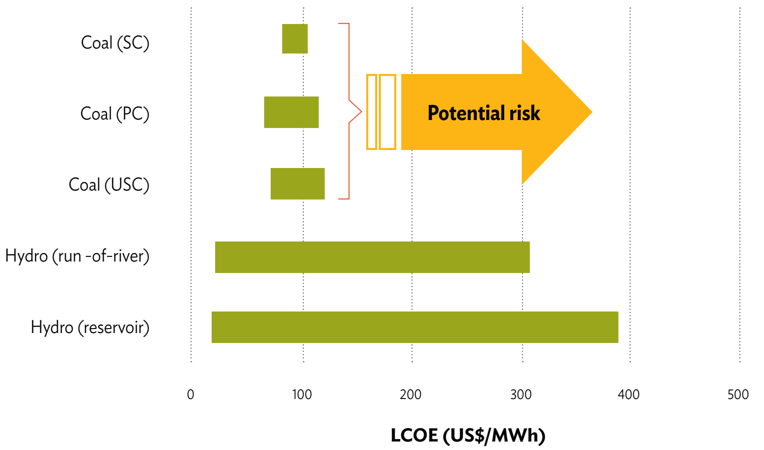
Source: Electricite Du Cambodge (2016) and author (outcome of the dialogue with the Ministry of Mines and Energy).

The reasons for the additional hydropower plant capacity are the following:

- To minimise the potential risk from the coal price
- To improve energy security
- To reduce the environmental impacts (air pollution, global warming)

Figure 2.4 shows the levelised cost of electricity (LCOE) for generating plants in 14 Organisation for Economic Co-operation and Development (OECD) countries plus Brazil, China, and South Africa. The LCOE of coal is relatively lower than for hydropower plants. However, the LCOE of hydro varies widely between US$15/MWh and US$388/MWh as the LCOE of hydropower is strongly correlated with the investment cost (Figure 2.5). Figure 2.6 shows the LCOE component ratios of coal and hydro. The LCOE for hydro contains an 85% investment cost. On the other hand, the LCOE component ratios for coal are 28% investment costs, 35% fuel costs, 27% carbon costs, and 10% operation and maintenance costs. Therefore, there is a possibility that the LCOE costs will be higher than for hydro due to an increase in the imported coal price in the future. Figure 2.7 shows the historical coal price change from 1998 to 2008 in the US, Japan, and northwest Europe. The annual coal prices in 2008 increased drastically by about 3.6–5.2 times from 1998. Where profitability is defined as revenues minus long-run operating costs, the Carbon Tracker Initiative's analysis finds that due to high fuel costs, 42% of coal capacity operating today could be losing money in the world.[2] Therefore, the higher dependency on fossil fuels, in this case coal, resulted in a higher risk potential, including the electricity price.

Figure 2.4 Levelised Cost of Electricity of Coal and Hydro in 2015



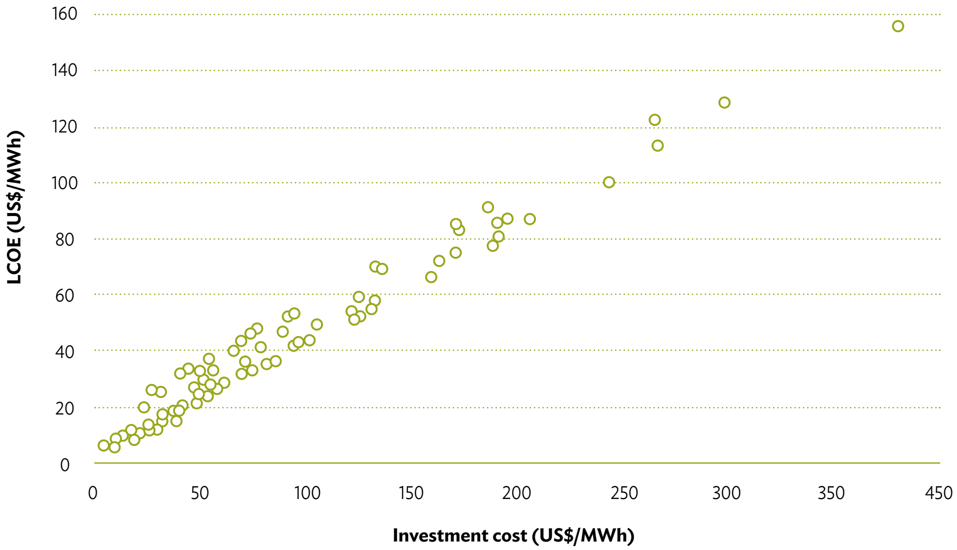
LCOE = levelised cost of electricity, SC = supercritical coal-fired, PC = pulverised coal-fired, USC = ultra-supercritical coal-fired.

Note: Includes 14 OECD countries (Austria, Belgium, Germany, Italy, Japan, the Republic of Korea, the Netherlands, New Zealand, Portugal, Spain, Switzerland, Turkey, the United Kingdom, and the United States) and three non-OECD countries (Brazil, China, and South Africa).

Source: IEA, NEA, and OECD (2015), https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf.

[2] https://www.carbontracker.org/reports/coal-portal/

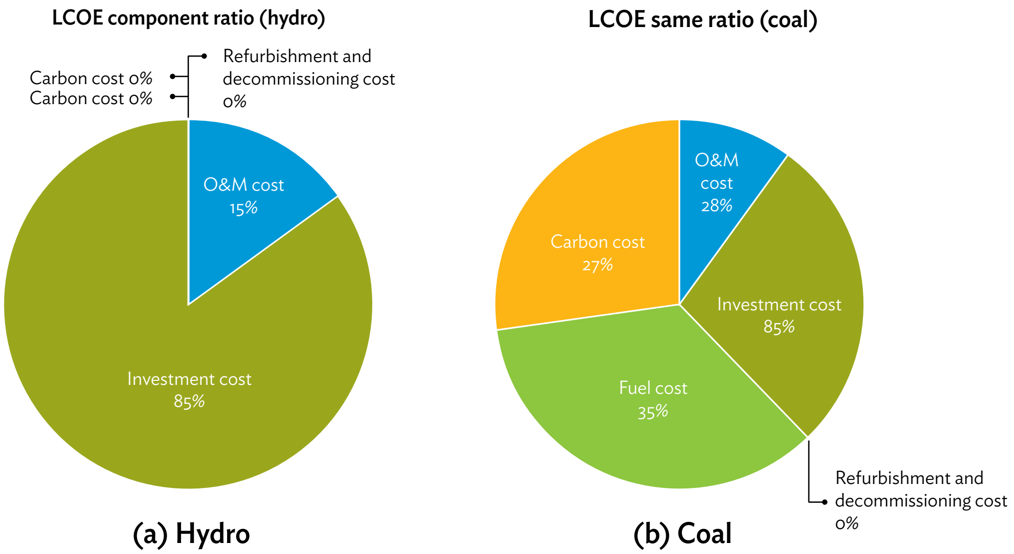
Figure 2.5 Comparison of the Levelised Cost of Electricity with the Investment Cost (hydro)



LCOE = levelised cost of electricity, MWh = megawatt hour.

Source: IEA, NEA, and OECD (2015), https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf.

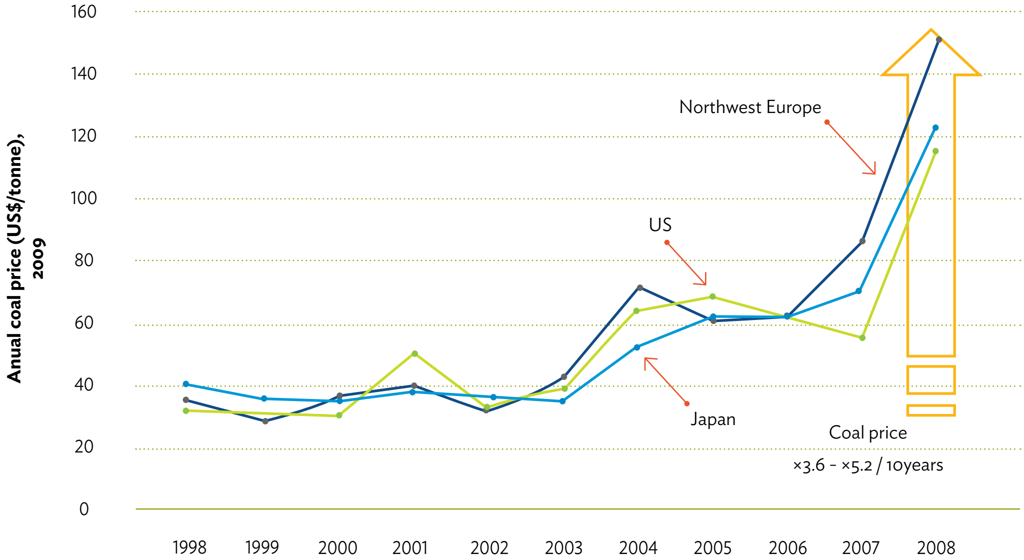
Figure 2.6 Levelised Cost of Electricity Component Ratios for Coal and Hydro in 2015



LCOE = levelised cost of electricity, O&M = operation and maintenance.

Source: IEA, NEA, and OECD (2015), https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf.

Figure 2.7 **Historical Coal Price Change from 1998 to 2008**



Source: Breeze, P. (2010), http://lab.fs.uni-lj.si/kes/erasmus/The%20Cost%20of%20Power%20Generation.pdf.

Cambodia relies on imported fossil fuels, including coal. The lack of energy security is linked to the negative economic and social impacts of either the physical unavailability of energy or prices that are not competitive or are overly volatile. Details on energy security are described in Chapter 5.

The conventional coal-fired plants generally used in Cambodia generate some significant disadvantages, including greenhouse gas (GHG) emissions, mining destruction, the generation of millions of tonnes of waste, and the emission of harmful substances. The greater the number of constructed conventional coal-fired plants, the greater the negative impact on the environment. GHG emissions are the result of harmful waste from the combustion of coal, which causes pollution and contributes to global warming. The increase in carbon emissions by coal-fired plants has led to further global warming, which has an impact on climate change. Thermal plants like coal-fired plants emit harmful substances into the environment. These include mercury, sulphur dioxide, carbon monoxide, mercury, selenium, and arsenic. These harmful substances not only cause acid rain but are also very harmful to humans. To mitigate the situation, clean coal technology, such as ultra-supercritical (USC), integrated gasification combined cycle (IGCC), and carbon capture and storage (CCS), will be needed when Cambodia plans new coal power plants.

The targets by 2030 are summarised as follows.

Targets by 2030

- Basic energy mix: Coal/gas (35%), hydro (55%), RE (biomass, solar, and wind) (10%)
- Export electricity to neighbouring country.
- Improve the utilisation of diverse energy sources.

2.2.2 Necessary action plans and policies

The necessary action plans and policies to reach the targets by 2030 are described here. To achieve the targets by 2030, additional capacity is required of approximately 3,000 MW by hydro plants, 300 MW by biomass plants, and 400 MW by solar/wind plants by 2030. However, there will be several challenges in implementation due to the high initial costs, the balance of the environment, and the significant impact of the dry season. In consideration of these challenges, the 'best energy mix' is an alternative solution.

To achieve the target of the best energy mix, the following are necessary:

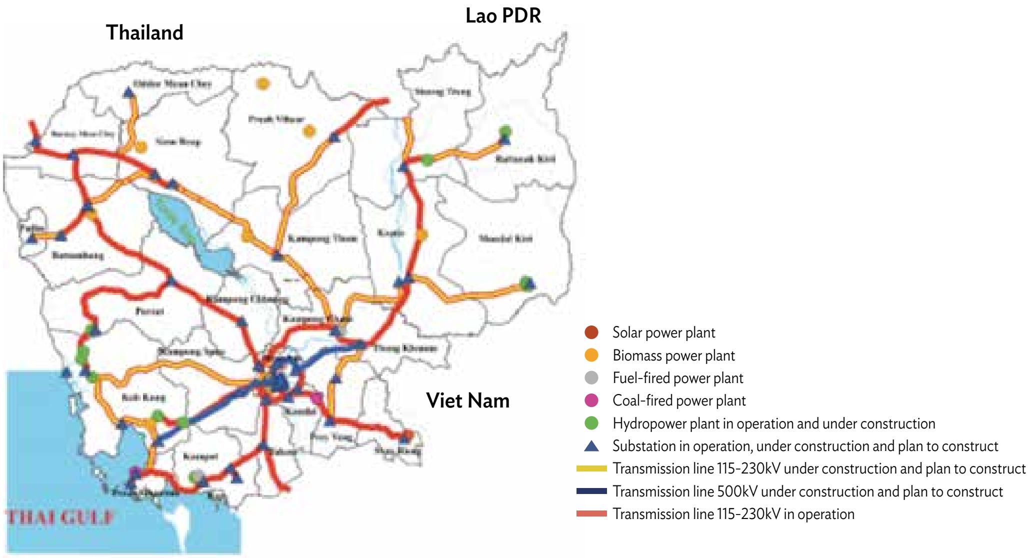
- Massive utilisation of hydro and RE potential
- Application of clean coal technology (USC, IGCC, CCS)
- Conducting power trading (exports and imports) through the GMS and the ASEAN Power Grid (APG)
- Utilisation of domestic gas potential

According to the necessary action plans and policies, it is recommended that the electricity of the BEPC be reviewed on a routine basis (every 2–5 years). The electricity of the BEPC with the best energy mix should be modified as needed.

2.3 Transmission

The national grid consists of three main components: high voltage (HV) substations, HV transmission lines, and the dispatching centre. The development of the national grid has three main objectives: (i) provide the opportunity to develop and integrate all power sources in the country into one grid system, (ii) expand the substations and transmission lines to provide electricity to cities and provinces throughout the country, and (iii) manage and control the operation of power sources to provide electricity to all areas efficiently, sustainably, and safely. The goal of national grid development by 2020 is shown in Figure 2.8. The national transmission master plan of 2016 is presented in Tables 2.6 to 2.8.

Figure 2.8 Goal of National Grid Development by 2020



Source: Electricity Authority of Cambodia (n.d.).

Table 2.6 National Transmission Master Plan (115 kV)

No.	115 kV transmission line	Length (km)	Year	Development partner
1	GS2 – GS Hunsen Park and Grid Substation	5	2017	BT
2	GS7 (SPP) – GS Prey Veng – GS Bavet	160	2017	CEIB
3	Laos Border to GS Preah Vihear	60	2017	CEIB
4	GS Battambong – GS Pailin	80	2017	EDC
5	GS3 – GS Toul Kork	5	2017	EDC
6	GS5 – GS Chroy Changvar	18	2017	Remain from Phnom Penh Loop Line project (CEIB)
7	GS Kampong Cham – GS Praek Prosab (Kratie)	91	2018	AFD
8	GS Svay Antor – GS Prey Veng	46	2018	CEIB
9	GS Preah Sihanouk – GS Ream	12	2018	CEIB
10	GS Ream – GS Chamkar Loung	60	2018	LDP
11	GS Chamkar Loung – Kiriom III Hydro Power	27	2018	LDP
12	GS Kampong Thom – GS Preah Vihear	140	2018	CEIB
13	GS Krolanh – GS Oddar Meanchey	80	2018	LDP
14	Underground Line from GS1 – GS EDC HQ – Stadium – NCC – GS3	14	2019	JICA Phase 1
15	GS Praek Prosab – GS Kratie	30	2021	LDP
	Total	**828 km**		

AFD = Agence Française de Développement, BT = build and transfer, CEIB = Cambodian Export-Import Bank, EDC = Electricite du Cambodge, JICA = Japan International Cooperation Agency, LDP = looking for development partner.

Source: Electricite Du Cambodge (2016).

Table 2.7 National Transmission Master Plan (230 kV)

No.	230 kV transmission line	Length (km)	Year	Development partner
1	GS Kampong Cham – GS Kratie	125	2017	BOT
2	GS Kratie – GS Stung Treng	115	2017	IEB
3	GS Stung Treng – Lwer Sesan II	26	2017	BOT
4	GS Battambang – East Siem Reap – Kampong Thom – Kampong Cham	350	2018	CEIB
5	Phnom Penh Loop Line Phase 2 (NPP – Chroy Changvar – EPP - NPP)	96	2018	CEIB
6	Tatay Hydropower – Phnom Penh	182	2018	BOT
7	GS Koh Kong – GS Koh Kong City	20	2018	AFD
8	GS Chamkar Loung – GS Botumsakor	54	2018	AFD
9	GS Botumsakor – Tatay Hydropower	70	2018	LDP
10	GS Kratie – GS Mondulkiri	170	2019	CEIB
11	GS Ratanakiri – GS Stung Treng	120	2019	CEIB
12	GS Stung Treng – Laos Border	48	2019	LDP
13	GS Beak Chan – GS5 – NCC	20	2020	JICA Phase II
14	GS Tropang Prasat – GS Siem Reap	30	2021	BOT
	GS Tropang Prasat – GS Siem Reap	**1,426 km**		

BOT = build, operate, and transfer, IEB = India Exim Bank.

Source: Electricite Du Cambodge (2016).

Table 2.8 National Transmission Master Plan (500 kV)

No.	500 kV transmission line	Length (km)	Year	Development partner
1	Phnom Penh – Preah Sihanouk	198	2019	BOT
2	Phnom Penh – Soung	96	2021	LDP
3	Soung – Sambo – Stung Treng	-	2025	LDP
	Total	**294 km**		

Source: Electricite Du Cambodge (2016).

2.3.1 Targets by 2030

2.3.1.1 National grid expansion

The HV transmission system, i.e., the 'national grid', will gradually establish grid substations in each district to provide outlets for supplying electricity from the national grid. The grid substations are to be located in the central area of each province to facilitate the development of a sub-transmission system to transmit electricity from the national grid to rural areas. The projects for the expansion of the electricity supply from the national grid and from networks importing electricity from neighbouring countries to the rural areas are to be implemented as the first priority, as they will provide a higher quality and less expensive electricity supply compared to the supply from the existing diesel generators. On the other hand, sudden expansion of the power transmission and distribution network may easily cause electricity shortages for the entire national grid, especially in the dry season. This naturally requires a secure, continuous supply. The current choice in which the power source completely depends on IPP and imports is not necessarily the only way to avoid an intermittent electricity supply from the energy security point of view, yet it should be one of the effective options in the process of promoting electrification. From the above, the direction to preferentially consolidate the transmission and distribution network can be regarded as reasonable.

2.3.1.2 Interconnection line with neighbouring countries

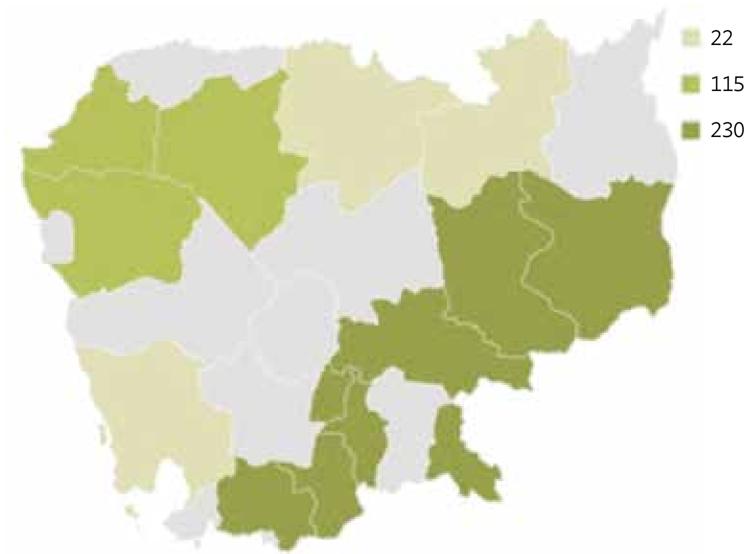
In 2016, Cambodia connected regional countries via several transmission lines.[3] The importing of electricity from Thailand, Viet Nam, and the Lao PDR started at the end of 2007, in 2009, and 2010, respectively. Electric power between Cambodia and Thailand is transmitted at the 115 kV and 22 kV levels. The 115 kV transmission line from Aranya Prathet substation, connecting Thailand to Banteay Meanchey, Battambang, and Siem Reap, was commissioned in 2007. An agreement was signed with Trat Province (Thailand) to supply power to Koh Kong Province and Poi Pet via the 22 kV line. EDC imported power from Viet Nam via a 230 kV transmission line to supply Phnom Den, Takeo Province, and Phnom Penh in March 2009. Since 2002, EDC has imported power from PC2 (Viet Nam) to supply power to Memut and Pnhea Krek Districts of Kampong Cham Province, Bavet in Svay Rieng Province, Kampong Trach in Kampot Province, Koh Thom and Chrey Thom in Kandal Province, Snuol District in Kratie Province, Keo Seima District in Mondulkiri

[3] http://lab.fs.uni-lj.si/kes/erasmus/The%20Cost%20of%20Power%20Generation.pdf

Province, and Kompong Ro in Svay Rieng Province. The 22 kV interconnection line from the Lao PDR to Stung Treng was charged in 2010. In 2015, a new interconnection point from Champasak Province, Ban Hat Substation, Lao PDR, to Kampong Sralu, Preah Vihear Province, Cambodia, was created and the initial design and construction for the 115 kV transmission line was energised at the 22 kV voltage level for the first stage until the transmission line from the Lao PDR border to Chey Sen Substation was completed.

Figure 2.9 shows the areas of electricity imports from neighbouring countries. Each connection between countries has a different grid standard (voltage control or frequency control, etc.) due to the different demand in each area. Therefore, to connect to the national grid and start multilateral trading, harmonisation of the grid standard is needed.

Figure 2.9 Power Installed in Provinces via Several Voltage Interconnections from Neighbouring Countries



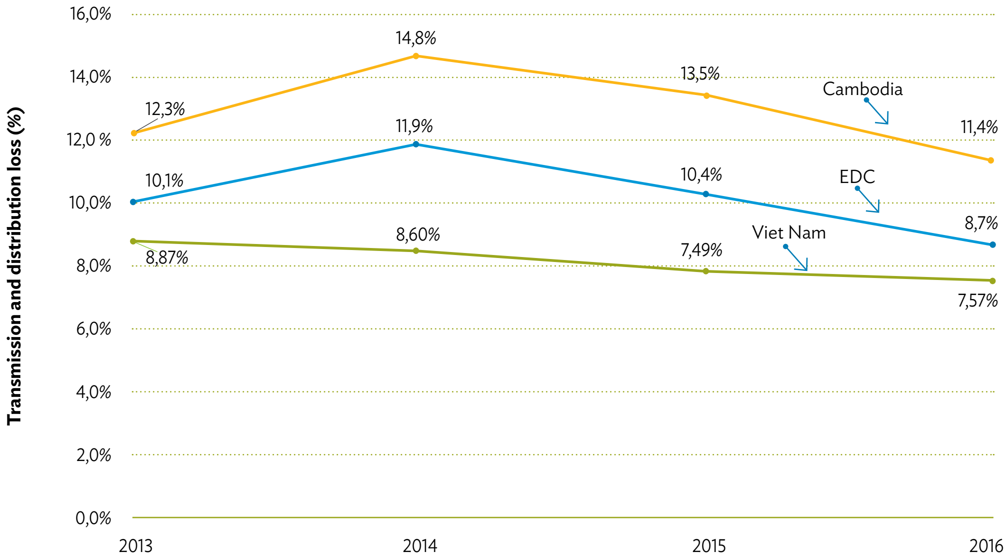
Source: Electricite Du Cambodge (2016) and Electiricty Authority of Cambodia (EAC) (2017).

In order to achieve affordable electricity and to ensure regional energy security by promoting the efficient utilisation of resources in the future, it is recommended to conduct not only bilateral trading but also multilateral trading amongst GMS and ASEAN countries. In the case of Cambodia, although improving the national grid connection, transmission capacity, and interconnection capacity are prioritised projects, Cambodia should conduct a study and trading trial for exporting electricity to neighbouring countries in a parallel way. This would improve connections to the national grid and improve access to energy services in the region.

2.3.1.3 Transmission and distribution loss

Figure 2.10 shows the transmission and distribution loss from 2013 to 2016 for Viet Nam as a reference. The whole country received electricity not only from EDC but also another rural electricity enterprise (REE) distributor. Based on this figure, the transmission loss of the whole country was higher than for EDC. If the whole country can connect to the EDC grid in the future, the difference in the loss between the two lines in the graph will be reduced to the loss by EDC.

Figure 2.10 Transmission and Distribution Loss, 2013–2016



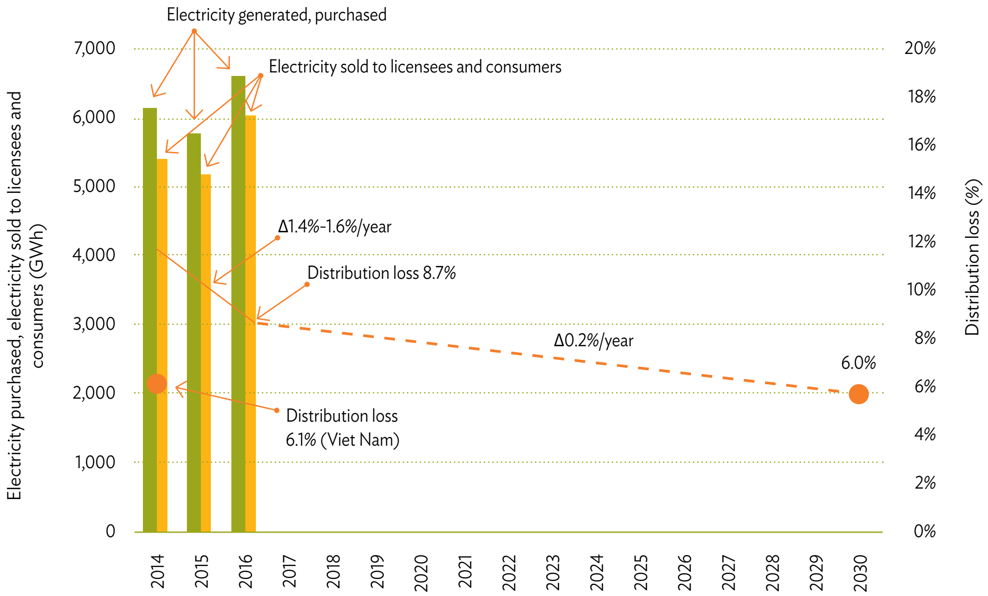
EDC = Electricite du Cambodge.

Source: Electricite Du Cambodge (2016) and EVN (2017a).

Figure 2.11 shows the distribution losses from 2014 to 2016.[4] A higher bar represents purchased energy, while a lower one represents sold energy. The decreasing line is the distribution losses in total by year. At the end of 2016, the Cambodia system distribution loss was 8.7%, which was higher than the distribution loss for Viet Nam (6.1% in 2014, falling in 2016 as an assumption). Therefore, improvement in the quality of electricity (stable voltage level and frequency) through distribution network development is needed for the distribution loss to decrease to be the same as the percentages in neighbouring countries. The distribution loss percentage decreased by 1.4%–1.6% per year from 2014 to 2016. Reducing the loss requires more efforts. Hence, we assume the decreasing percentage is 0.2% per year until 2030 towards 6.0% distribution losses in 2030.

[4] https://www.egat.co.th/en/images/annual-report/2017/egat-annual-eng-2017.pdf

Figure 2.11 Distribution Losses



Source: Author (outcome of the dialogue with the Ministry of Mines and Energy); Electiricty Authority of Cambodia (EAC) (2017); and Asian Development Bank (ADB) (2016).

To improve the distribution losses, the development of distribution lines, maintenance of infrastructure, and standards for distribution equipment are necessary. Table 2.9 shows the distribution network support projects until 2020. In 2012, the Asian Development Bank (ADB) supported the improvement of the electrification rate in some provinces, and today, the Japan International Cooperation Agency (JICA) currently supports the Phnom Penh distribution system until 2020. It is recommended to continue long-term relationships with external support and the development of guidelines for maintaining distribution quality.

Table 2.9 Distribution Network Support Projects

Year	Project	Province	Development partner
2014	Rural Energy Project	Svay Reing	ADB
2016	Second Power Transmission and Distribution Project	Shihanoukville Kampot	ADB (31%) JICA (43%) EDC (21%)
2018	Medium-Voltage Sub-transmission Expansion Sector Project	Kampong Thom Kampong Cham Siem Reap	ADB
2020	Transmission and Distribution System Expansion Project (Phase 2)	Phnom Penh	JICA

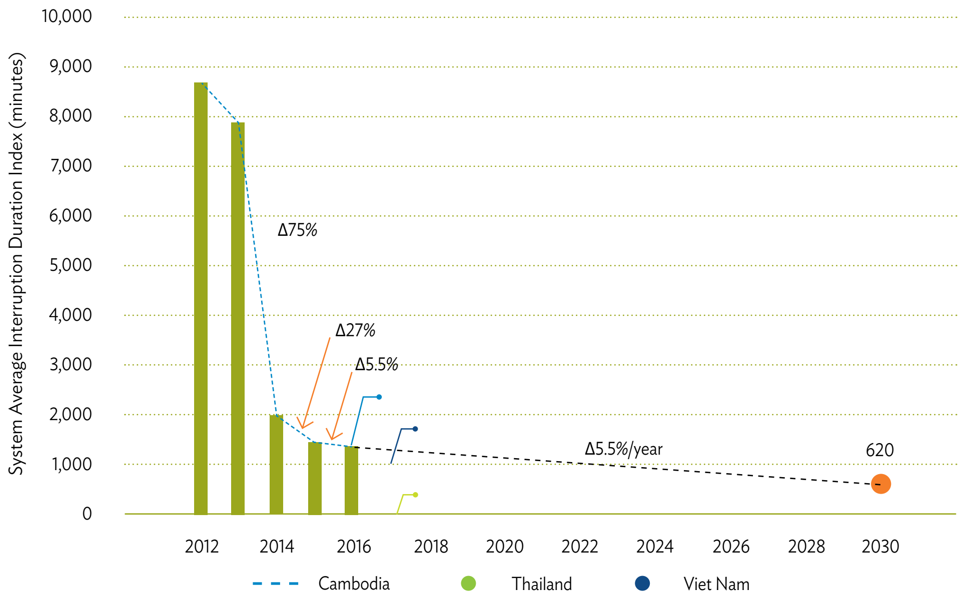
ADB = Asian Development Bank, EDC = Electricite du Cambodge, JICA = Japan International Cooperation Agency.

Source: Kingdom of Cambodia (2014).

2.3.1.4 System Average Interruption Duration Index and Frequency Index

The System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI) are commonly used indicators for monitoring the reliability of distribution systems and the actual situation of the stable power supply at affordable prices. It is recommended to improve the reliability of power statistics by decreasing the number of minutes and times by years represented in the SAIDI and SAIFI. Figure 2.12 and Figure 2.13 show the progress of the SAIDI and SAIFI from 2012 to 2016, with Viet Nam in 2017 as a reference.[5] The SAIDI and SAIFI decreased from 2012 through increasing electricity capacity. The SAIDI decreased by 5.5% and the SAIFI decreased by 6.5% from 2015 to 2016. If the SAIDI and SAIFI are planned to decrease by the same percentages, 5.5% per year and 6.5% per year from 2016 to 2030, there would be a high possibility of achieving less than 620 minutes for the SAIDI and less than 7.3 times for the SAIFI in 2030. As a further improvement, it is suggested to ameliorate the reliability of the transmission system, such as by improving the relay system, expanding transmission lines, and establishing new grid substations.

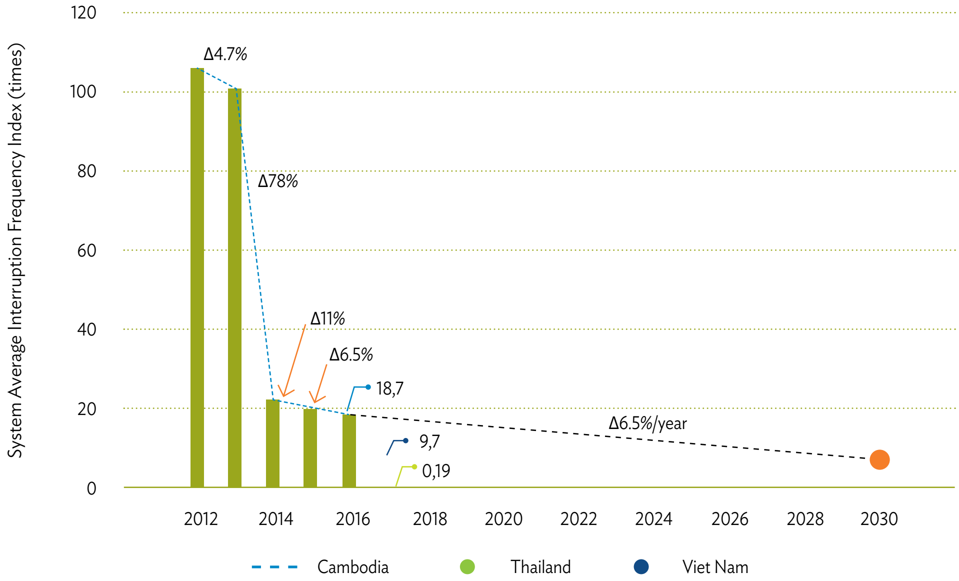
Figure 2.12 System Average Interruption Duration Index (minutes)



Source: Electricity Generating Authority of Thailand (EGAT) (2017); EVN (2017a); and Kingdom of Cambodia (2012).

[5] https://en.evn.com.vn/userfile/User/huongbtt/files/2018/2/AnnualReport2017.pdf

Figure 2.13 System Average Interruption Frequency Index (times)



Source: Electricity Generating Authority of Thailand (EGAT) (2017); EVN (2017a) and Kingdom of Cambodia (2012).

2.3.1.5 Household electrification rate and national grid quality

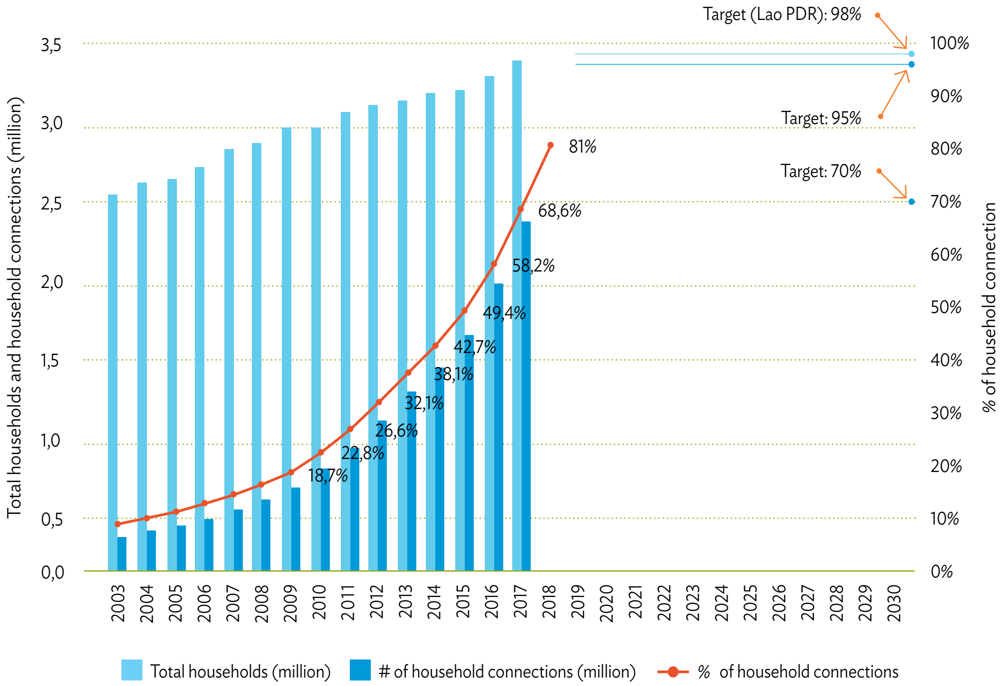
On 30 November 2011, the Government of Cambodia issued the Strategy and Plan for Development of Rural Electrification in the Kingdom of Cambodia (SPDR), a specific strategy and plan to achieve essential targets for rural electrification as prakas (ministry ordinance). This plan was discussed by the Ministry of Mine and Energy (MME), Electricity Authority of Cambodia (EAC), Rural Electrification Fund (REF), and Electricite du Cambodge (EDC) based on the results obtained through cooperation with international organisations and set up as the national goal according to the SPDRE. Under the plan, each organisation is supposed to take action for the targets below:

- Village areas: Achieve an electrification rate of 100%, including battery illumination, by 2020.
- Household electrification: Achieve an electrification rate of at least 70% connection to the national grid by 2030.

Regarding the grid extension, which is the best method for electrification, 80% and 95% of all villages will receive electricity supply from the national grid or from neighbouring countries by 2020 and 2030, respectively, if the government receives funding support to extend the grid. The target is for 70% of households to connect to the national grid by 2030.

Figure 2.14 shows the progress of household electrification until 2018.[6,7] Compared with the target for 2030, which is 70% electrified households, household electrification in 2018 is 81%. In other words, the percentage for 2018 is beyond the target of 70% in 2030. The national grid connection is associated with affordable prices, sustainable supply, and high security. Thus, the target by 2030 should be re-planned to reach over 70%. The new target was set in our meeting with the MME, which is 95% in 2030.

Figure 2.14 Number of Households and the Electrification Rate



Source: Author (outcome of the dialogue with the Ministry of Mines and Energy); Killeen, P. (2013); and EAC's Consolidated report for year 2017.

The targets by 2030 are summarised below.

Targets by 2030

- Transmission and distribution loss: less than 8%
- SAIDI, SAIFI: Less than 620 minutes and 7.3 times, respectively
- Household electrification rate: Change from 70% to 95% of households connected to the national grid

[6] https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf
[7] http://www.worldwatch.org/system/files/Laos%20Atlas%20Case%20Study%20FINAL.pdf

2.1.1 Necessary action plans and policies

In order to reach the targets by 2030, the following action plans and policies are necessary.

Achieve less than 8% transmission and distribution losses

To reduce transmission and distribution losses, establishing equipment standards, changing to higher voltage transmission lines, and utilising materials that cut heat loss are recommended. A 500 kV transmission line will be constructed from 2019 to 2025, which will contribute to reducing transmission losses.

- Action 1: Establish equipment standards.
- Action 2: Change to a higher voltage transmission line.
- Action 3: Utilise materials for cutting heat loss.

Achieve less than 620 minutes for the SAIDI and 7.3 times for the SAIFI

To improve the SAIDI and SAIFI, we recommend ameliorating the reliability of the transmission system, such as improving the relay system, expanding transmission lines, and establishing new grid substations.

- Action 1: Build-up the transmission and substation systems (e.g., indoor transmission, two lines/loop connection).
- Action 2: Adopt supervisory control and data acquisition and distribution management systems.
- Action 3: Use underground electric cables.

Achieve 95% of households connected to the national grid

To achieve the recent target for household electrification of 95% of households being connected to the national grid by 2030, continuing national grid expansion and conducting a national grid expansion study, including on grid reliability and multilateral trading amongst neighbouring countries, are needed. The current national transmission master plan will be finalised by 2021 or 2025.

- Action 1: Continue the national grid expansion.
- Action 2: Update the current national transmission master plan, considering grid reliability and multilateral trading amongst neighbouring countries.

2.1.2 Roadmap

For the necessary action plans and policies, the recommended roadmap is as follows.

Short term, 2019–2022:

- Establish equipment standards for the transmission and distribution networks with implementation of the national transmission master plan.
- Study improvements in transmission and distribution losses, SAIDI, and SAIFI.
- Set a new target of national grid electrified households.

Medium term, 2023–2026:

- Continue implementation of the national transmission master plan.
- Consider implementation of a study (transmission and distribution losses, SAIDI, and SAIFI).
- Develop and maintain standardised substations and distribution lines in each province.

Long term, 2027–2030:

- Grid guidelines by the MME for maintaining the quality of electricity.
- Set the next goals for achieving further benefits from electricity.

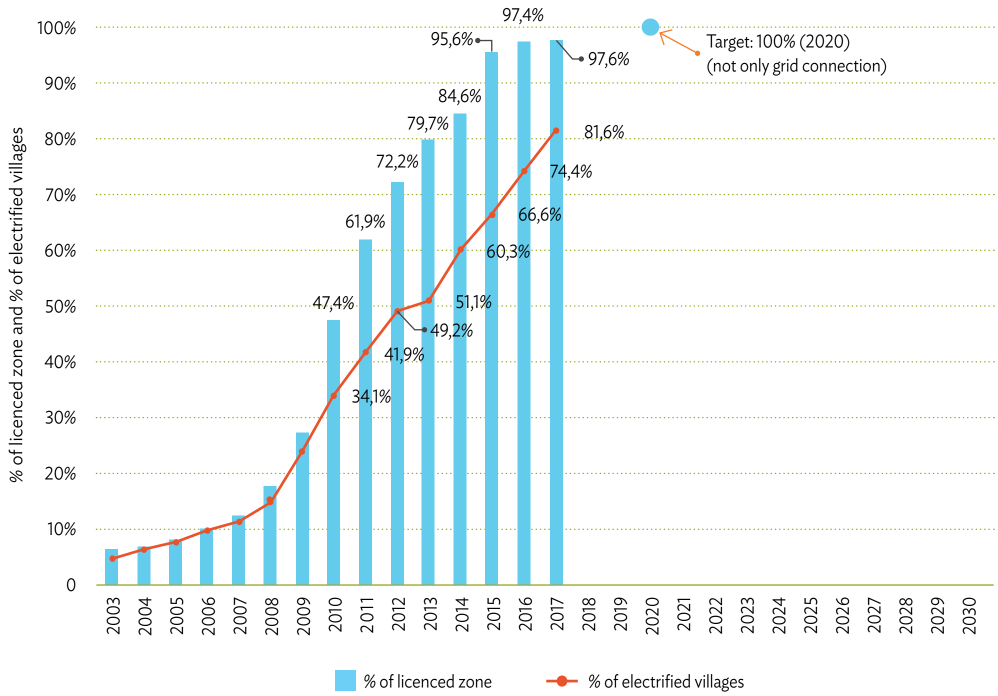
2.4 Distribution and tariffs

The Cambodian government's plan will ensure all villagers will have access to electricity by 2020.[8] The growth in distribution network development and village electrification is shown in Figure 2.15, which presents the shares of grid connections and dispersed power sources. The vertical lines show the share of licenced zones as a bar graph and the share of electrified villages as a line graph. In the last 10 years, electrified zones increased significantly. In 2017, the percentage of achieved electrification licenced zones was 97.6% and the electrified villages rate was 81.6%. According to government plans, the target for the electrified villages rate is 100% in 2020.

The distribution of licenced zones granted and the megavolt (MV) backbone of electrical energy supply system constructed by the end of 2016 are shown in Figure 2.16.[9] In 2016, Cambodia reported that 81.58% (11,558) of villages in the country had access to electricity via the distribution network in operation, and 15.85% (2,245) of villages were related to the distribution network. Looking at the remaining electrification area, 2.37% (336) of villages live without the benefit of electricity.

8 https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf
9 https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf

Figure 2.15 Progress of Distribution Network Development and Village Electrification

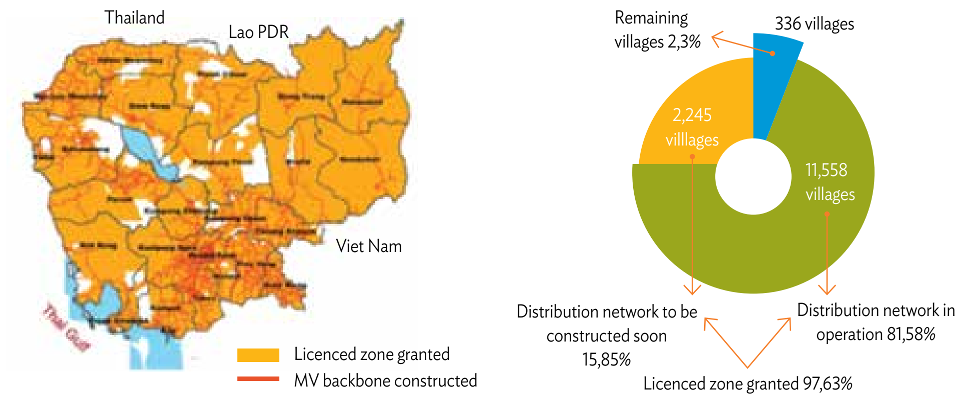


Source: Author (outcome of the dialogue with the Ministry of Mines and Energy) and EAC's Consolidated report for year 2017.

Figure 2.16 Distribution of Licenced Zones and the State of Electrification at the End of 2016

Distribution of licenced zones granted and MV backbone constructed for year-end 2016

Situation of electrification in Cambodia (city + rural as of December 2016)



MV = megavolt.

Source: EAC's consolidated report for year 2017.

2.4.1 Targets by 2030

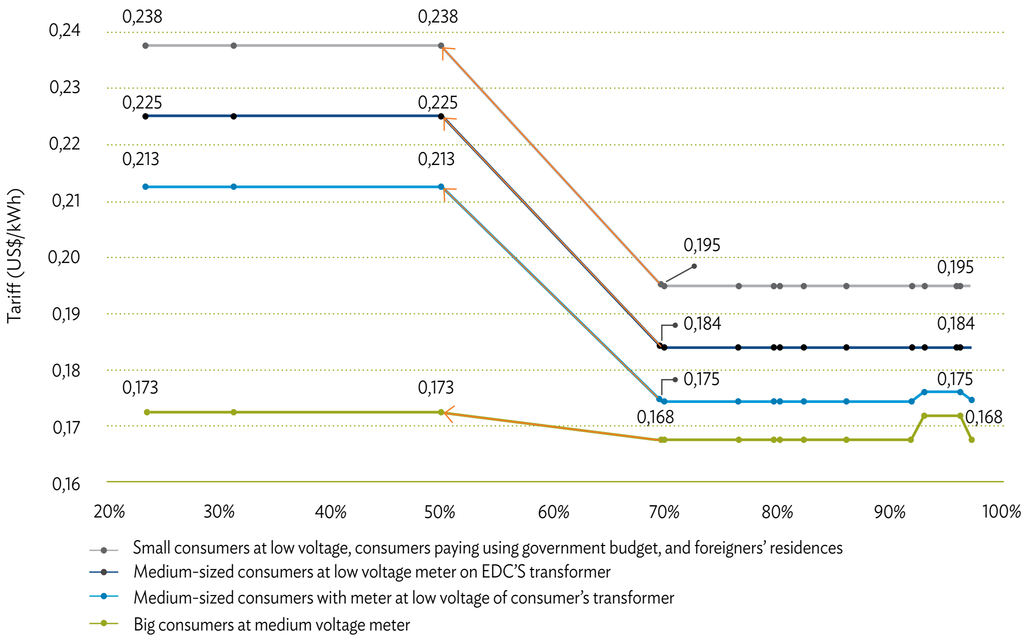
To achieve the targets of the basic energy plan by 2030 of affordability, sustainability, and security, the content should consider not only expanding electrification but also electricity tariffs, especially in rural areas. Cambodia's electricity tariffs are higher than in neighbouring countries, and electricity tariffs in rural areas are higher than in urban areas due to the dependency on high-cost generation, such as small generation systems running on imported diesel fuel, high distribution network power losses, and the lack of subsidies.

2.4.1.1 Tariff differences between urban and rural areas

Figure 2.17 shows all administration, commercial, and industrial consumer tariff differences for villages covered by electricity licenced areas.[10] These tariffs decrease when the covered villages are over 50%. The cost of electricity from own generation, purchases from IPP, and purchases from neighbouring countries or other licensees are the largest components of the cost of electric supply by licensees to the consumers. Hence, the tariffs for electricity depend on the cost of the electricity generated or purchased. With the development of a grid system, the tariffs of licensees purchasing electricity from the grid have become stable. Therefore, the higher percentage of villages covered, the lower the applied tariffs. The tariff differences are 1.03 times for the yellow line and 1.22 times for the remaining lines. In association with the graph, the tariffs also depend on the electricity sources purchased or utilised by licensees. For instance, if diesel/heavy fuel oil (HFO) is utilised, the tariff will be calculated based on it. Generally, diesel costs are higher than other sources and, eventually, the grid connection must be considered from the cost perspective.

[10] 'Salient Features of Power Development in Kingdom of Cambodia', EAC's Consolidated Report for 2017.

Figure 2.17 Difference in Tariffs by Percentage of Villages Covered by Electricity Licenced Areas



Source: EAC's Consolidated report for year 2017 and Electiricty Authority of Cambodia (EAC) (2017).

2.4.1.2 Times of use for tariffs

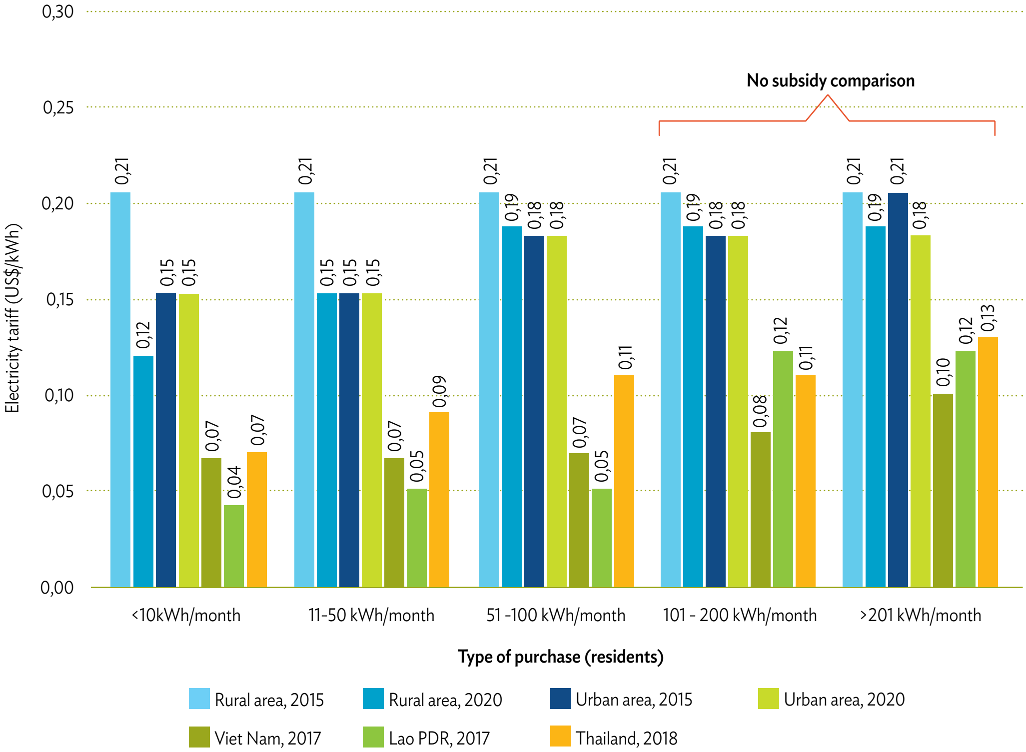
From the above reasonable facts, Cambodia is trying to reduce electricity tariffs. In accordance with the Ministry of Mine and Energy's Prakas (regulation) No. 0094 dated 24 February 2015, the government set out a tariff reduction plan for electric power from the national grid for 2015–2020. Figure 2.18 shows the plan for household tariff reductions from 2015 to 2020 with neighbouring countries as references.[11,12,13] In 2015, the rural and urban area tariffs for electricity usage <10 kWh/month were US$0.205/kWh and US$0.1525/kWh, respectively. The purchase-type tariffs of <10 kWh/month and 11–50 kWh/month had the largest tariff gaps between the rural and urban areas in 2015. In this case, the purchase type >201 kWh/month had no gap between these two areas. According to the reduction plan, such gap is expected to decrease drastically in 2020, with the purchase type <10kWh/month. The subsidised price for only small-type purchases is included in the electricity tariff of neighbouring countries (Thailand, less than 90 kWh/month; Viet Nam, less than 50 kWh/month).[14,15,16] Despite the plan to decrease

11 https://en.evn.com.vn/d6/gioi-thieu-d/RETAIL-ELECTRICITY-TARIFF-9-28-252.aspx
12 https://policy.asiapacificenergy.org/node/580
13 http://www.boi.go.th/index.php?page=utility_costs
14 https://hal-enpc.archives-ouvertes.fr/hal-01572126/file/main.pdf
15 http://www.eria.org/RPR_FY2015_No.21_Annexes.pdf
16 https://www.iisd.org/gsi/sites/default/files/ffs_thailand_czguide.pdf

the tariff for rural areas in 2020 for all purchase types, the tariff is still higher than the tariff in neighbouring countries.

For increasing the priority of defraying rural area electricity costs, it is recommended to conduct cross-subsidies between high and low electricity consumption.

Figure 2.18 Electricity Tariff Differences for Households



Source: EAC's consolidated report for year 2017; EVN (2017b); Policy.Asiapacificenergy (n.d.); and Thailand Board of Investment (n.d).

At its 267th Session, held on 28 August 2014, the EAC approved a time-of-use (TOU) tariff for MV consumers of the EDC supply. The TOU tariff approved is shown in Table 2.10. The TOU tariff is optional, which means it will be an applicable option for MV consumers. For example, if a province is connected at the MV to a grid substation of the national grid, the tariff will be decreased from US$0.139/kWh (during the day time, 7am to 9pm) to US$0.095/kWh (night time, 9pm to 7am). Without the TOU, the basic tariff will be decreased only from US$0.129/kWh to US$0.126/kWh in 2020 by the tariff reduction plan. Conceptually, this TOU tariff is applied for suppressing the electricity utilisation of peak demand under current circumstances. The TOU tariff is expected to become the time-of-day rate system in the future.

Table 2.10 and Figure 2.19 show the MV tariff differences between rural, grid-connected, and urban areas planned until 2020, along with neighbouring countries as references.[17,18] The MV tariff of each rural, national grid, and urban area has been planned to decrease from 2015 to 2020. However, the electricity tariff in Cambodia is still the highest amongst its neighbouring countries despite TOU implementation or after the cost reduction plan to 2020. In terms of achieving affordable tariffs, these TOU and cost reduction plans should be extended to 2030.

Table 2.10 Time-of-Use Tariffs

Applicable to MV consumers	Tariff of use (US$/kWh)	
	7:00–21:00	21:00–7:00
Connected at MV to grid substation of national grid	0.139	0.095
(Ref.) Without TOU tariff in 2015	0.129	
(Ref.) Without TOU tariff in 2020	0.126	
Connected at MV to sub-transmission line of national grid	0.179	0.140
Connected at MV to substation of Phnom Penh system	0.175	0.135
(Ref.) Without TOU tariff in 2015	0.177	
(Ref.) Without TOU tariff in 2020	0.162	
Connected at MV to sub-transmission line of Phnom Penh system	0.190	0.150

TOU = time of use.

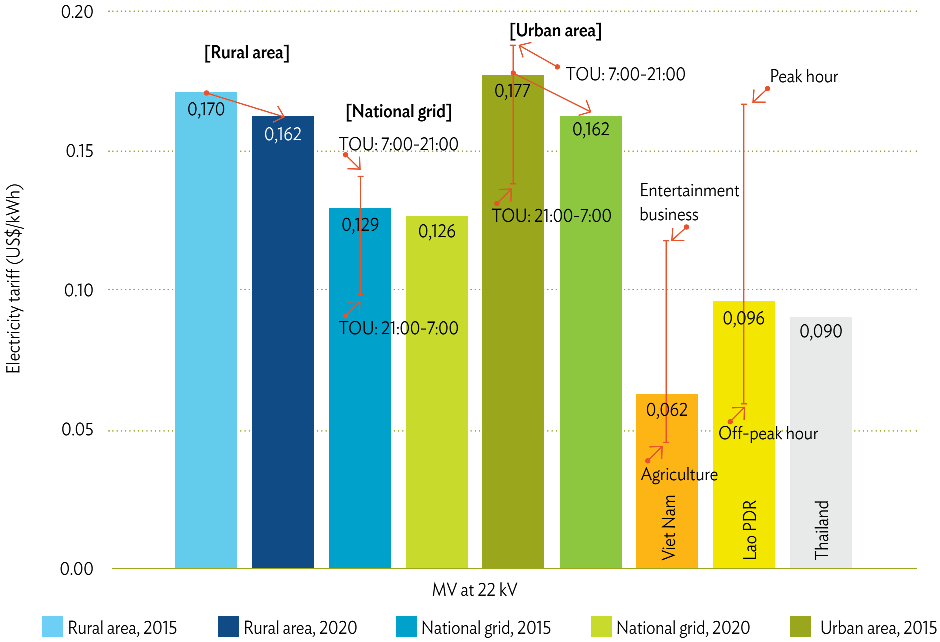
Note: The sub-transmission line is part of an electric power transmission system that runs at relatively lower voltages. It is uneconomical to connect all distribution substations to the high main transmission voltage because the equipment is larger and more expensive.

Source: EAC's consolidated report for year 2017.

17 https://www.egat.co.th/en/images/annual-report/2017/egat-annual-eng-2017.pdf

18 https://en.evn.com.vn/userfile/User/huongbtt/files/2018/2/AnnualReport2017.pdf

Figure 2.19 Electricity Tariff Differences in the MV at 22 kV



MV = megavolt, TOU = time of use.

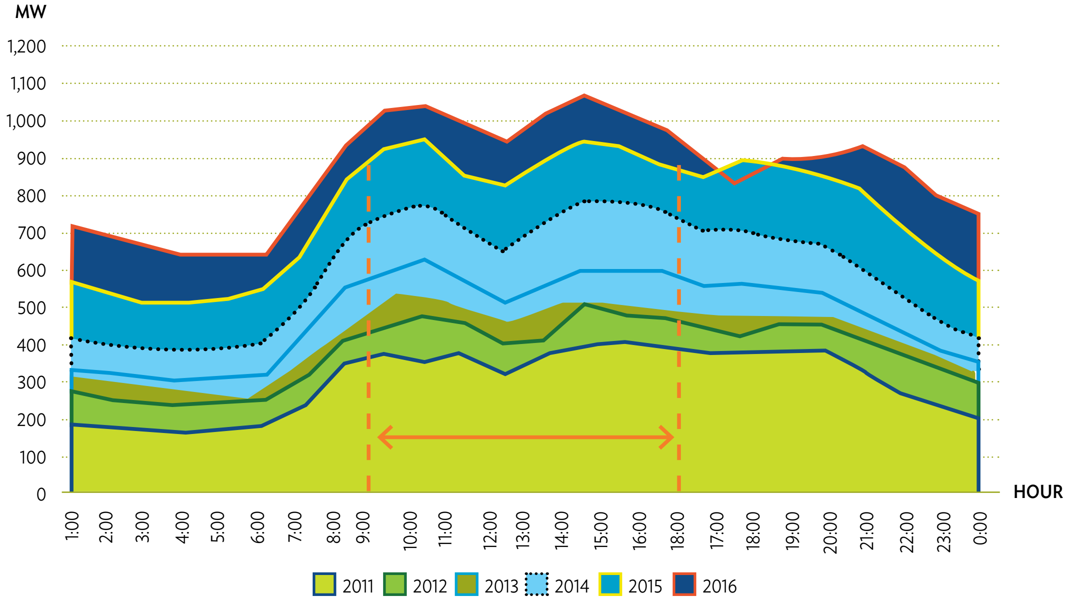
Source: EAC's consolidated report for year 2017; Electricity Generating Authority of Thailand (EGAT) (2017); EVN (2017a); and Policy. Asiapacificenergy (n.d.).

The implementation of the TOU has a positive impact. This can be seen in Figure 2.20, showing peak demand curves for a whole day for 2011–2016.[19] Throughout the years, the curves fluctuate by hours, and the consumption increases. Due to operational and planned reasons, a flat demand curve will benefit operators and planners who choose a beneficial electricity resource.

To improve this situation, two plans are recommended. The first plan is, as an example, an hourly base tariff system applying tariff differences between day and night periods (TOU). Cambodia is conducting basic actions in the agricultural sector and for MV consumers. Water pump tariffs for agriculture from 9pm to 7am are cheaper than during other times. As mentioned above, the TOU has been applied for MV consumers and is expected to be planned for all low-voltage (LV) consumers.

[19] http://lab.fs.uni-lj.si/kes/erasmus/The%20Cost%20of%20Power%20Generation.pdf

Figure 2.20 Demand Differences

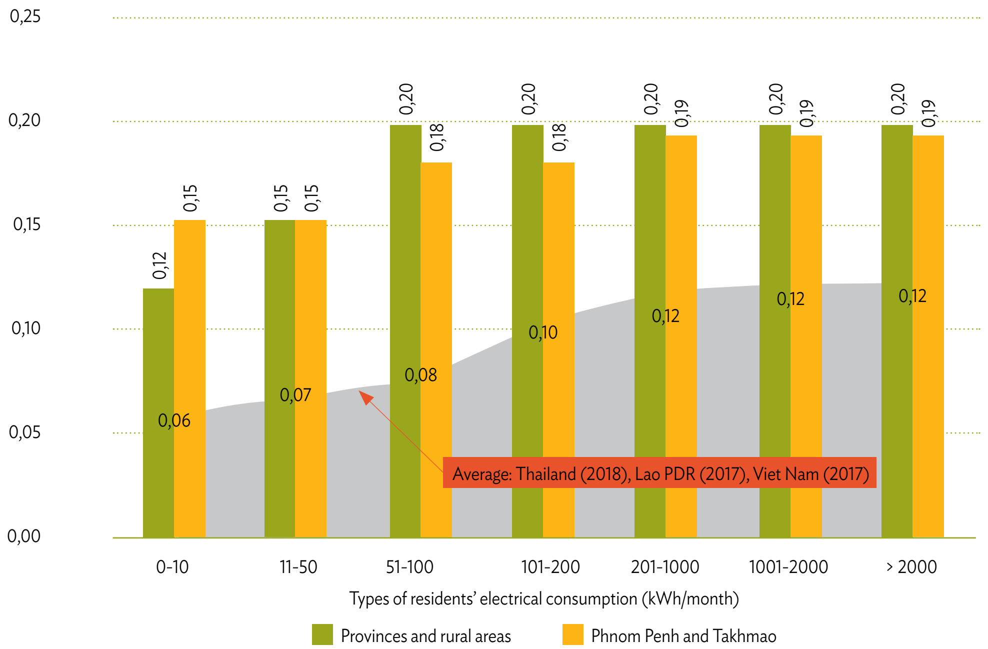


Source: Electricite Du Cambodge (EDC), (2016).

The second plan is for cross-subsidies from high-consumption users to low-consumption users, which increases tariff differences. According to Figure 2.18, the tariffs for electricity use in rural areas for the <10 kWh purchase type in 2020 will decrease more than in urban areas in 2020, although other purchase types of electricity will decrease to almost the same level as the urban tariff in 2020. Figure 2.21 and Table 2.11 show the tariff differences of provinces and Phnom Penh's electrical consumption in 2017.[20,21] The graph shows that the higher the electrical consumption, the higher the applied tariff. Hence, a tariff excess for higher consumption is able to subsidise a tariff for lower consumption.

20 https://www.egat.co.th/en/images/annual-report/2017/egat-annual-eng-2017.pdf
21 https://en.evn.com.vn/userfile/User/huongbtt/files/2018/2/AnnualReport2017.pdf

Figure 2.21 Tariffs for All Types of Residents' Electrical Consumption in 2017



Source: EAC's consolidated report for year 2017; Electricity Generating Authority of Thailand (EGAT) (2017); EVN (2017a); Policy.Asiapacificenergy (n.d.); and Derbyshire, W. (2015).

Table 2.11 Number of Residents Categorised by Capacity of Supply in 2017

Electricity supply (kWh)	Types of residents' electrical consumption (kWh/month)						
	0–10	11–50	51–100	101–200	201–1000	1001-2000	>=2000
Provinces and rural areas							
Number of residents	241,147	902,268	312,543	152,398	90,401	7,564	3,480
Electrical power tariff [US$/kWh]	0.120	0.153	0.198	0.198	0.198	0.198	0.198
Phnom Penh and Takhmao							
Number of residents	116,942	193,369	70,076	92,199	124,200	7,170	2,173
Electrical power tariff [US$/kWh]	0.153	0.153	0.180	0.180	0.193	0.193	0.193
Average tariff (Thailand (2018), Viet Nam (2017), and Lao PDR (2017))							
Electrical power tariff [US$/kWh]	0.060	0.069	0.076	0.104	0.118	0.118	0.118

Source: EAC's consolidated report for year 2017.

To achieve affordable tariffs for residents with low electricity consumption, the case example of cross-subsidies by higher consumption is considered. Table 2.12, Table 2.13, Figure 2.22, and Figure 2.23 show case examples of cross-subsidies for low consumption from high consumption in the rural and urban areas. The targets are set in such a way that the lower tariff is the same as the average of the neighbouring countries. The target of Case 1 is the tariff of '0–10 kWh/month' of electricity consumption, 'US$0.12/month' in the provinces and rural areas, and 'US$0.15/month' in Phnom Penh and Takhmao of 'US$0.06/month'. The target of Case 2 is Case 1 and the tariff of '11–50 kWh/month'. The target of Case 3 is Case 2 and the tariff of '51–100 kWh/month'. Each case is considered to be the same tariff in total. In the most aggressive case, Case 3, the additional tariff is +US$0.32/kWh by over 2,000 kWh/month in the provinces and rural areas. The tariff will be '0.52 kWh/month' from '0.20 kWh/month'. The tariff of less than 100 kWh/month will be the same level as for neighbouring countries.

The acceptable additional tariff in Cambodia can be estimated based on the GDP per capita for Thailand's case.[22] Table 2.14 shows the composition by macroeconomic position in 2018. The maximum cross-subsidy of Cambodia is +US$0.32/kWh (Table 2.12). However, the 1,000 capita of cross-subsidy/GDP per capita shows +US$0.22/kWh, which is still higher than for Thailand. If this case is acceptable, Phnom Penh and Takhmao (Table 2.13) hold the potential for achieving the affordable tariff of less than 100 kWh/month via a cross-subsidy while the provinces and rural areas have the chance to achieve the affordable tariff of less than 50 kWh/month via the cross-subsidy. Therefore, the low consumers are expected to receive the benefits from the cross-subsidy from high consumers in Cambodia.

Table 2.12 Case Example of Cross-subsidy for Low Consumption from High Consumption in Rural Areas

Case	Provinces and rural areas						
	0–10	11–50	51–100	101–200	201–1000	1001–2000	>=2000
1	-0.06 (-0.72%) [0.12->0.06]	+0.00 (+0.00%) [0.15->0.15]	+0.00 (+0.00%) [0.20->0.20]	+0.00 (+0.00%) [0.20->0.20]	+0.00 (+0.00%) [0.20->0.20]	+0.00 (+0.04%) [0.20->0.20]	+0.00 (+0.10%) [0.20->0.20]
2		-0.08 (-1.3%) [0.15->0.07]	+0.00 (+0.03%) [0.20->0.20	+0.00 (+0.06%) [0.20->0.20]	+0.01 (+0.10%) [0.20->0.20]	+0.06 (+1.2%) [0.20->0.26]	+0.13 (+2.6%) [0.20->0.33]
3			-0.12 (-2.3%) [0.20->0.08]	+0.01 (+0.15%) [0.20->0.20]	+0.01 (+0.25%) [0.20->0.21]	+0.15 (+2.9%) [0.20->0.35]	+0.32 (+6.4%) [0.20->0.52]

Notes:

Case 1: Electrical consumption (0–10 kWh/month): Tariff 0.12 -> 0.06 US$/kWh

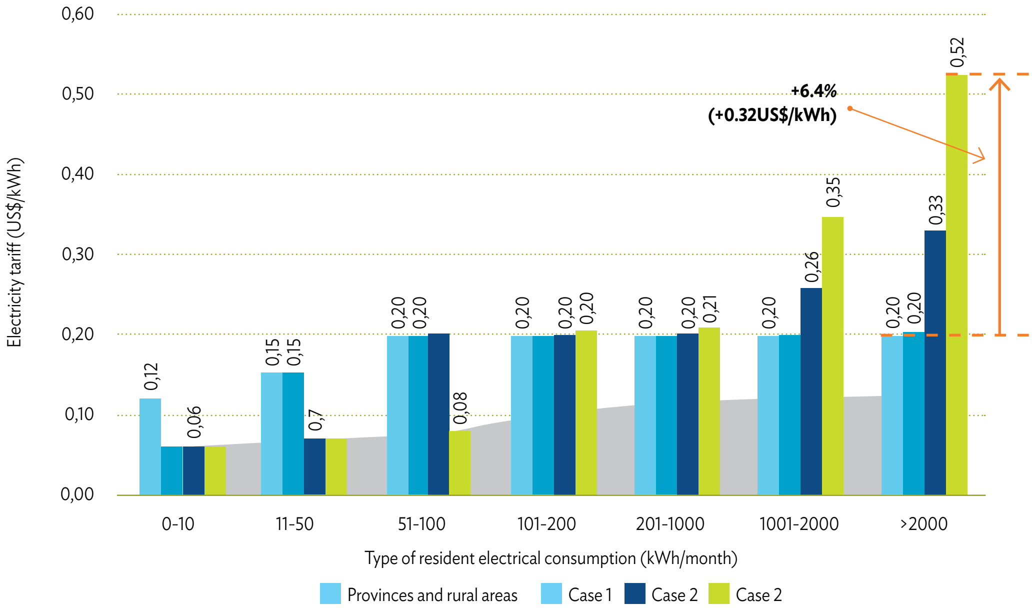
Case 2: Case 1 and electrical consumption (11–50 kWh/month): Tariff 0.15 -> 0.07 US$/kWh

Case 3: Case 2 and electrical consumption (51–100 kWh/month): Tariff 0.20 -> 0.08 US$/kWh

Source: Author (As an outcome of the dialogue with MME, Ministry of Mines and Energy).

22 https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

Figure 2.22 Case Example of Cross-subsidy for Low Consumption from High Consumption in Rural Areas



Source: Author (outcome of the dialogue with theMinistry of Mines and Energy); EAC's consolidated report for year 2017.

Table 2.13 Case Example of Cross-subsidy for Low Consumption from High Consumption in Urban Areas

<table>
<tr><th rowspan="2">Case</th><th colspan="7">Phnom Penh and Takhmao</th></tr>
<tr><th>0–10</th><th>11–50</th><th>51–100</th><th>101–200</th><th>201–1000</th><th>1001–2000</th><th>>=2000</th></tr>
<tr><td>1</td><td rowspan="3">-0.09 (-1.41%)
[0.15->0.06]</td><td>+0.00 (+0.00%)
[0.15->0.15]</td><td>+0.00 (+0.00%)
[0.18->0.18]</td><td>+0.00 (+0.00%)
[0.18->0.18]</td><td>+0.00 (+0.00%)
[0.19->0.19</td><td>+0.00 (+0.03%)
[0.19->0.19]</td><td>+0.01 (+0.12%)
[0.19->0.20]</td></tr>
<tr><td>2</td><td rowspan="2">-0.08 (-1.3%)
[0.15->0.07]</td><td>+0.00 (+0.03%)
[0.18->0.18]</td><td>+0.00 (+0.02%)
[0.18->0.18]</td><td>+0.00 (+0.02)
[0.19->0.19]</td><td>+0.01 (+0.29%)
[0.19->0.21]</td><td>+0.05 (+0.97%)
[0.19->0.24]</td></tr>
<tr><td>3</td><td>-0.10 (-1.8%)
[0.18->0.08]</td><td>+0.00 (+0.05%)
[0.18->0.18]</td><td>+0.00 (+0.04%)
[0.19->0.19]</td><td>+0.03 (+0.63%)
[0.19->0.23]</td><td>+0.11 (+2.1%)
[0.19->0.30]</td></tr>
</table>

Notes:

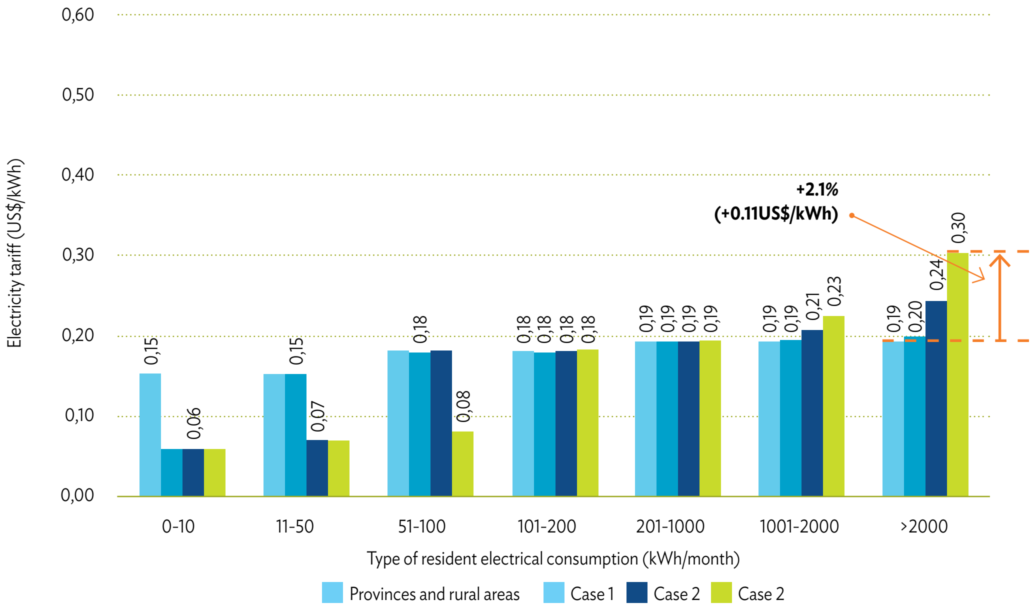
Case 1: Electrical consumption (0–10 kWh/month): Tariff 0.15 -> 0.06 US$/kWh

Case 2: Case 1 and Electrical consumption (11–50 kWh/month): Tariff 0.15 -> 0.07 US$/kWh

Case 3: Case 2 and electrical consumption (51–100 kWh/month): Tariff 0.18 -> 0.08 US$/kWh

Source: Author (As an outcome of the dialogue with MME, Ministry of Mines and Energy)

Figure 2.23 Case Example of Cross-subsidy for Low Consumption from High Consumption in Urban Areas



Source: Author (outcome of the dialogue with the Ministry of Mines and Energy); EAC's consolidated report for year 2017.

Table 2.14 Composition by Macro-economic Position in 2018

Country	Population (millions)	GDP per capita (US$)	Cross-subsidy (US$/kWh)	Cross-subsidy/GDP per capita*1,000 (US$)
Cambodia	16.3	1,485	... +0.32 (Estimated result in 2017)	... +0.22
Thailand	69.2	7,084	... +1.43 (Actual case in 2011 to 2012)	... +0.20

Source: International Monetary Fund (n.d); International Institute for sustainable development (2014).

As described in Figure 2.21, the tariff of Cambodia is higher than that of neighbouring countries despite the continuing increase in electrification rate. The high rates of electricity tariff make Cambodia less competitive in global and regional trade and investment. One factor is due to high generation and transmission costs.[23,24] The main cause regarding the generation cost is the restrictive power purchase agreements, causing unused capacity excess during the rainy season and investment rewards. In order to achieve an affordable tariff, Cambodia should continue national grid expansion and pursue agreements with neighbouring countries to allow exports of surplus generation. In the longer term, Cambodia should actively encourage the expansion of cross-border power trading in the

[23] http://www.seac-cambodia.org/wp-content/uploads/2016/06/Cambodia-in-depth-study-on-electricity-cost-and-supplies-Final-Report.pdf

[24] http://www.adb.org/publications/series/proceedings-meetings-gms-regional-power-trade-coorcination-committee-rptcc

GMS under the institutional arrangements in place and, in particular, the development of shorter-term trading arrangements. This will provide a means for Cambodia to better balance supply and demand on its electricity system.

In most countries around the world, there is a significantly increasing trend in grid-connected distributed generation, and also a decreasing trend in the generation cost of renewable energy. Therefore, it is also necessary to design a framework for considering grid connection.

The heads of ASEAN power utilities and authorities are implementing a study for establishing the institution for the ASEAN Power Grid, named the APG Generation and Transmission System Planning (AGTP) and APG Transmission System Operator (ATSO).[25] This related institution will support establishing the framework and guidelines for a standardised national grid amongst ASEAN countries.

Below are the summarised targets for 2030.

Targets by 2030

- Prolong the tariff cost reduction plan from 2020 to 2030 in terms of obtaining an electricity tariff at an affordable price.
- Consider the extension of a TOU tariff to LV consumers and enhance the tariff differences between high and low consumption.
- Continue to pursue an agreement with neighbouring countries allowing exports of surplus generation.
- Develop the guidelines for standardised grid connection.[26]

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25 Chea Vannak (2017), 'Cabinet approves power projects', *The Khmer Times*, 20 February.

26 http://www.meti.go.jp/policy/trade_policy/apec/img/APEC_Guideline_for_Quality_Electric_Power_Infrastructure.pdf

2.4.2 Necessary action plans and policies

Achieve affordable tariffs

Extending the cost reduction plan to 2030, expanding the TOU to LV consumers, and cross-subsidy tariff considerations are expected to achieve affordable tariffs in Cambodia. Under the electricity law, there are two governmental entities responsible for regulating the electricity supply sector: the EAC and the MME.[27] Possessing different functions and responsibilities, these two institutions are expected to conduct the study of a TOU tariff for LV consumers in the short term. As a result, the tariff will be applied accordingly with the type of electricity consumption.

- Action 1: Consider cross-subsidies from high consumers to low consumers.
- Action 2: Conduct a study of the TOU tariff for LV consumers.

Achieve low generation and distribution costs

- Action 1: Continue to pursue an agreement with neighbouring countries allowing the exports of surplus generation.
- Action 2: Develop the guidelines for standardised grid connection.

2.4.3 Roadmap

According to the necessary action plans and policies, the recommended roadmap will consist of three terms as follows:

Short term, 2019–2022:

- Consider the cross-subsidy from high consumers to low consumers.
- Study TOU tariff for LV consumers and tariff difference expansion.
- Study the guidelines for considering a standardised grid connection.
- Cite ‘cost reduction’ and ‘development distribution network’ as important legislative goals.

[27] http://www.vdb-loi.com/wp-content/uploads/2018/04/Cambodia-Power-Update-April-2018.pdf

Medium term, 2023–2026:

- Prolong the tariff reduction plan as supported by the current study in the short term.
- Amend the electricity regulation to operate a tariff system by the MME and EAC.
- Establish the guidelines for a standardised grid connection.

Long term, 2027–2030:

- MME and EAC operate a tariff system according to electricity consumption from the economic perspective.
- Review on a routine basis every 2–5 years to attain further benefits of electricity.

References

Asian Development Bank [ADB] (2016), *Vietnam Energy Sector Assessment, Strategyy and Road Map*. Manila: ADB. Available at: https://www.adb.org/sites/default/files/institutional-document/178616/vie-energy-road-map.pdf (access 15 February2019).

Breeze, P. (2010), *The Cost of Power Generation*. Warwick: Business Insight. Available at: http://lab.fs.uni-lj.si/kes/erasmus/The%20Cost%20of%20Power%20Generation.pdf (access 15 February2019).

Derbyshire, W. (2015), *Cambodia – In Depth Study on electricity Cost and Supplies Final Report*. Phnom Penh: Solar Energy Association Cambodia [SEAC]. Available at: http://www.seac-cambodia.org/wp-content/uploads/2016/06/Cambodia-in-depth-study-on-electricity-cost-and-supplies-Final-Report.pdf (access 15 February2019).

EAC's Consolidated report for year 2017 (unpublished paper)

Electiricty Authority of Cambodia (EAC) (2017), *Report on Power Sector of the Kingdom of Cambodia, 2017 Edition*, Phnom Penh: EAC. Available at: https://eac.gov.kh/site/viewfile?param=annual_report%2Fenglish%2FAnnual-Report-2016-en.pdf&lang=en (access 15 February2019).

Electricite Du Cambodge [EDC], (2016), *Annual Report 2016*. Phnom Penh: EDC. Available at: http://www.edc.com.kh/images/Annual%20Report%202016%20publish%20English%20version.pdf (access 15 February2019).

Electricity Authority of Cambodia (n.d.) Home Page. Available at: https://eac.gov.kh/site/index?lang=en (access 15 February2019).

Electricity Generating Authority of Thailand [EGAT] (2017), *Annual Report 2017*. Bangkok: EGAT. Available at: https://www.egat.co.th/en/images/annual-report/2017/egat-annual-eng-2017.pdf (access 15 February2019).

EVN (2017a), *Vietnam Electricity Annual Report 2017*, Hanoi: EVN. Available at: https://en.evn.com.vn/userfile/User/huongbtt/files/2018/2/AnnualReport2017.pdf (access 15 February2019).

EVN (2017b), *Retail Electricity Tariff*. EVN website. Available at: https://en.evn.com.vn/d6/gioi-thieu-d/RETAIL-ELECTRICITY-TARIFF-9-28-252.aspx (access 15 February 2019).

IEA, NEA, and OECD (2015), *Projected Cost of Generating Electricity 2015 edition*. Paris: IEA. Available at: https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf (access 15 February2019).

International Institute for sustainable development (2014), *'A Citizen's Guide to Energy Subsidies in Thailand*, Geneva: IISD. Available at: https://www.iisd.org/gsi/sites/default/files/ffs_thailand_czguide.pdf (access 15 February2019).

International Monetary Fund [IMF] (n.d), 'Real GDP Growth', IMF. Available at: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD (access 15 February2019).

Killeen, P. (2013), 'Laos Electrification Rural Program Planning', Report of Program SHS and P2P. Laos: World watch Insititute. Available at: http://www.worldwatch.org/system/files/Laos%20Atlas%20Case%20Study%20FINAL.pdf (access 15 February2019).

Kingdom of Cambodia (2014), *Preparatory survey for Phnom Penh city transmission and distribution system Expansion Project Phase II in the kingdom of Cambodia, final report 2014*, JICA, NEWJEC Inc. The Chugoku Electric Power Co., Inc. Available at: http://open_jicareport.jica.go.jp/pdf/12182697_01.pdf (access 15 February2019).

Policy.Asiapacificenergy(n.d.), LAO PDR: Electricity Price 2018', Available at: https://policy.asiapacificenergy.org/node/580 (access 15 February2019).

Thailand Board of Investment (n.d), 'Utility Cost'. BOI website:http://www.boi.go.th/index.php?page=utility_costs (access 15 February2019).

CHAPTER 3

RENEWABLE ENERGY

3.1 Current situation of renewable energy

Cambodia is blessed with substantial renewable energy sources such as hydro, solar, biomass (including biogas), and wind. However, these renewable energy resources, particularly non-hydro renewable energy, have not yet been tapped to fulfil energy demand in Cambodia. The total primary energy supply (TPES) in 2015 was 7 million tonnes of oil equivalent (Mtoe), supplied by renewable energy (mostly biomass) (62.4%), oil (27.4%), coal (8.3%), and electricity imports (1.9%). In terms of electricity, the total installed capacity in 2015 was 1,657.2 megawatts (MW), coming from hydro (56.1%), coal (24.3%), oil (18.4%), and biomass (1.2%).

(1) Hydropower

In 2006, the Ministry for Industry, Mines and Energy (now known as the Ministry of Mines and Energy) and the Cambodian National Mekong Committee (CNMC) reviewed hydropower and identified 60 possible sites for hydro development in Cambodia with the potential for approximately 10,000 MW of power generation, of which 50% was on the mainstream Mekong, 40% on its tributaries, and 10% in the southwest outside the Mekong Basin. There are about 63 possible sites for small and large hydropower projects throughout the country. However, currently only around 1,330 MW has been tapped, which is only 13% of the potential, and other projects are under development and feasibility studies. The production of electricity from hydropower dams has increased significantly in recent years. For example, hydropower electricity production in 2011 was just 51.5 gigawatt hours (GWh) and increased almost 50 times to 2567.9 GWh in 2016.

(2) Biomass (including biogas)

The potential of biomass mostly comes from a variety of agricultural residues, such as rice husks, cassava, coconuts, and animal waste. Biomass is commonly used in rural areas for cooking. Rural households still rely on traditional biomass energy, mainly fuelwood, as their primary cooking fuel. However, most households burn biomass in traditional ways, by using traditional and inefficient stoves, which produce toxic smoke that pollutes the air inside and outside homes. The toxic smoke can be a major health risk factor in Cambodia, such as for asthma and acute respiratory infections, particularly amongst children. A number of studies show that the use of solid fuels, especially amongst households in rural areas, is closely linked to a high incidence of respiratory diseases. To reduce or mitigate such household pollution, improved or advanced stoves that burn biomass in cleaner and more efficient ways should be promoted.

Biogas from animal waste for generating high-quality gas for lighting and cooking has been used by rural households. Around 25,383 biogas digesters with capacities varying from 2 m^3 to 15 m^3 were constructed in rural areas until 2016.

In terms of electricity, Cambodia has used biomass power plants since 2006 with an installed capacity of 4.50 MW, and this has gradually increased to around 22.64 MW in 2016.

(3) Solar

The average solar radiation in Cambodia is around 5 kWh/day, with an average sunshine duration of 6–9 hours per day, or around 1,400–1,800 kWh/m2. At present, one solar photovoltaic (PV) unit of 10 MW has been installed and connected to the grid, and another three solar PV units with a total capacity of 25 MW are under development. In addition, since 2012, around 48,980 units (5–50 W peak) of solar home systems with a total capacity of 625 kW have been installed in rural areas.

The 2016 Mekong Strategic Partners report projected the potential for solar PV in Cambodia to be 700 MW, which can be installed on 1,400 hectares of land. Solar PV projects are projected to increase. However, as land is a sensitive issue in Cambodia, the development of rooftop solar PV is potentially to be developed for residential buildings and also existing dam reservoirs instead of land.

(4) Wind

Cambodia's wind potential is located mostly in the southern part of the great lake Tonley Sap, the mountainous districts in the southwest and the coastal regions, such as Sihanoukville, Kampot, Kep, and Koh Kong, which have an annual average wind speed of 5 m/s.

3.2 Major issues

Electricity demand in Cambodia has grown at an average of nearly 20% per year since 2010. Electricity demand is mostly supplied by large-scale hydropower and coal-fired power plants. Although Cambodia has the potential for non-hydro renewable energy, such as biomass, wind, and solar, non-hydro renewable energy is not yet utilised optimally due to barriers such as higher up-front costs and no clear target for renewable energy in the energy mix.

(1) No clear target

Renewable energy targets are defined as numerical goals established by governments to achieve a specific amount of renewable energy production or consumption in the entire energy mix (TPES or total final energy consumption [TFES]). They can apply to electricity or heating/cooling or to the energy sector as a whole. For example, Indonesia has set a renewable energy target of 23% by 2025 and Thailand of 40% by 2036, while ASEAN's renewable energy target is 23% by 2025. A renewable energy target sends an important signal to stakeholders, and it plays a significant role in informing investment decisions. Renewable energy targets contribute to developing a clearer vision for the development of the sector and enable stakeholders to allocate funding more effectively. Specific design issues for policymakers to consider include whether the target should be established in absolute terms (a specific quantity of energy to be supplied) or relative to a moving baseline (i.e., in percentage terms) and whether electricity targets should be set in capacity (megawatts) or in output (megawatt-hour) terms. Renewable energy targets need to be accompanied by a clear strategy and backed by specific policies and measures.

Although the Government of Cambodia has issued policies and regulations in the energy sector, some of which are linked to renewable energy utilisation, the government has not yet set a national target for renewable energy utilisation. This means there is no clear signal to stakeholders, particularly to the private sector, to convince them or to guarantee that their investments in renewable energy projects will give them benefits and profit, especially for the national energy supply security.

(2) Lack of policy and regulations to support the promotion of renewable energy utilisation

The Government of Cambodia is committed to implementing sustainable energy security. The government has set up the Cambodia Energy Policy, which aims to provide an adequate supply of energy throughout Cambodia at a reasonable and affordable price; to ensure a reliable and secure electricity supply at a reasonable price, which facilitates investment in Cambodia and the development of the national economy; to encourage exploration and the environmentally and socially acceptable development of energy sources needed for supply to all sectors of the Cambodian economy; and to encourage the efficient use of energy and to minimise the detrimental environmental effects resulting from energy supply and consumption.

The government has also set up policy targets: by 2020, 100% of villages in the country should have access to electricity, and by 2030, at least 70% of the total households in the country should have access to quality grid-supplied electricity. Achieving these targets will depend on the utilisation of all types of electricity sources and the participation of the relevant stakeholders.

The Electricity Law (2001) provides the governing framework for the electricity power supply and services throughout the Kingdom of Cambodia. The law covers all activities related to the supply of electricity, provision of services, and use of electricity and other associated activities in the power sector.

The National Policy on Rural Electrification by renewable energy has the objectives of providing clean, reliable, safe, and reasonably priced electricity in rural areas based on primarily renewable energy in a fair and equitable way.

The Development Plan 2008–2021 projects that 2,770 MW will be constructed in 2020, of which 2,241 MW will be supplied by hydropower.

The National Climate Change Strategic Plan 2014–2023 is a comprehensive national policy that promotes the use of renewable energy to mitigate greenhouse gas emissions. The Government of Cambodia has made a major commitment to reducing the carbon intensity of its energy sector as part of its Intended Nationally Determined Contribution (INDC). Under its INDC, Cambodia proposed a contribution to mitigating greenhouse gases, conditional upon the availability of support from the international community, of a 16% reduction from the 2030 energy sector business-as-usual scenario. The priorities of the INDC actions are the following:

- national grid-connected renewable energy generation (solar energy, hydro, biomass, and biogas);
- connecting decentralised renewable generation to the grid;
- off-grid electricity, such as solar home systems, hydro (pico, micro, and mini); and
- promoting energy efficiency by end users.

In 2013, Prime Minister Hun Sen launched the Cambodian Climate Change Strategic Plan 2014–2023, the National Policy for Green Growth 2013–2030, and the National Strategic Plan for Green Growth 2013–2030, all of which propose policy actions in the energy sector that can support greener, more inclusive growth, including increasing renewable energy deployment, facilitating loans for sustainable projects, and improving the energy efficiency of industries and households.

To realise sustainable energy security, particularly in the field of the power sector, the government set up strategies for developing generation through increasing the diversification of the power supply, such as through hydro, coal power, importing electricity, and other renewable energy sources (biomass, solar, and wind), to meet the electricity demand and reduce oil for power generation. However, since there is no specific target for the renewable energy share in the national energy mix and no clear regulation or policy, the renewable energy business in Cambodia is relatively low, particularly for non-hydro.

The Government of Cambodia ratified the Paris Agreement in 2016 and has agreed to reduce greenhouse gas emissions, but the reduction of greenhouse gas emissions, particularly in the energy sector, cannot be achieved without increasing the utilisation of renewable energy significantly. Therefore, sustainable energy security, environmental protection, and climate change mitigation in Cambodia are major drivers for scaling up renewable energy deployment. The government should take action to develop strong policies, regulations, and incentives for investors to make them more interested in investing in the renewable energy industry. Cambodia has some good experience in implementing renewable energy projects, but it needs to develop policy instruments based on the lessons learned in other countries that have already successfully implemented renewable energy projects. The Ministry of Mines and Energy of Cambodia, together with related institutions, such as the Ministry of Environment, Ministry of Finance, and the Electricity Authority of Cambodia, will start drafting regulations and incentives for renewable energy, such as feed-in tariffs (FITs), reducing import taxes on renewable energy technology/equipment, financing support mechanisms, the simplification of permit procedures, and grid system and renewable energy standards.

3.3 Assessment of the voluntary renewable energy target

Electricity demand in Cambodia has been increasing significantly by around 18% annually from 2010 to 2016. Coal (29%) and hydro (52%) are two primary sources of power, together accounting for 81% of the total installed capacity in 2017, while other renewable power plants using wood and other biomass comprised only 5%. The total installed capacity was 1,867 MW. Cambodia does not have fossil energy resources, so for its coal and diesel power generation, the country imports coal and fuel oil from other countries. To strengthen the national energy security of supply as well as to achieve the national target of emission reduction as already stated in the INDC, the Government of Cambodia should increase the use of renewable energy, which is locally available. The government should reduce the use of coal and diesel power plants. Based on the Cambodia Energy Outlook, the most possible energy mix in the year 2030 comprises hydro at 55% and non-hydro renewable energy at 10% (biomass, solar PV, and wind) of the projected total electricity output of 26.2 TWh.

3.4 Necessary renewable energy policies

To achieve the target as mentioned, there needs to be strong regulation.

(1) Hydro

The average production cost of electricity from hydropower is less than US$0.07/kWh, which is less than the national electricity tariff of US$0.20/kWh. So, from the economical point of view, there is no need for the government to issue new regulation, since hydropower can be developed on a commercial basis. However, hydropower projects are always subject to environmental issues. Most hydropower project developments are strongly opposed by environmentalists and local people. Even a common study by the Mekong River Commission shows that dam construction has negative impacts on the riparian ecosystem, sustainability, and food security associated with fish production in Cambodia. In order to maximise the use of hydropower but minimise its negative impacts, the government needs to have strategies on how to mitigate the predicted negative impacts. For such purposes, the government should issue regulations that guarantee that hydropower project developments comply with all steps to achieve a high-quality environmental impact assessment and also a transparent decision-making process.

(2) Wiser use of biomass through efficient cooking stoves

As mentioned, many rural households rely on biomass, particularly for cooking, by using simple traditional cooking stoves (three big stones). Unaware of the harmful effects of household air pollution, the users of firewood stoves expose themselves daily to toxic smoke, increasing the risk of asthma, lung tuberculosis, and acute respiratory infections, particularly amongst children. A World Health Organization publication (2018) estimates that over 4 million people around the globe die each year from using traditional cooking stoves. Realising the importance of biomass in rural areas, the Government of Cambodia has taken action since some years ago to examine how to use biomass/fuelwood in efficient ways as well as tackle indoor pollution. There are several improved cookstoves that have already been introduced to rural households, such as the New Lao Stove introduced by the Group for the Environment, Renewable Energy and Solidarity in 2003. The New Lao Stove is more resistant and consumes less biomass fuel, using 22% less fuelwood, and each stove saves 0.4 tonnes of CO_2-equivalent per year. In 10 years until 2013, 2 million New Lao Stove units have been distributed by the Group for the Environment, Renewable Energy and Solidarity. Promoting the wide use of efficient biomass cookstoves, particularly in rural areas, requires strong policies and regulations that emphasise improving energy access for remote and poor populations. The policies and regulations should be able to create an enabling environment for developing the biomass cookstove business and markets by providing incentives.

The Ministry of Energy and Mining of Cambodia should take the lead in developing a road map or a master plan to scale up access to clean biomass cooking stoves and developing national standards, testing, and certifications for biomass cookstoves.

(3) Gradual increase of solar PV and wind

At present, the use of solar PV and wind power generation in Cambodia is small compared to other countries, both in the ASEAN region and internationally. The development of solar PV generation is expected to improve the overall energy sector in Cambodia. With the relatively high potential of solar PV and wind power in Cambodia, it is projected that solar PV and wind power will gradually increase, both to strengthen the security of the energy supply and to tackle climate change. The projection is also supported by the decline in cost. The International Renewable Energy Agency states that from 2010 to 2017, the cost of solar fell by 60% and wind by 40%. The predicted cost will continue to fall because of more efficient designs and advances in materials and manufacturing. Solar rooftops will also increase because of the price of land. However, to scale up solar PV and wind power projects will require huge investment. Therefore, cooperation and collaboration with international financing are strongly needed, such as from the Asian Development Bank, World Bank, USAID, Japan International Cooperation Agency, European countries, KfW of Germany, and Agence Française de Développement of France.

(4) Introduction of existing renewable energy policies

In general, renewable energy is mostly claimed to have a high cost of production, which results in a cost per kilowatt-hour of electricity that is relatively expensive compared with that of conventional power plants. On the contrary, renewable energy is clean energy, which means the emissions from renewable energy are very low compared to fossil energy. However, there are still some barriers facing the development of renewable energy projects. To increase renewable energy utilisation, the barriers should be removed by creating an enabling policy environment that can encourage the private sector to participate in investment in the renewable energy projects. Countries with a low level of renewable energy development and small-scale projects, such as Cambodia, need regulations to scale up renewable energy deployment.

In many countries around the world, such as in Europe, the United States, Japan, India, and ASEAN countries such as Thailand, the Philippines, Indonesia, and Malaysia, governments have issued various policies and regulations to scale up renewable energy deployment. Various regulations have been implemented in many countries, such as FITs, Renewable Portfolio Standards (RPS), net metering systems, and other incentives to encourage and scale up renewable energy business.

1) Renewable Portfolio Standards

RPS mandate that certain percentages of all electricity in the country come from renewable energy sources. The RPS mechanism commonly places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. The RPS can be achieved through three mechanisms: (1) by producing renewable energy itself, (2) by purchasing renewable energy produced by another supplier, or (3) by buying renewable energy credit certificates. These certificates are issued to renewable energy producers based on the amount of energy they feed into the grid. Selling the certificates is another way for renewable energy producers to supplement their revenue. The RPS encourages the development of renewable energy markets by ensuring that some specified minimum amount of renewable energy is included in the supplier's portfolio of generating fuels. The RPS can play an integral role in a country's efforts to diversify its energy mix, promote domestic energy production, and reduce emissions. However, the RPS can cause electricity price increases because, in many cases, the cost of electricity from renewable energy is higher than that of conventional energy. This means that consumers will spend more for electricity. In addition, the RPS need transmission and integration system upgrades to enable the absorption of more electricity from renewable energy. Because of the intermittent nature of renewable energy, in terms of planning reserves, as the amount of variable generation gets added to the electricity system, it is possible that more fossil peak-power generation will be needed in order to maintain reserve requirements.

The RPS mechanism has been adopted in many countries. For example, Germany set the RPS at 18%, 30%, and 60%, respectively, in 2020, 2030, and 2050.

2) Feed-in tariffs

FITs are an instrument for encouraging large-scale renewable energy projects since they provide a stable income to developers. A FIT is a fixed price or standard purchasing price that is paid to renewable energy producers for each unit of electricity produced and injected into the electricity grid. A FIT is intended to encourage the adoption of renewable energy by overcoming the high upfront costs of renewable energy projects. FITs offer an effective way of achieving the RPS. FITs are usually differentiated from renewable energy technology due to the differences in generation costs between the renewable energy technology. FITs are also used for the size of the renewable energy project, such as for small and medium capacity.

The payment of the FIT is guaranteed for a certain period of time, which is often related to the economic lifetime of the respective renewable energy project. A FIT is usually paid by the electricity grid system or market operators in the long-term contract of the power purchase agreement.

The level of a FIT is determined on the basis of a calculation of the levelised cost of electricity produced from renewable energy. This allows the renewable energy investor to recover the different costs (capital, operation and maintenance, fuel, and finances) while realising a return on the investment that depends on the assumed financing cost. It is also possible to determine the FIT level by means of a tendering mechanism. As a FIT is a cost-based price, the price for a renewable energy-based power plant will be higher than for a conventional-based power plant or national electricity tariff. As a consequence, the government should allocate budget to cover the gap; or the FIT can be passed through to consumers, and it is possible to increase the electricity tariff.

When introducing a FIT, some key components must be considered:

- Determining a good tariff rate. If the tariff rate is too high, producers will benefit more, but the government will bear or provide more subsidies, or consumers will pay a higher electricity tariff. If the tariff rate is too low, there will be little or no investment.
- Imposing a priority purchase obligation for renewable energy. Grid operators should prioritise connecting and transmitting electricity from renewable resources before energy from other sources.

- Guaranteed tariff rates for a specific time period/length of contract. This ensures the security of investment for producers, investors, and suppliers.
- Determining the renewable energy technologies to be covered.
- The size of the eligible project.

The advantages of FITs include the following:

- Guaranteed long-term contracts (usually 15–20 years).
- Increased drive for technology innovation. Good FIT rates for renewable energy encourage investment in renewable energy business.
- Secure domestic energy supply. Countries will become less dependent on imported fossil fuels when the domestic renewable energy supply market expands.
- Creation of jobs. The growth of the renewable energy market will increase job opportunities. Analysis by the International Renewable Energy Agency has shown that the renewable energy sector is already creating jobs across Southeast Asia, estimated at 611,000 jobs in 2016, of which 362 jobs were in bioenergy, while the rest were in hydropower, solar, wind, and geothermal energy.
- Reduction of CO_2 emissions because renewable energy is from clean energy sources.
- Enables renewable energy technologies to compete with conventional energy sources.
- Easier for developers to get project financing.

The disadvantages of FITs include the following:

- Likely to cause an increase in the cost of electricity for customers unless subsidies or incentives are available.
- Utilities need to improve their grid system to enable absorbing more renewable energy.

REN 21 (2014) states that 73 countries have adopted FITs. The lessons learned from many countries, such as Germany, Denmark, Spain, Japan, India, Thailand, Indonesia, the Philippines, and Malaysia show that FITs have proven to be very effective in speeding the transitions to the use of renewable energy for producing electricity and also for helping society to effectively address climate change. The example of Japan's FIT is shown in Table 3.1.

Table 3.1 Feed-in Tariff for Renewable Energy in Japan, 2012

Resource	JPY/kWh	US$/kWh	Period of contract (years)
Wind			
< 20 kW	55.75	0.735	20
> 20 kW	23.1	0.294	20
Geothermal			
< 15 MW	42	0.534	15
> 15 MW	27.3	0.347	15
Hydro			
>200 KW	35.7	0.454	20
>200 KW < 1 MW	30.45	0.387	20
> 1 MW < 30 MW	25.2	0.321	20
Photovoltaics			
< 10 KW	42	0.534	10
> 10 KW	42	0.534	20

JPY = Japanese yen, kWh = kilowatt-hour, US$ = United States dollar.

Source: IEA, 2017.

3) Net metering

Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. If residential customers have a PV system on their house rooftops, they may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backward to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their 'net' energy use.

Net metering allows utility consumers to generate their own electricity cleanly and efficiently. Net metering is more suitable for small-scale renewable-based distributed generation. During the day, most solar consumers produce more electricity than they consume, which allows them to export that power to the grid and reduce their future bills. As such, solar PV enables local self-consumption that can deliver savings to the grid. This can result in a significant reduction in the monthly electricity consumption of the owner of a solar PV system. It can complement the grid and provide benefits and potential cost reductions for both the end consumers and the grid system. A net metering system is easy and inexpensive. With the net metering system, the installed solar PV does not need a battery backup to store power, meaning that the investment for the solar PV system can be reduced. Net metering increases demand for solar energy systems, which in turn creates jobs for the installers, electricians, and manufacturers who work in the solar supply chain. However, for utility companies, the net metering system means shrinking profits because consumers buy less power from the utility.

4) Financial and fiscal incentives

Financial and fiscal incentives are aimed at decreasing the production cost of renewable energy projects and increasing their affordability and bankability. Financial and fiscal incentives are needed to improve access to capital, lower financing costs, and reduce the burden of the high upfront costs of large-scale renewable energy projects. They can be in the form of tax incentives, rebates, or grants. Tax incentives are typically offered in the form of a reduction in value-added, tax allowance/accelerated depreciation, or investment tax credit. Tax incentives can reduce the cost of renewable energy systems for the developer and can increase their affordability and profitability. Many countries have adopted tax incentives to increase renewable energy deployment.

Table 3.2 Summary of Advantages and Disadvantages of Renewable Portfolio Standards, Feed-in Tariffs, and Net Metering

	Renewable portfolio standards	Feed-in tariffs	Net metering
Advantages	• RPS can play an integral role in countries' efforts to diversify their energy mix, promote domestic energy production, and reduce emissions. • RPS encourage the development of renewable energy markets by ensuring that some specified minimum amount of renewable energy is included in the supplier's portfolio of generating fuels.	• Guaranteed long-term contracts (usually 15–20 years) • Increased drive for technology innovation. Good FIT rates for renewable energy encourage investment in renewable energy business. • Secure domestic energy supply. Countries will become less dependent on imported fossil fuels when the domestic renewable energy supply market expands. • Creation of jobs. The growth of the renewable energy market will increase job opportunities. Analysis by the International Renewable Energy Agency has shown that the renewable energy sector is already creating jobs across Southeast Asia, estimated at 611,000 jobs in 2016, of which 362 jobs were in bioenergy while the rest were in hydropower, solar, wind, and geothermal energy. • Reduction of CO_2 emissions because renewable energy is from clean energy sources. • Enables renewable energy technologies to compete with conventional energy sources. Easier for developers to get project financing.	• Net metering allows utility consumers to generate their own electricity cleanly and efficiently. • Net metering allows consumers to export power to the grid and reduce their future bills. • It can complement the grid and provide potential cost reductions to both the end consumers and the grid system. • The net metering system is easy and inexpensive. • With the net metering system, the installed solar PV does not need a battery backup to store power. This means that the investment for solar PV system can be reduced. • Net metering increases demand for solar energy systems, which in turn creates jobs for the installers, electricians, and manufacturers who work in the solar supply chain.
Disadvantages	• RPS can cause the electricity prices because the cost of electricity from renewable energy is higher than conventional energy. • RPS needs transmission and integration system upgrades to enable the absorption of more electricity from renewable energy. • Because of the intermittent nature of renewable energy, it is possible that more fossil peak-power generation will be needed in order to maintain reserve requirements.	• Likely to cause an increase in the cost of electricity to customers unless subsidies or incentives are available. • The utility needs to improve its grid system to enable it to absorb more renewable energy.	• The utility companies may have shrinking profits because consumers buy less power from the utility.

PV = photovoltaic, RPS = Renewable Portfolio Standards.

Source: Summary taken from section 3.4.

5) Rural electrification

Cambodia as a developing country has many rural areas that have not yet been reached by the national grid. To increase access to electricity, using locally available renewable energy may be a solution. However, the development of renewable energy-based power plants in rural areas may not be commercially viable because people's ability to pay is low.

The Government of Cambodia has set an electrification target of increasing the level of villages' access to grid-quality electricity to 100% by 2020; and at least 70% of all households in Cambodia are to have access to grid-quality electricity by 2030. This means that in 2030, it is projected that around 30% of households will not have access to the grid, and these households will mostly be in rural areas that face difficulty or high costs of being reached by the grid system. For such areas, the implementation of standalone or decentralised systems using renewable energy is an appropriate option. Solar home systems, for example, are standalone systems, and micro hydropower and solar PV decentralised systems may be economical for remote rural households that do not have access to the grid for long periods.

Since the production cost of renewable energy-based power plants is high, and the electricity price from renewable energy is higher, the high cost of providing services to remote areas and the low consumption mean that rural electrification schemes are usually more costly than urban schemes. However, it seems there is a strong correlation between rural poverty and access to electricity because electricity is a pre-requisite for productive activities. Rural electricity programmes seem to be crucial for implementing improved living conditions and promoting production and better health and education for households. However, the electricity tariffs in rural areas do not need to be the same as in urban areas. Rural electricity tariffs should be set at a level that is affordable for the majority of customers. Therefore, to increase the access of rural people to electricity, the government should support rural electrification programmes through collaboration with international banks. For such purposes, the Government of Cambodia, supported by the World Bank, established the Rural Electrification Fund (REF) in 2004. The REF is intended to provide grants for promoting rural electrification by renewable energy technologies. The REF has facilitated access by rural people to electricity through solar home systems by providing subsidies of US$100 per solar home system unit. With the subsidy, solar home systems have become more competitive in rural areas.

Since the government's funding for rural electrification is limited, to accelerate the implementation of rural electrification programmes, the Ministry of Mines and Energy should actively seek international support such as from the Asian Development Bank, the Japan International Cooperation Agency, USAID, Global Environment Facility, the Carbon Fund of the World Bank, and from European countries, such as Germany's GIZ, Denmark, the Netherlands, France, Finland, and Norway, which provide some assistance to developing countries to develop rural electrification. In addition, the government should take into consideration the open access of rural people to microfinance.

3.5 Recommendations

Based on Cambodia's energy situation, in order to speed up the deployment of renewable energy, the government needs to take action, particularly in setting up policy and regulations. For such purposes, we recommended the following measures:

- **In the short and medium terms**
  - → Set up a target for renewable energy in the energy mix for 2030.
  - → Set up regulations on environmental issues for hydropower development.
  - → Set up regulations for using biomass-efficient cooking stoves and developing national standards, testing, and certifications for biomass cookstoves. The government, through the Ministry of Mines and Energy, should actively seek international funding resources (grants and soft loans).

- **In the medium and long terms**
  - → Study to apply FITs (up to a certain capacity, for example a capacity up to 10 MW) for biomass, solar, and wind power generation.
  - → Study to apply a net metering system to encourage the use of solar rooftops.
  - → Study to apply renewable portfolio standards and financing and fiscal incentives.

Reference

International Energy Agency [IEA] (2017] Feed-in Tariff for Renewable Electricity and Solar PV Auction. Access at [https://www.iea.org/policiesandmeasures/pams/japan/name-30660-en.php]. Access date [27 January 2019].

CHAPTER 4

ENERGY EFFICIENCY AND CONSERVATION

4.1 Introduction

Energy is fundamental to a nation's economic development and progress, and it is needed for industry, commercial, and residential activities besides transportation. Therefore, energy security is critical to any nation. Energy efficiency (EE) as discussed in this chapter includes energy efficiency and conservation (EEC). EE may not be attractive as it is not straightforward, and achieving it may involve a combination of measures and technical and financial understanding. It may also involve developing an effective plan for the efficient utilisation of energy. Nevertheless, according to a report by the International Energy Agency (IEA, 2018), it is becomingly increasingly clear that EE can bring many significant economic and environmental benefits.

The energy savings brought about by EE improvement strategies can yield a range of benefits. The benefits of holistic and effective EE plans can be summarised as follows:

(1) Efficient utilisation of energy will improve the self-sufficiency of the energy supply and, hence, energy security.

(2) Efficient utilisation of electricity will delay the planting up of power plants and, hence, reduce the financing burden on the nation and improve the energy economics.

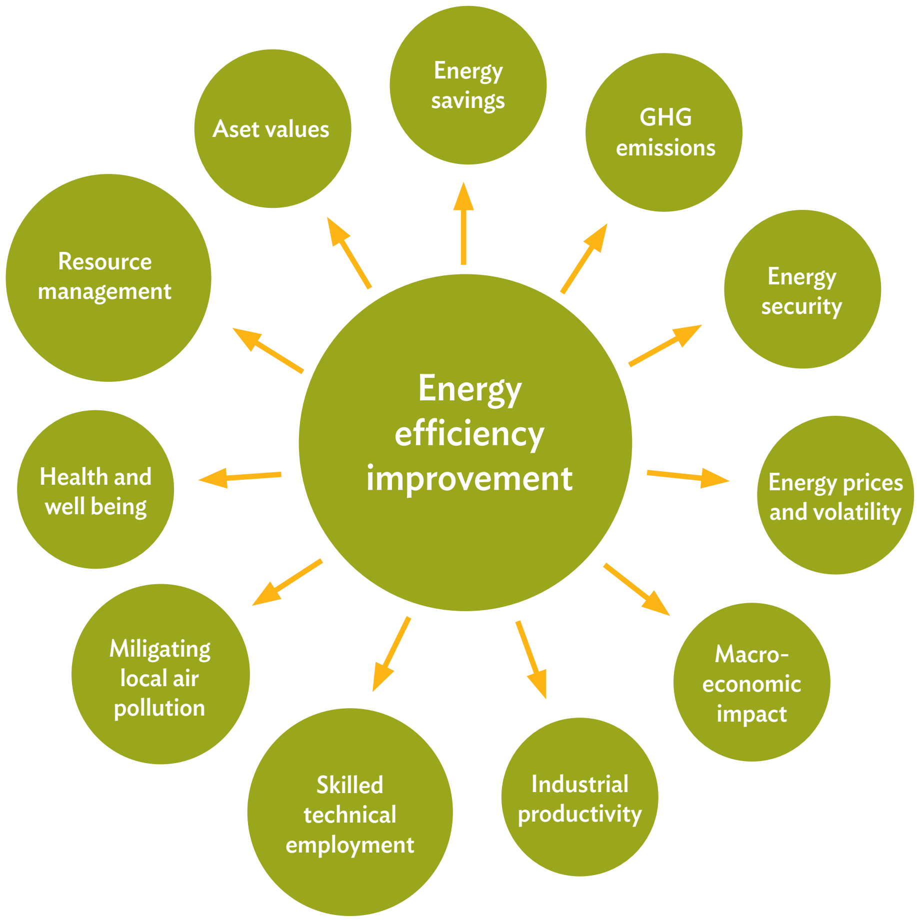
(3) Government policies and energy plans on energy EE will help business organisations improve their energy performance, thus reducing both energy consumption and costs, which can translate into improved productivity, eventually resulting in improved national energy intensity.

(4) Efficient utilisation of energy will help improve the availability of electricity as the available power supply capacities can reach out to a greater proportion of the population. In addition, savings in electricity can delay the planting up of new power plants, which can translate into savings in the financing costs of investments for new power plants.

(5) An overall reduction in national energy intensity will make positive contributions toward reducing the depletion of energy resources and mitigating the effects of energy use, such as reductions in greenhouse gas (GHG) emissions and global warming.

According to the IEA, EE is 'the first fuel'. Strong EE policies are vital for achieving the key energy-policy goals of reducing energy bills, addressing climate change, improving energy security, and increasing energy access. Figure 4.1 shows a summary of the multiple benefits of energy efficiency.

Figure 4.1 The Multiple Benefits of Energy Efficiency

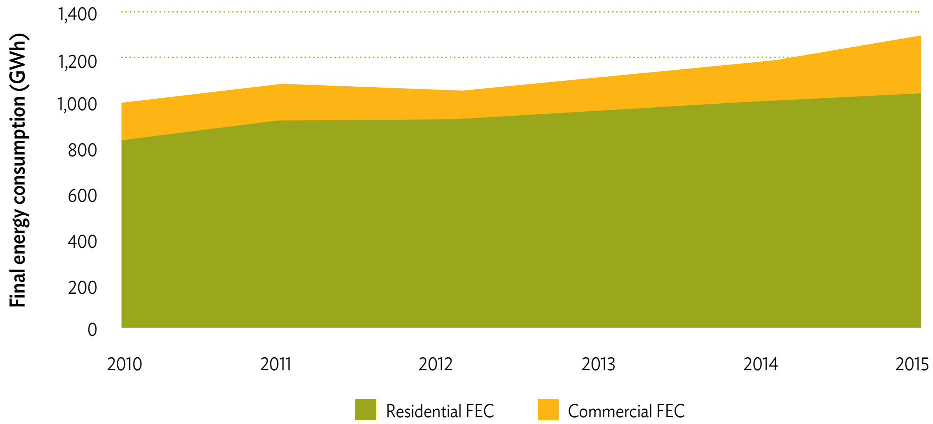


Source: Adapted from IEA (2017).

4.2 Review of the current situation

Based on the historical data from 2010 to 2015, as reported by ERIA (2016), energy consumption in Cambodia has been increasing, as illustrated in Figures 4.2, 4.3, 4.4, and 4.5. The demand for electricity by the residential, commercial, and industry sectors has seen a steeper rise in consumption compared with the overall final energy consumption by all sectors. Figure 4.5 shows that electricity consumption by the residential, commercial, industry, and other sectors in 2015 was more than 2.3 times the demand in 2010.

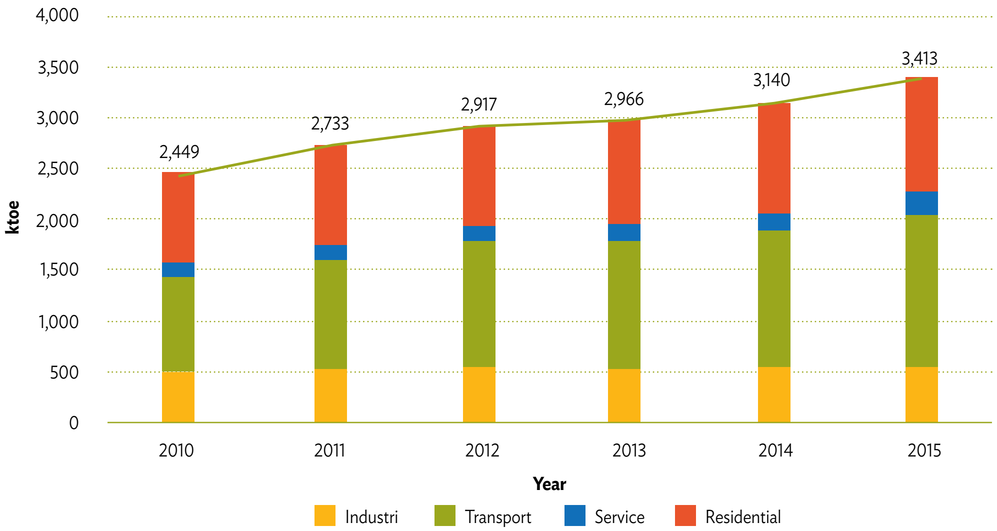
Figure 4.2 Historical Final Energy Consumption by Commercial and Residential Sectors



FEC = final energy consumption, ktoe = kilotonnes of oil equivalent.

Source: Author's calculations; ERIA (2016).

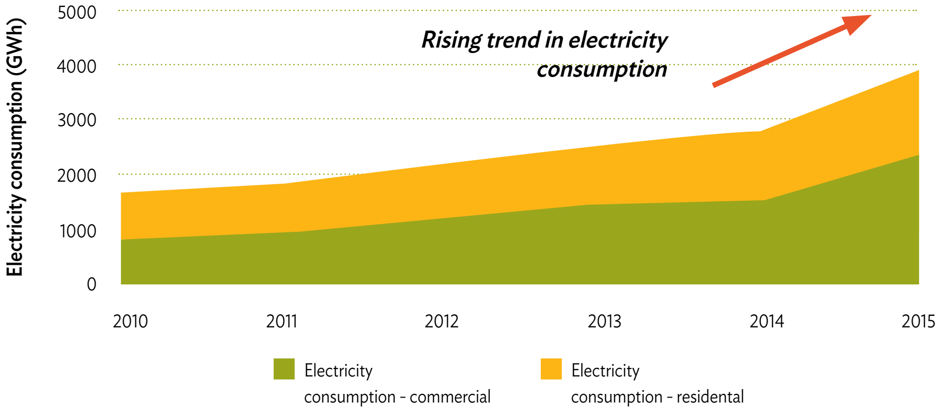
Figure 4.3 Historical Final Energy Consumption by All Sectors in Cambodia



ktoe = kilotonnes of oil equivalent.

Source: ERIA (2016).

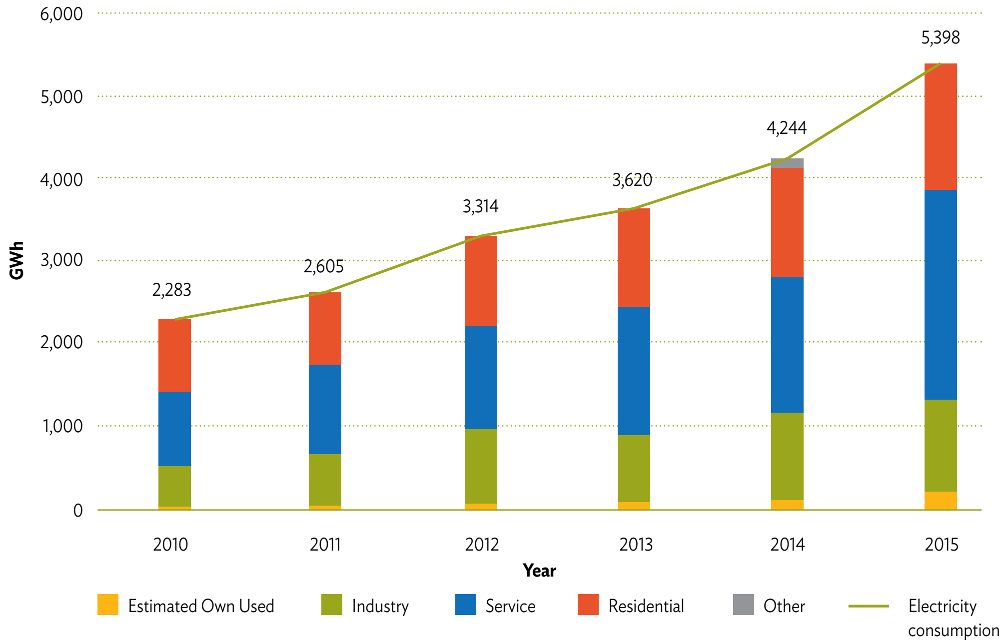
Figure 4.4 Historical Electricity Consumption by the Commercial and Residential Sectors



GWh = gigawatt hours.

Source: Author's calculations; ERIA (2016).

Figure 4.5 Historical Electricity Consumption by the Residential, Commercial, Industry, and Other Sectors

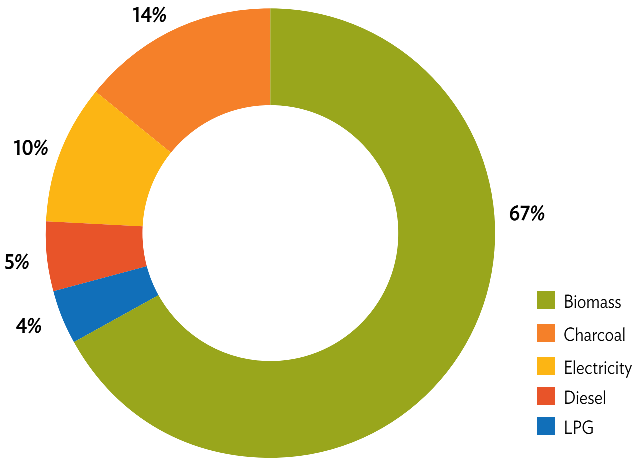


GWh = gigawatt hours.

Source: ERIA (2016).

Figure 4.6 shows the percentage shares of energy sources for the residential, commercial, and industry sectors. However, based on the current trend in energy demand, it is expected that the share of electricity as an energy source will increase, as illustrated in Figure 4.7. The share of electricity demand in 2030 is projected to increase to about 27% from 10% in 2015 under the business-as-usual (BAU) scenario.

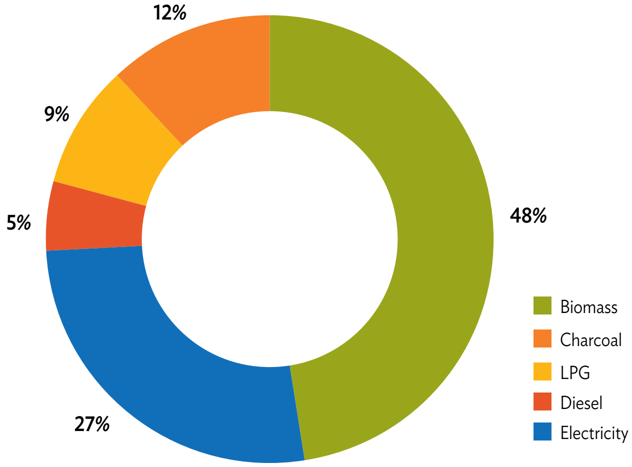
Figure 4.6 Percentage Shares of Energy Sources for the Residential, Commercial, and Industry Sectors in 2015



LPG = liquefied petroleum gas.

Source: Author's calculations based on the Energy Balance Table of Cambodia, 2018.

Figure 4.7 Projected Percentage Shares of Energy Sources for the Residential, Commercial, and Industry Sectors in 2030 Under the BAU Scenario



BAU = business as usual, LPG = liquefied petroleum gas.

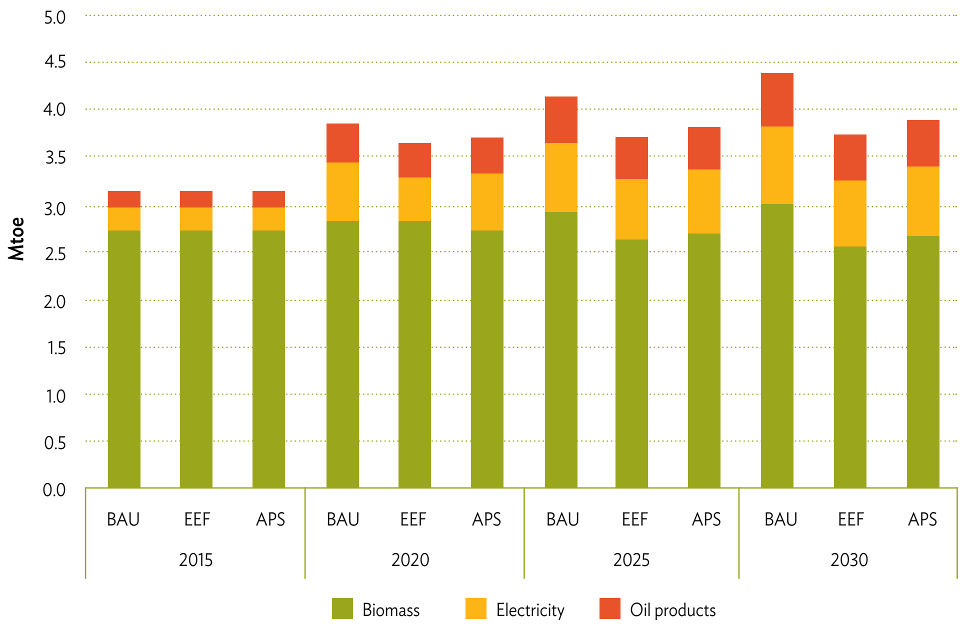
Source: Author's calculations based on Energy Balance Table of Cambodia, 2018.

4.3 Review of energy demand trends

4.3.1 Residential sector

The residential sector consumes much more energy than the commercial and industry sectors, at about 73% of the total energy consumption by these three sectors (residential, commercial, and industry) in 2015. As shown in Figure 4.8, biomass was the main source of energy that catered for the residential sector in 2015, at about 87%. Electricity was next at about 7%, while oil products catered to the remaining demand at 6%. Energy demand for the residential sector is projected to increase. As shown in Figures 4.8 and 4.9, the energy demand by the residential sector by 2030 is projected under the BAU scenario to reach 4.39 Mtoe with an annual average growth rate of 2.3%. Under the alternative policy scenario (APS), the energy demand by 2030 is projected to be 3.9 Mtoe with an annual average growth rate of 1.5%. Under the energy efficiency framework (EEF) scenario, the energy demand by 2030 is projected to be 3.73 Mtoe at an annual average growth rate of 1.2%.

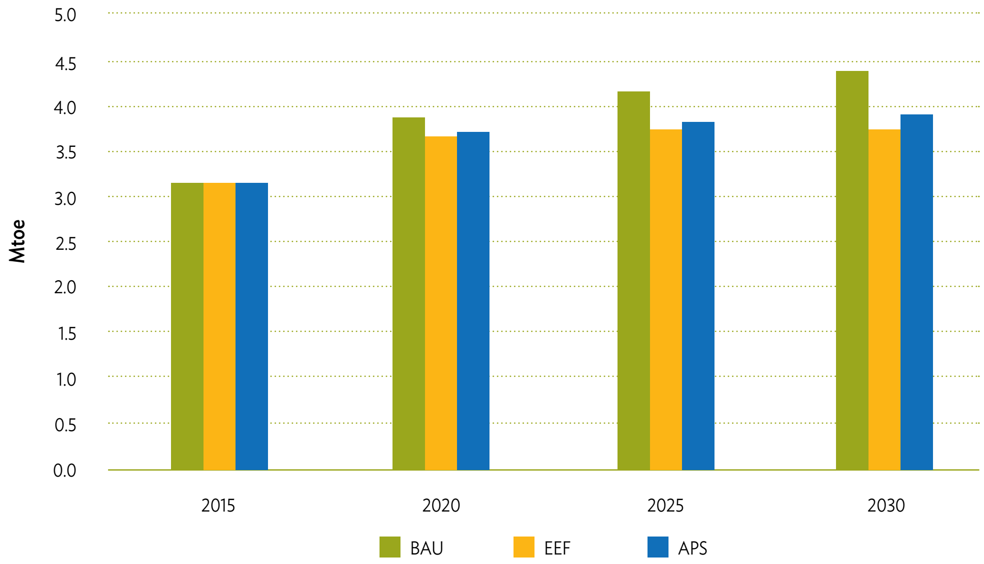
Figure 4.8 Historical and Projected Energy Demand and Energy Sources for the Residential Sector



APS = alternative policy scenario, BAU = business as usual, EEF = energy efficiency framework, Mtoe = million tonnes of oil equivalent.

Source: Cecilya Malik, EBT Cambodia 2018, ERIA.

Figure 4.9 Historical and Projected Energy Demand for Residential Sector Under the BAU, EEF, and APS



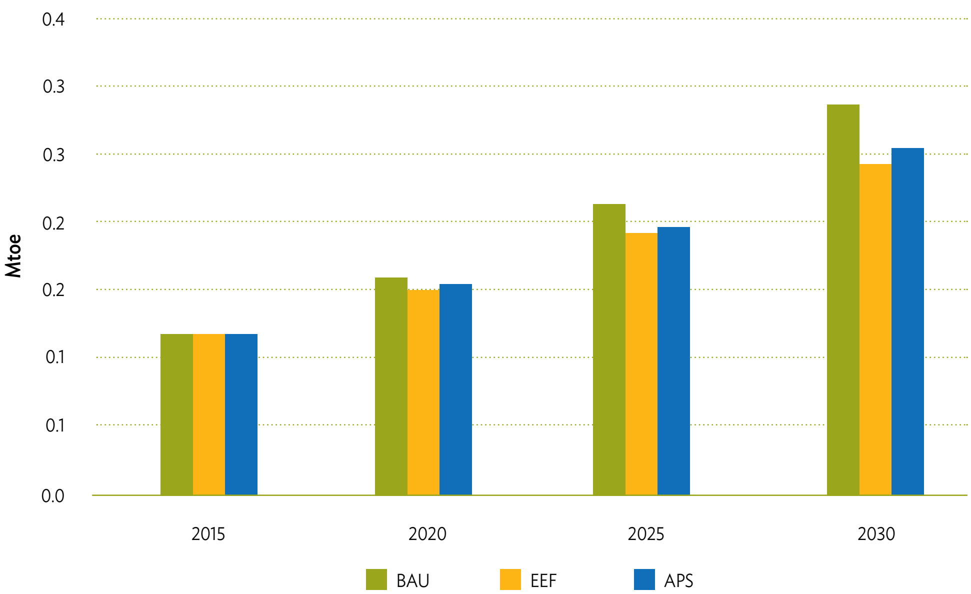
APS = alternative policy scenario, BAU = business as usual, EEF = energy efficiency framework, Mtoe = million tonnes of oil equivalent.

Source: Cecilya Malik, EBT Cambodia 2018, ERIA.

4.3.2 Commercial sector

Amongst the three sectors (residential, commercial, and industry), the total energy demand for the commercial sector is the lowest. In 2015, the commercial sector comprised about 3% of the total demand of the three sectors. However, the rate of increase in the projected demand by this sector is high, at an annual average growth rate of 6.1%. By 2030, the total demand by the commercial sector is projected to increase to 0.29 Mtoe from 0.12 Mtoe in 2015 under the BAU scenario as shown in Figure 4.10. Similarly, under the APS scenario, the total demand is projected to increase to 0.25 Mtoe at an annual average growth rate of 5.2%, while under the EEF scenario, the total demand is projected to increase to 0.24 Mtoe at an annual average growth rate of 4.9%. Therefore, in view of this high projected growth rate, it will be strategic and beneficial to implement EEC plans for the commercial sector.

Figure 4.10 Historical and Projected Energy Demand for the Commercial Sector Under the BAU, EEF, and APS



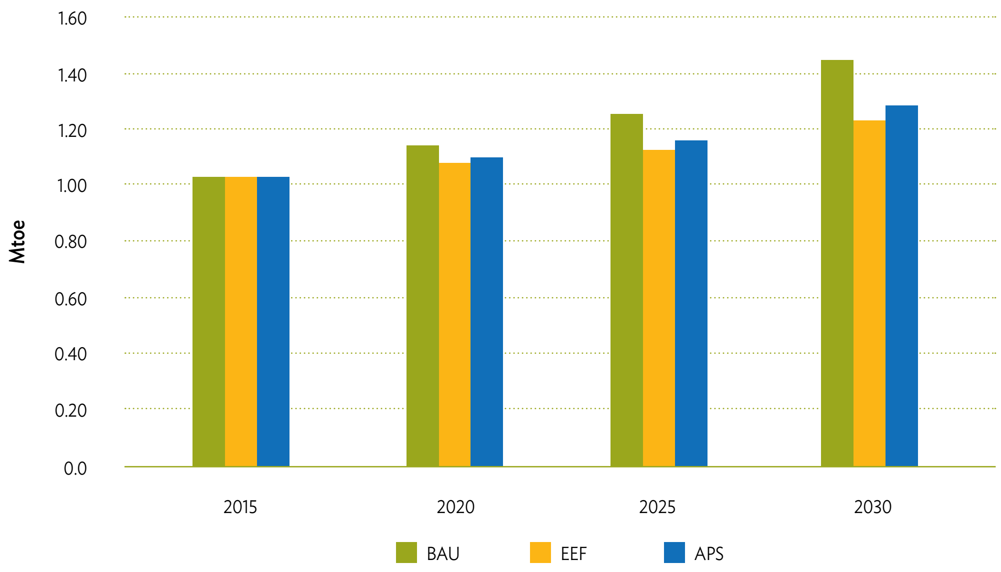
APS = alternative policy scenario, BAU = business as usual, EEF = energy efficiency framework, Mtoe = million tonnes of oil equivalent.

Source: Cecilya Malik, EBT Cambodia 2018, ERIA.

4.3.3 Industry sector

The industry sector consumes the second-largest share of total energy demand amongst the three sectors at about 24%, compared with 73% and 3% for the residential and commercial sectors, respectively. However, the annual growth rate is not as high as that of the commercial sector. The projected total demand for the industry sector is 1.45 Mtoe by 2030 at an annual average growth rate of 2.3% under the BAU scenario, as shown in Figure 4.11. Similarly, the projected total demand for the industry sector is 1.29 Mtoe at an annual average growth rate of 1.5% under the APS scenario, while under the EEF scenario, the projected total demand is 1.24 Mtoe at an annual average growth rate of 1.2%. Although the growth rate is not as high as that of the commercial sector, it is still important to implement EE plans for the industry sector as the total demand for this sector is relatively substantial.

Figure 4.11 Historical and Projected Energy Demand for Industry Sector Under the BAU, EEF, and APS



APS = alternative policy scenario, BAU = business as usual, EEF = energy efficiency framework, Mtoe = million tonnes of oil equivalent.
Source: Cecilya Malik, EBT Cambodia 2018, ERIA.

4.4 Energy efficiency strategies

It would be prudent to review and interpret the energy data and trends in the energy demand before establishing EE strategies or setting priorities for the implementation of EE policies. Based on the review of the current situation and energy demand trends discussed above, it is important to note that the following energy situations are prevalent in Cambodia under the BAU scenario:

(1) Energy demand for the residential, commercial, and industry sectors is on a rising trend.

(2) The annual average growth rate of energy demand for the commercial sector is the highest at 6.1%.

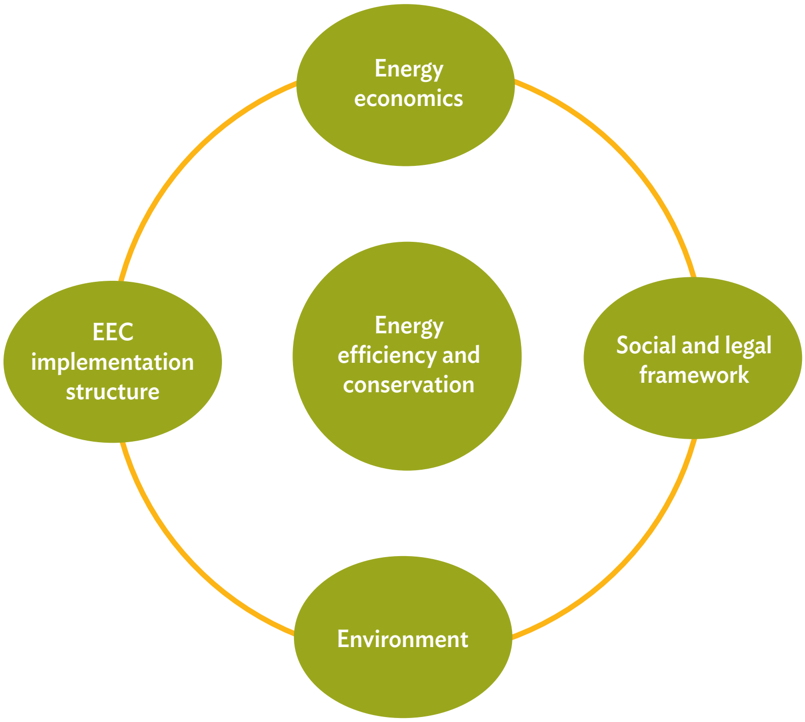
(3) The percentage share of electricity demand for the three sectors will increase from its 2015 level of 10% to 27% by 2030.

(4) The percentage share of the biomass energy source will decrease from its 2015 level of 67% to 48% by 2030, but the combined fuel energy sources, comprising biomass, charcoal, LPG, and diesel, will still be significant at 73% of the total demand for the three sectors by 2030.

(5) The residential sector consumes the largest share of energy demand amongst the three sectors at about 70.5%, while the industry sector consumes the second-largest share at about 23% in 2015 under the BAU scenario. The share of energy demand by the residential sector is projected to increase to 71.6%, and, similarly, the industry sector is projected to increase to 23.7% by 2030.

In view of the trends in energy demand summarised above, policymakers may consider a holistic and systematic approach to formulating and implementing short, medium, and long-term EEC plans for the efficient use of various energy sources. Figure 4.12 provides an overview of a recommended strategic framework for formulating an EEC plan. The strategic framework comprises four core strategy areas, namely, energy economics, a social and legal framework, the environment, and an EEC implementation structure. The details are described in the following sub-sections. In order to be effective and achievable, the EEC plan should be formulated based on a top-down approach, both from the government's perspective and the private sector's perspective. Nevertheless, the EEC plan should be kept simple, practical, and cost-effective, although EE is not straightforward when compared with renewable energy.

Figure 4.12 Strategic Framework for Formulating an EEC Plan



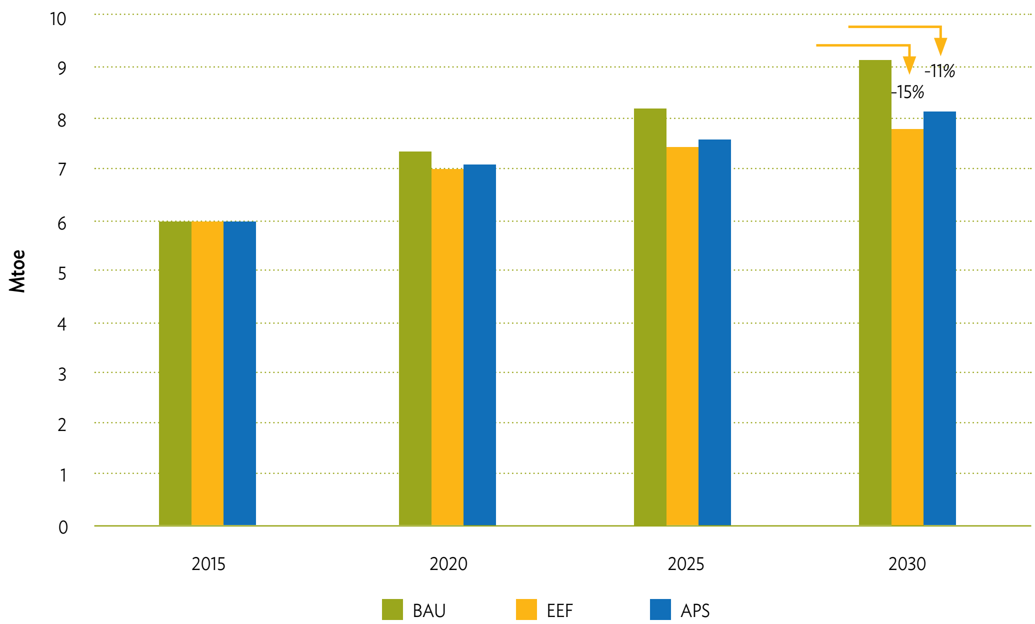
EEC = energy efficiency and conservation.

Source: author.

4.4.1 Energy economics

It should be recognised that EE plans will yield energy savings. EE alone can deliver substantial economic, environmental, and social benefits (IEA, 2018). The energy saved can be translated into an energy resource for the nation as it will become energy available for other economic activities and provide energy supply to a greater share of the population. The savings in electricity consumption are even more significant as every electricity unit of kilowatt hours saved would result in greater savings in fuel energy from power generation. Based on the outlook for energy demand summarised above, it makes economic sense for Cambodia to embark on EEC plans. The benefits of the EEC plans highlighted in Section 4.1 of this report will have a positive impact on the Cambodian economy. It can be seen from Figure 4.13 that an 11% reduction in total energy demand can be targeted under the APS case, while a 15% reduction in total energy demand can be targeted under the EEF case in comparison with the BAU case by 2030. In other words, energy demand will be much greater in future if Cambodia does not embark on an EEC plan now.

Figure 4.13 Historical and Projected Total Energy Demand in Cambodia Under the BAU, EEF, and APS



APS = alternative policy scenario, BAU = business as usual, EEF = energy efficiency framework, Mtoe = million tonnes of oil equivalent.

Source: Cecilya Malik, EBT Cambodia 2018, ERIA.

The economic component of the EEC strategy would result in promoting the growth of EEC technology, equipment, and materials supply. In addition, Cambodia will benefit from skilled manpower capacity building as a result of the EEC plan implementation, which will generate demand for upgraded levels of skilled employment. Therefore, it would be prudent to adopt strong policies to promote and enable EE investments at a reasonable scale. According to the IEA (2018), all investment opportunities in the efficient world scenario are highly cost-effective and would bring significant economic benefits.

4.4.2 Social and legal framework

From the national perspective, the top-down approach is through the government's plan to establish legal frameworks, such as an EEC act or regulations, which should be planned as the 'push' factor instead of a legal framework to mete out penalties. The objective of having legal frameworks is to establish mandatory requirements for efficient energy management and also to empower the department or agency that is tasked with the responsibilities for implementing EEC plans and, consequently, achieving EE and productivity for Cambodia.

For the private sector, the top-down approach requires top management or owners of companies to undertake efficient energy management practices. The legal framework would require business operations that exceed a certain threshold value of annual energy consumption to adopt an energy management system or practices. The results of EE practices and energy productivity will eventually benefit business operations.

The top-down approach may not be applicable for the residential sector, except for the legislative building codes, which would require housing developers to build energy-efficient houses and apartments. Similarly, building codes will also cover the commercial sector in terms of energy-efficient buildings. In this regard, the top-down approach will be an important strategy under the social and legal framework strategy.

As part of the social strategies, it is important to create an EEC culture by incorporating EE subjects in education curriculums and conducting EE promotional campaigns for the public in the residential sector and awareness and capacity-building training programmes for the commercial and industry sectors.

4.4.3 Environment

The promotion and adoption of EEC measures and practices will enhance the achievement of a sustainable environment in Cambodia. As part of the EEC targets, the national energy intensity will improve, which in turn will contribute towards improving the carbon emissions intensity.

4.4.4 EEC implementation structure

The third strategy is to establish a means of achieving EE. This can be achieved in many ways, but simple and more direct ways are recommended and summarised as follows:

(1) Engage professional bodies and stakeholders to incorporate energy-efficient strategies and measures in preparing building codes for the commercial and residential sectors.

(2) Engage professional bodies and stakeholders to prepare EE standards, including minimum energy performance standards (MEPS) and guidelines for the residential, commercial, and industry sectors.

(3) Involve professional bodies and stakeholders to establish the labelling of appliances for the residential sector.

(4) Promote and generate an EE investment environment by
   a. establishing a competent energy services company (ESCO) business to facilitate and expedite the achievement of energy savings for the commercial and industry sectors;
   b. establishing green building certification for the recognition of green practices, including EE; and
   c. providing facilities and investment tax allowance schemes for EE projects deemed beneficial.

   It is recommended that formulating the EEC plan should take into consideration the following:
   i. The plan should be cost-effective, such that the use of existing technologies and techniques to achieve EE would be sufficient.
   ii. The plan should be basic and simple in order to facilitate effective implementation.
   iii. Resources need to be allocated for the establishment of the EEC plan.
   iv. The proposed EEC plan should comprise short-, medium-, and long-term plans incorporating EE strategies and measures as described below.

Short-term strategies and measures, 2019–2021

(1) Identify and establish the responsible department or agency to take charge of the EEC plan.
- In order to ensure the success of the EEC plan, dedicated and committed resources need to be established. The responsible department or agency will be the custodian fully responsible for formulating and implementing the EEC plan.

(2) Formulate EEC structure and action plans.
- The EEC plan should be structured for practical implementation with achievable targets.

(3) Engage with professional bodies and stakeholders to formulate the EEC plans.
- Professional bodies and stakeholders should be invited to participate in consultative forums in formulating the EEC plans.

(4) Develop and implement EE promotional and awareness programmes.
- Greater awareness of the benefits of EE will give a better chance of achieving success in the EEC plans.

(5) Develop and conduct EE capacity-building programmes.
- EE capacity-building programmes are important because the commercial and industry sectors need trained personnel to adopt EE practices in their respective workplaces.

(6) Develop an EE syllabus for education.
- In order to achieve sustainability in EE, the younger generations need to be educated on EE culture and practices.

(7) Develop EE guidelines and standards for the residential, commercial, and industry sectors.
- EE guidelines and standards provide an important link and means of implementing and achieving EE.
- EE guidelines and standards should incorporate passive and active EE measures.

(8) Develop a labelling system for appliances.
- EE labelling of appliances is useful for achieving energy savings in the residential sector.
- Distributors and suppliers of appliances are recommended to be trained by the respective manufacturers on the significance of EE labelling and energy-saving potential so that consumers can benefit through better understanding of EE labelling.
- Distributors and suppliers of air conditioners are recommended to be trained by the respective manufacturers on the sizing and selection of air conditioners in order to avoid the oversizing of air conditioners for all the sectors, but in particular the residential sector, because house owners depend mostly on the

suppliers' and installers' recommendations. Correct sizing and selection will help save capital costs and running costs.

(9) Develop MEPS for equipment.
- MEPS specifying minimum energy performance requirements are useful for achieving energy savings in the commercial and industry sectors.

(10) Prepare building codes incorporating EE.
- Buildings codes are particularly useful for achieving energy savings in the commercial and residential sectors.
- Building codes should incorporate passive and active EE measures.

(11) Prepare efficient energy management regulations.
- Efficient energy management regulations are mandatory requirements and are key to achieving success in EE in the industry and commercial sectors.
- Premises that exceed a certain level of annual energy consumption would need to engage a qualified energy manager.

(12) Initiate EE measures for government buildings.
- The government can lead in the implementation of the EEC plan by adopting EE practices in government buildings.

(13) Establish ESCO support services.
- Competent energy saving and management services provided by ESCOs can help expedite achieving the results of energy-saving strategies and measures.

Medium-term strategies and measures, 2021–2025

(1) Implement energy management systems for the industry and commercial sectors.
- Energy management systems provide guidelines for systematic energy management methods and best practices for industry and commercial sectors.

(2) Establish EE financing infrastructure support and incentive schemes.
- Financial institutions can help finance investment-scale EE projects.
- The government may consider investment tax allowances and the waiver of duties for imports of EE equipment.

(3) Establish EE recognition awards.
- Awards recognising outstanding and successful EE projects in commercial and industry projects given by the government will help promote the adoption of EE.

(4) Continue capacity-building programmes.
- Capacity-building programmes should be continuous, and a higher level of EE training is recommended.

Long-term strategies and measures, 2025–2030

(1) Develop an EE legal framework.

- It is recommended that ultimately, a legal framework, such as the establishment of an EEC Act, is developed.

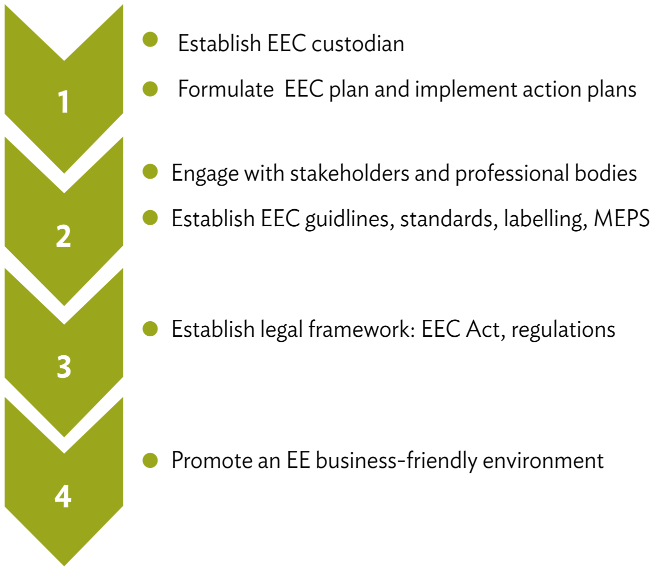
(2) Develop an energy efficiency indicator (EEI) system for the establishment of benchmarking for the commercial and industry sectors.

- An EEI system based on the IEA's EEI methodology (IEA, 2014) should be established.

(3) Incorporate EE into the education syllabus.

- For a long-term and sustainable strategy, Cambodia's education system should incorporate EEC concepts and practices into its syllabus.

Figure 4.14 Suggested EEC implementation structure



EE = energy efficiency, EEC = energy efficiency and conservation.

Source: Prepared by the author.

4.5 Recommendations

- Strong EE policies are vital for achieving the key energy-policy goals of reducing energy bills, addressing climate change, improving energy security, and increasing energy access. The economic benefits for the implementation of an EEC plan have been highlighted, and the implementation of an EEC plan is highly recommended, which is in line with most other ASEAN countries' aspirations and also the IEA's recommendations.

- The recommended strategic framework for formulating and implementing an EEC plan is based on four simple, cost-effective, and practical core strategy areas: energy economics, a social and legal framework, the environment, and an EEC implementation structure. The economic component of the EEC strategies would result in promoting the growth of EEC technology, equipment, and materials supply. In addition, Cambodia will benefit from skilled manpower capacity building as a result of the EEC plan implementation, which will generate demand for upgraded levels of skilled employment.

- Based on the outlook for energy demand, it makes economic sense for Cambodia to embark on an EEC plan. Energy consumption can be reduced in future demand if Cambodia embarks on an EEC plan now.

- Short-, medium-, and long-term EEC strategies and measures are recommended for implementation in stages, which can be adjusted to suit needs and resource allocations. The EEC plan should be simple, practical, and cost-effective, and it should also be formulated based on a top-down approach, both from the government's perspective and the private sector's perspective. In summary, this recommended EEC plan has identified the needs, means, and action plans to achieve EE and energy savings besides the economic benefits for Cambodia.

References

Economic Research Institute for ASEAN and East Asia (ERIA) (2016), *Cambodia National Energy Statistics 2016*. Jakarta: ERIA.

International Energy Agency (IEA) (2014), *Energy Efficiency Indicators: Essentials for Policy Making*. Paris: IEA.

IEA (2017), *Energy Efficiency Indicators Highlights*. Paris: IEA.

IEA (2018), *Energy Efficiency 2018: Analysis and Outlooks to 2040*, Market Report Series. Paris: IEA

CHAPTER 5

ENERGY SECURITY

5.1 Current situation of energy security in Cambodia

A sustained population and economic growth in Cambodia are the key drivers in significantly increasing energy demand to more than double for both primary and final energy demand during 2015–2040. In absolute terms, Cambodia's primary energy supply is projected to increase from 7.02 million tonnes of oil equivalent (Mtoe) to 15.24 Mtoe during the period, while final energy demand is also expected to rise from 5.93 Mtoe to 11.77 Mtoe (Kimura and Han, 2019). The strongest growth in final energy consumption is likely to occur in the transportation and industry sectors, with average growth rates of 3.9% and 3.5%, respectively. Cambodia's electricity demand is projected to have strong growth, with an average annual growth rate of 9% between 2015 and 2040. The fastest growth in electricity generation will be in hydropower (9.1% per year), followed by coal (7.5% per year). Generation from oil-fired power plants will decrease considerably due to high fuel costs. In the past, until 2001, almost 100% of electricity generation came from oil-fired power plants. In 2002, a hydropower plant started operation in Cambodia, and by 2013, its share in the power generation mix had increased to 57.4%. Coal power generation was also introduced to Cambodia rather late, in 2009. By 2015, the share of coal in the power generation mix had risen to 48.4%, the highest share in the power generation mix.

Cambodia has a very high import dependency as the country relies heavily on imports of coal, oil (petroleum products), and electricity. To fuel economic growth, Cambodia continues to increase imports of these fossil fuels, which puts pressure on energy security. Cambodia's import dependency increased from 50% to almost 60% during 2013–2016. The increase in energy demand in Cambodia will also see an increase in carbon dioxide (CO_2) emissions from the combustion of fossil fuels. It is projected that CO_2 emissions will increase by 5.6% per year from 1.96 million tonnes of carbon in 2015 to 8.62 million tonnes of carbon in 2040 under the business-as-usual scenario. Oil and coal are the largest sources of carbon emissions.

The increasing energy demand in Cambodia poses a threat to supply security. Yet, oil stockpiling and other security measures are yet to be developed to cope with an unexpected supply disruption as they may arise from external factors, such as conflict in the Middle East, natural disasters, accidents, or terror attacks on oil supply cargo. Almost 80% of oil exports from the Middle East are bound for Asia. So far, piracy and armed robbery have played a role in disrupting the free movement of vessels, causing delays, financial losses, and even loss of life. Data from the International Maritime Bureau of the International Chamber of Commerce reveals that globally, acts of piracy and robbery at sea have declined over the past 5 years. However, piracy incidents in Southeast Asia and South Asia are either rising or continuing unabated, which could pose threats at any time to the supply security in the region, including Cambodia.

Besides the oil supply security risks, Cambodia is affected by tropical weather, with plentiful rainfall that results in floods almost every year. Flooding is the major natural disaster in Cambodia, especially in the lower Tonlé Sap basin and the lower Mekong River provinces. The significant probability of flooding, combined with the relatively underdeveloped state of the road system in the country, results in the risk of oil supply disruption, especially the supply transported by lorry. This was evident when Typhoon Ketsana hit the country in 2009. Extreme weather, as Cambodia has become increasingly vulnerable to climate change, typhoons, and flooding, could possibly damage not only roads but (in an extreme case/scenario) could possibly damage the Sihanoukville port and railways, which could prevent oil transportation to major parts of Cambodia. In such an extreme but plausible case, it may take at least 1 month before oil transportation could be resumed normally as Cambodia does not have any strategic oil stockpiling to address the supply shortage during an oil supply disruption. Oil supply in Cambodia has been undertaken by private companies such as Chevron, Total, and PTT, as well as Cambodian suppliers like Sokimex and Tela. Based on government regulations, these companies are supposed to hold inventory of (operational) oil stock at the terminals for about 30 days. However, these oil importing companies, in reality, may hold operational oil stock of only about 15–20 days as the country does not have a mechanism in place to monitor the petroleum product stock holdings of these companies. The government's imposition on companies to hold inventory oil stock of about 30 days will require these companies to invest more in oil facilities, to which oil-importing companies may not comply with without government inspection and monitoring systems in place.

Notably, the government is aware of these energy security issues, especially for oil supply security. The government has been working on improving road conditions and developing other forms of transport such as railways and barges to diversify the modes of oil transportation. The government's efforts for the improvement of the disaster forecasting system, as well as emergency schemes for distributing fuel by various transport modes, are seen as a move in the right direction to reinforce oil supply resilience in the country. The current development of the oil refinery in Sihanoukville by Cambodian Petrochemical Company, with outsourcing of the construction contract to the state-owned Chinese National Petroleum Company, is to be completed by 2019, and the expected domestic oil production developed by KrisEnergy Ltd, the operator of Cambodian's offshore Block A in the Gulf of Thailand, will likely increase Cambodian energy security in the near future.

The government is making efforts to develop energy infrastructures, such as oil refineries, and tap domestic oil production by 2020, but Cambodia may still face many challenges regarding how to manage resources effectively, which could threaten energy security, as well as the need to have adequate energy policy in both downstream petroleum products regulation and upstream resource extraction. While Cambodia is expecting indigenous oil production with the completion of its oil refinery by the end of 2019, the current energy security of Cambodia remains weak, with rising oil imports to meet the growing energy demand in the country. The energy security situation is worsening from the viewpoint of the lack of fuel diversification in the energy mix. For power generation, Cambodia mainly relies on hydropower and coal-fired power generation for its cities and provinces that are connected to the national grid. However, the electrification rate remains a critical issue for Cambodia, as about 40% of the population does not have access to electricity. Biomass remains a dominant source of energy for cooking in most rural parts of Cambodia. Thus, all these daunting issues of inaccessibility to commercial energy use contribute to energy insecurity. In addition, Cambodia has its Law on Disaster Management for Flood and Drought but not a law for an energy emergency response during the disruption of the energy supply. Given the background of the energy landscape of Cambodia, it is crucial for the government and specialised agencies to set energy security policies and provide suggested policy recommendations to overcome the energy security challenges.

5.2 Current policies related to energy security

The Government of Cambodia defined its energy sector development policy in October 1994. Later on, this evolved to become the Power Sector Strategy 1999–2016, with objectives to (1) provide an adequate supply of energy throughout Cambodia at reasonable and affordable prices, (2) ensure a reliable and secure electricity supply at prices that allow sufficient investment in Cambodia and the development of the national economy, (3) encourage the exploration and environmentally and socially acceptable development of the energy resources needed to supply all sectors of the Cambodian economy, (4) encourage the efficient use of energy and minimise the detrimental environmental effects resulting from energy supply and use. This strategy guided the development and policy framework of all energy sectors in Cambodia, including the Rural Electrification by Renewable Energy Policy, Renewable Electricity Action Plan 2002–2012, and the energy efficiency and conservation (EEC) goals.

In early 2001, the Electricity Law was passed with the aims of (1) ensuring the protection of the rights of consumers to receive reliable and adequate supply of electric power services at reasonable costs; (2) promoting private ownership of the facilities for providing electric power services; (3) establishing competition wherever feasible in the sector; (4) establishing the Electricity Authority of Cambodia (EAC) for regulating electricity power services, granting the right and obligation to penalise, if necessary, the suppliers and consumers of electricity in relation to electricity generation and supply facilities; and (5) creating favourable conditions for investment in, and the commercial operation of, the electric power industry.

The EAC is an autonomous body set up to regulate and monitor the electric power sector throughout the country. Its duties include issuing licenses, approving and enforcing performance standards for licensees to ensure quality supply and better services to consumers, and the determination of tariff, rates, and charges for electric power services that are fair to both consumers and licensees.

The law also sought to promote private investment and the ownership of power facilities and to encourage competition in the sector. The Electricity Law established the EAC as a legal public entity with the power to act as the regulator for power sector business activities. It also defined the roles of the Ministry of Mines and Energy (MME), formerly known as the Ministry of Industry, Mines and Energy. The MME is responsible for the overall administration of the energy sector. It is responsible for developing policies and strategies, power development plans, electricity trade with neighbouring countries, major investment projects, and the management of the rural electrification sector. Along with the Ministry of Economy and Finance, the MME is the joint owner of Electricité du Cambodge (EDC).

EDC was established in 1996 and became a state-owned company with the responsibility to generate, transmit, and distribute electricity throughout Cambodia. Its main functions are supplying electricity, developing the transmission grid, and facilitating the import and export of electricity to and from neighbouring countries. Independent power providers are private companies that have received a license from the EAC to generate electricity for public consumption. They generate electricity and sell it on to EDC, which then distributes it through the national grid.

In 2006, the government approved the Rural Electrification by Renewable Energy Policy. Its main objective is to create an enabling framework for renewable energy technologies to increase access to electricity in rural areas. The policy acknowledges the Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia as the guiding document for the implementation of projects and programmes. The Master Plan envisions the following: (1) to achieve a 100% level of village electrification, including battery lighting, by 2020; and (2) to achieve a 70% level of household electrification with grid-quality electricity by 2030. In addition, Cambodia aims for 15% of rural electricity supply from solar and small hydro by 2015. The Master Plan also lays out clear targets, investments, and responsibilities. About 1.83 million households are to be connected to the national grid by 2020. An additional 260,000 households in very remote areas – too far from the planned grid extension – will be supplied through isolated mini-grids using diesel-generated power and/or renewable energy (220,000 households) and solar home systems (40,000 households). The total cost for expanding the rural grid is estimated at US$1.37 billion. In the plan, EDC will be responsible for the overall planning, development, investment, and operation of the rural medium-voltage (22 kV) sub-transmission lines; and it will partner with private rural energy enterprises to expand, operate, and maintain low-voltage distribution and service lines (<0.4 kV).

The EEC goals submitted to the 5th East Asia Summit Energy Ministers Meeting, held on 20 September 2011 in Brunei Darussalam, state that the country uses final energy demand as the energy efficiency (EE) indicator and aims at a 10% reduction from the business-as-usual scenario by 2030. The action plans to achieve the EEC goals cover the use of energy by the industry, transport, commercial, and residential sectors, such as the introduction of energy efficient equipment and EE labelling as well as the promotion of EE awareness amongst the public.

5.3 Setting up energy security policy

Securing the energy supply with affordable prices and environmentally sustainable energy uses is the main objective of Cambodia's overall vision for energy policy. However, Cambodia has experienced rapid growth of energy demand, higher oil import dependence, a growing share of coal use for meeting electricity demand, and, thus, greater challenges to energy security and CO_2 emissions towards 2040. These could threaten the stable supply of energy with affordable prices at the national and local levels.

Thus, Cambodia needs to be well-prepared for possible oil supply disruptions and enhance EE, reduce oil demand, particularly in the transport sector; engage in the clean use of fossil fuels; and promote energy diversification to such sources as natural gas and renewable energy.

Any measures to strengthen Cambodia's energy security could be more efficiently and effectively pursued by regional collaboration (any mechanism of bilateral and regional energy cooperation), which includes coordinated emergency response measures, cross-country energy interconnections (Mekong subregion power connectivity), and the harmonisation of energy-related standards and the regulatory environment for energy industries. Pursuing energy security policies also requires capacity building and enhanced awareness by the general public. Specific actions towards addressing energy security for policy, institution, and energy infrastructure investment are vital for addressing the key salient policies for energy security in Cambodia.

5.4 Policy recommendations

- As Cambodia is expected to have stable economic growth in the medium-to-long term, in which the industry sector will play a major role in contributing significantly to GDP, the country will need a stable, reliable, and affordable energy price to ensure that Cambodia is competitive in the global market. In this regard, the country may need to establish an institution, such as a national emergency strategy organisation, to deal with energy supply disruption in the future.

- The Cambodian government may consider establishing hard infrastructure, such as oil stockpiling by the government, on top of what oil importing companies hold in inventory oil stock of 30 days of net imports. Having oil stock is significant for ensuring that important industries and sectors, such as the healthcare, food, and electronics industries, are well protected during an emergency response to an energy supply disruption.

  However, having a stock of oil is a good signal to investors, and it could attract more important investment to Cambodia, such as in electronics and other sectors, as these will require a stable energy supply without blackouts, and energy input is key to overall production costs to ensure Cambodia's industries remain competitive for products produced outside of Cambodia. The government should note that having an oil stock is good for energy security, but the effects could also increase the price of petroleum products, which could affect industry and other sector competitiveness as these sectors may use petroleum products as inputs of production.

- Policymakers may need to develop energy policies to shelter the country from potential risks by bringing energy resiliency through appropriate energy policy and energy infrastructure investment, such as for oil-receiving terminals, ports, pipelines, and strong electricity grids.

- As Cambodia only has an operational oil stock of 30 days, other response measures during an oil disruption may be need to be considered, such as (i) demand restraint measures, which can range from being light-handed (e.g., public information campaigns to promote voluntary actions) to more medium- and heavy-handed measures (e.g., driving restrictions or fuel rationing). These measures can be applied differently across various sectors, but road transportation is commonly targeted due to the high proportion of oil consumption it represents; (ii) fuel-switching measures, which comprise the substitution of one form of fuel for another (e.g., natural gas is a possible alternative to oil in the event of an oil disruption, particularly in those power generators capable of operation using either fuel; (iii) surge production measures, comprising the rapid activation (within 30 days) of spare crude oil production capacity to increase oil supply; and (iv) fuel specification measures, such as environmental or quality standards, which can be temporarily relaxed by governments to increase the flexibility of supply.

- In addition, Cambodia could see huge energy savings in the transformation sector if policies are formulated to ensure that new fleets of power generation be deployed for high efficiency and low-emission power generation. Currently, coal-fired power plants are deployed in Sihanoukville based on sub-critical technology as these plants are installed with a small capacity (50–100 MW) in which high-efficient technology such as Ultra Super Technology cannot be used unless the installed capacity is at least 400–500 MW. In addition, low technology, such as sub-critical technology, is relatively cheaper in terms of capital cost, and, thus, Cambodia may opt for low technology. However, this low technology is associated with low efficiency, high CO_2 emissions, and other pollutants, such as sulphur dioxide, nitrogen dioxide, and particulate matters, which could threaten the health of residents living near the plants, and acid rain could be a serious problem in the future.

- Collective measures and actions to rapidly develop and deploy EE and savings in all sectors and double the share of renewable energy, such as off solar, wind, and biomass power generation, in the overall energy mix for inclusive and sustainable development are highly recommended as a holistic approach.

- Finally, electrifying Cambodia to the 100% electrification rate is a must and urgent as many households still cannot access commercial energy. Thus, appropriate energy policies to promote distributed energy systems, either using fossil fuel power generation or renewable energy, are highly recommended to ensure that remote and mountainous areas are able to access electricity as this energy is important for their day-to-day needs. The lack of this energy will affect their health, the capital formulation of children, and other businesses-related opportunities.

Reference

Shigeru, K. and H. Phoumin (2019), Energy Outlook and Energy Saving Potential in East Asia 2019. Jakarta: ERIA.

CHAPTER 6

ENERGY OUTLOOK

6.1. Future trend analysis by 2030

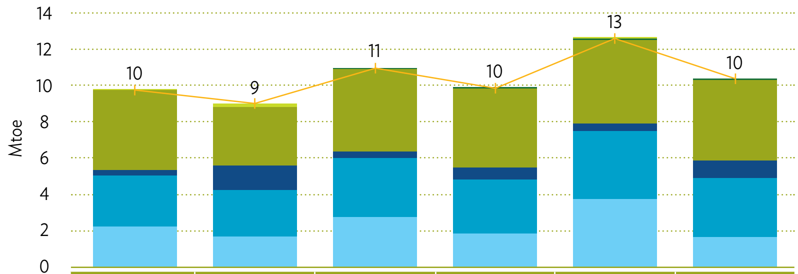
The Basic Energy Plan (BEP) outlook considers not only the business-as-usual (BAU) scenario but also the alternative policy scenario (APS), consisting of the energy efficiency and conservation (EEC) scenario (APS1) and the development of more renewable energy (APS2). These two scenarios were based on the policy intervention assumed for the BEP. Under APS1, the assumption is to reduce total final energy consumption (TFEC) in all sectors by 10% by the year 2030 relative to the BAU. Under APS2, the BEP sets the generation share from fossil-fuelled plants to be 35% in 2030, while hydro is 55% and other renewable is 10%. The APS will be the combination of APS1 and APS2.

6.1.1. Total primary energy supply by energy

Under the BAU, Cambodia's total primary energy supply (TPES) is projected to increase to almost 13 million tonnes of oil equivalent (Mtoe) in 2030 at an average rate of almost 4% per year (Figure 6.1). Fossil fuels will still dominate Cambodia's future TPES with a share increasing to 60% in 2030. The increasing share of fossil fuels in the TPES is due to the rapid increase of coal consumption in the country, particularly for power generation. Oil consumption will also continue to increase in the future due to the growth in the number of cars and motorbikes. The rate of increase, however, will be slower than it was during 2010–2016. Consequently, the share of oil in the TPES will decline to 30% in 2030.

Under the APS, the TPES will grow more slowly at around 3% per year, increasing to 10.5 Mtoe in 2030. The share of non-fossil fuels will be dominant in the APS (52% in 2030), while the fossil fuel share will fall to 48% in 2030. Non-fossil fuels are dominant in the TPES of the APS compared to the BAU because of the BEP assumption in APS2. The BEP sets the shares of hydro and renewable in total power generation at 55% and 10%, respectively. The remaining share of power generation in APS2 will come from coal (35%).

Figure 6.1 Primary Energy Supply, BAU and APS



	BAU	APS	BAU	APS	BAU	APS
	2020		2025		2030	
Electricty	0,01	0,19	0,00	0,02	0,01	0,00
Other renewable	0,01	0,01	0,03	0,04	0,03	0,06
Biomass	4,41	4,24	4,55	4,34	4,66	4,46
Hydro	0,33	0,34	0,35	0.69	0,38	0,95
Oil	2,83	2,56	3,26	2,96	3,78	3,28
Coal	2,25	1,73	2,82	1,93	3,81	1,70
Total	9,84	9.08	11,02	9,98	12,67	10,46

APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

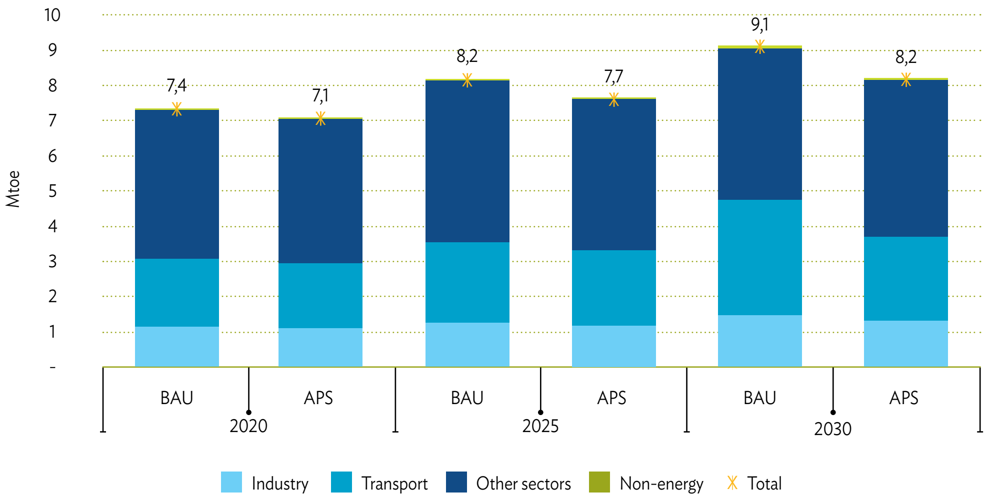
The coal supply in the TPES will be around 2.1 Mtoe (55.3%) lower than in the BAU in 2030, while oil and 'others' will be lower by only 13.2% (0.5 Mtoe) and 3.8% (0.2 Mtoe), respectively. The reductions in oil and 'others' in the TPES of the APS are not as much as for coal because the majority of these resources are consumed by the final sectors, not the power sector. 'Others' covers biomass, solar, wind, and electricity net trade. Hydro in the APS will be 2.5 times higher than in the BAU (151.1% or 0.6 Mtoe). Overall, the total saving for the TPES between the BAU and the APS in 2030 will be around 2.2 Mtoe or 17.4%

6.1.2. Total final energy consumption by energy and sector

Under the BAU, the TFEC in Cambodia is projected to increase at an average rate of 6.6% per year to around 9 Mtoe in 2030 (Figure 6.2). Amongst the other sectors, the strongest growth in the future will be in the 'others' sector, which consists mostly of the commercial and residential sectors, since the consumption of electricity in these sectors will increase rapidly in the future. The transport sector will still dominate Cambodia's future TFEC and also grow rapidly but at a slower rate than the 'others' sector.

Under the APS, the TFEC will grow more slowly at 5.8% per year, increasing to 8.2 Mtoe in 2030. Similar to the BAU, the 'others' sector in the APS will have the fastest growth rate, followed by the transport sector. Final energy demand savings between the APS and the BAU in 2030 will amount to 0.9 Mtoe (Figure 6.2). The bulk of the savings are expected to occur in the 'others' sector (0.5 Mtoe), followed by the transport sector (0.3 Mtoe) and the industry sector (0.1 Mtoe). Improvements in end-user technologies and the introduction of energy management systems are expected to contribute to the slower growth rate of consumption in all sectors.

Figure 6.2 Final Energy Consumption by Sector, BAU and APS

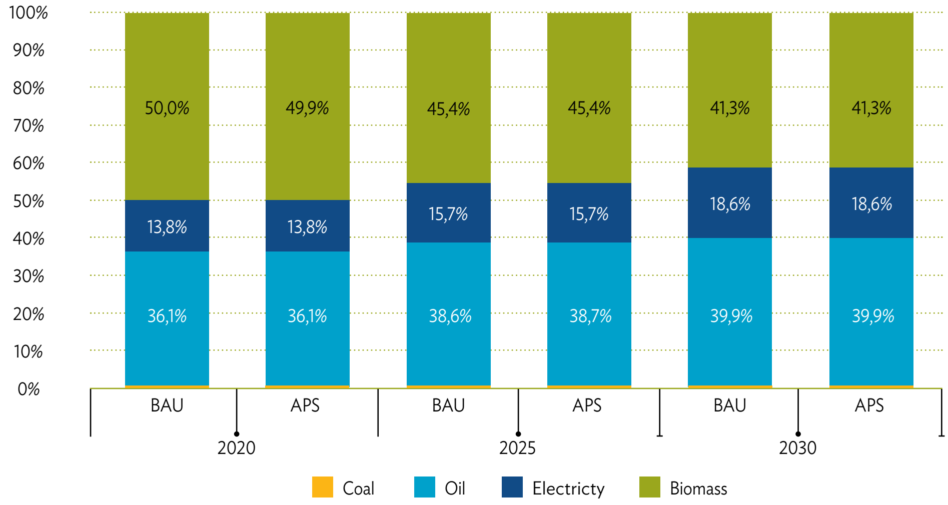


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

By type of fuel, electricity consumption will grow the fastest, at 8.8% per year under the BAU and 8% per year under the APS. Although electricity will have the fastest growth, biomass will have the highest share in the TPES (41% in 2030) for both the BAU and the APS (Figure 6.3). Similarly, oil will have the same share in both the BAU and the APS at around 40% in 2030.

Figure 6.3 Final Energy Consumption Share by Sector and Fuel, BAU and APS



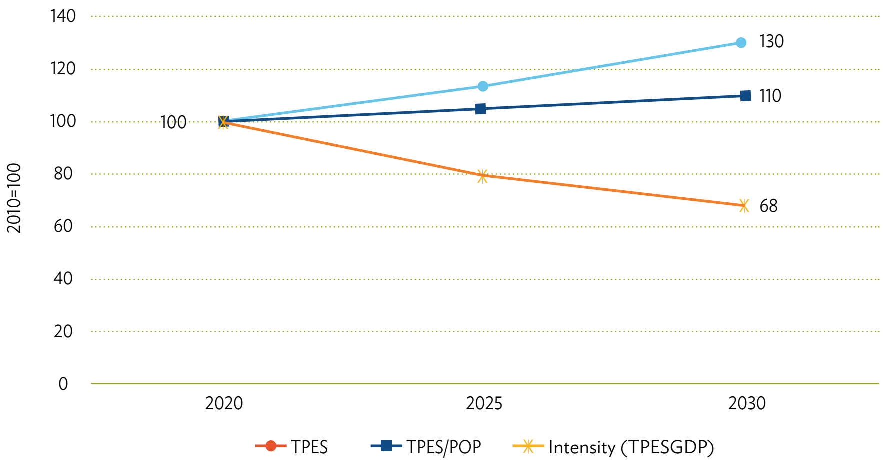
APS = alternative policy scenario, BAU = business as usual.

Source: Author's calculation.

6.1.3. Alternative policy scenario energy indicators

The gross domestic product (GDP) of Cambodia is assumed to grow at an average rate of 6.6% per year until 2030, with a population growth of 1.6% per year. As shown in Figure 6.4, GDP will almost double in the next decade (2020–2030), but the TPES will increase by only 1.3 times. The TPES energy intensity will decline, confirming that the BEP measure of a 10% reduction will be achieved by 2030.

Figure 6.4 Energy Indicators, APS



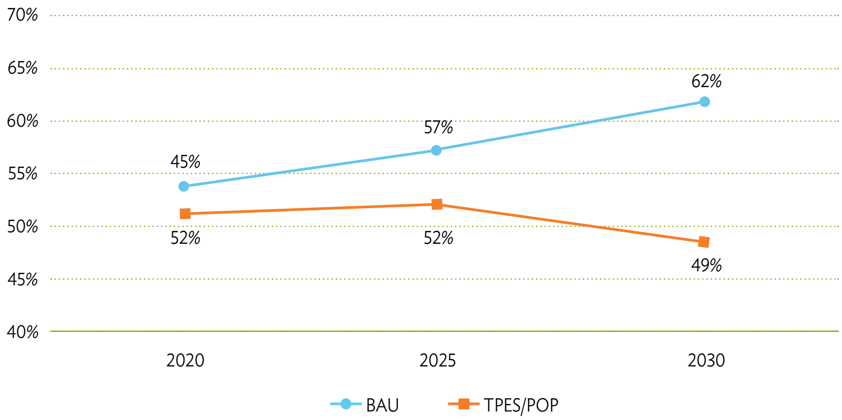
APS = alternative policy scenario, GDP = gross domestic product, POP = population,
TPES = total primary energy supply.

Source: Author's calculation.

6.1.4. Energy security

As coal and oil will still play a major role in the future energy mix of Cambodia, the country's dependence on these fuels from international market will still be significant. Import dependency will increase from 54% in 2020 to 62% in 2030 under the BAU (Figure 6.5). Under the APS, because of the BEPC, import dependency will decline to 49% in 2030 from 52% in 2020.

Figure 6.5 Energy Import Dependency, BAU



BAU = business as usual, POP = population, TPES = total primary energy supply.

Source: Author's calculation.

6.2. Monitoring of the Basic Energy Plan implementation

The energy outlook under the BEP for Cambodia provides the future magnitudes of energy demand and supply under both the BAU and APS conditions. The APS includes the energy saving target and renewable energy expansion plans proposed under the BEP.

The energy outlook under the BEP for Cambodia provides only the projected magnitudes of the future TFEC and TPES of Cambodia. Implementation of the BEP can be monitored by collecting the actual TFEC and TPES magnitudes annually. In this regard, the Ministry of Mines and Energy of Cambodia (MME) should continuously produce the country's Energy Balance Table and compare it to the BEP outlook.

In addition to the monitoring of the TFEC and TPES, the MME should also monitor the other energy indicators (TPES/GDP, TFEC/GDP, TPES per capita, TFEC per capita, and import dependency). Assessment of these indicators will assist the MME in identifying and understanding the key drivers of trends and in prioritising policy interventions to control energy consumption growth. The indicators can also be effective for quantifying the potential impacts and benefits of policy interventions.