



CAMBODIA

ENERGY SECTOR ASSESSMENT, STRATEGY, AND ROAD MAP

DECEMBER 2018

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ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Française de Développement
ASR	assessment, strategy, and road map
CCAP	Climate Change Action Plan
CPS	country partnership strategy
EAC	Electricity Authority of Cambodia
EDC	Electricite du Cambodge
EU	European Union
GMS	Greater Mekong Subregion
IDP	Industrial Development Policy
IPP	independent power producer
JICA	Japan International Cooperation Agency
Lao PDR	Lao People's Democratic Republic
MEF	Ministry of Economy and Finance
MME	Ministry of Mines and Energy
NCSD	National Council for Sustainable Development
NSDP	National Strategic Development Plan
OCA	Overlapping Claims Area
PDP	Power Development Plan
PPA	power purchase agreement
PRC	People's Republic of China
PSOD	Private Sector Operations Department
PV	photovoltaic
REE	rural electricity enterprise

REF	Rural Electrification Fund
RPTCC	Regional Power Trade Coordination Committee
SHS	solar home system
SREP	Scaling Up Renewable Energy Program in Low Income Countries
TA	technical assistance

WEIGHTS AND MEASURES

GWh	gigawatt-hour
ha	hectare
km	kilometer
kV	kilovolt
kWh	kilowatt-hour
MW	megawatt
TWh	terawatt-hour
Wp	watt-peak

CURRENCY EQUIVALENTS

(as of 15 November 2018)

Currency unit	=	riel/s (KR)
KR1.00	=	\$0.00024763
\$1.00	=	KR4,038.34

I. SECTOR ASSESSMENT

A. Introduction

1. This sector assessment, strategy, and road map (ASR) documents the current analysis of the Asian Development Bank (ADB) of the strategic investment priorities of the Government of Cambodia and ADB in Cambodia's energy sector. It highlights sector performance, major development constraints, government plans and strategy, past ADB support and experience, other development partner support, and ADB's future support strategy. The ASR is aligned with ADB's new Strategy 2030¹ and will inform ADB's country partnership strategy (CPS) for Cambodia, 2019–2023, which is currently under development. The ASR has been prepared as a living document and will help to provide sector background information for investment and technical assistance (TA) operations.

B. General Country Context

2. Cambodia has a land area of 181,035 square kilometers and a population of about 15.25 million in 2016. The population grew rapidly in the 1980s and 1990s, and continues to annually increase by about 1.3%, or almost 200,000 people. The age dependency ratio in Cambodia of 55% shows that the working-age population (aged 15–64) faces a greater burden to support the youth and elderly. The country is urbanizing rapidly, but from a low level. In 2017, 77.0% of the population still lived in rural areas, down from 80.8% in 2005.²

3. Cambodia's economy grew quickly with an average growth rate of 7.0% from 2006 to 2016, with poverty falling substantially from 47.8% in 2007 to 14.0% in 2014.³ The country graduated from low-income status to lower middle-income status in 2015. Nonetheless, the gross domestic product per capita, estimated at \$1,447 in 2017, remains among the lowest in Asia. In 2017, agriculture contributed 25.0% of the gross domestic product, industry contributed 32.7%, and services contributed 42.3%. The main subsectors in industry are garment production, construction, and food and beverage processing.⁴

¹ ADB. 2018. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific*. Manila.

² ADB. 2018. *Basic Statistics 2018*. Manila; and ADB. 2018. *Key Indicators for Asia and the Pacific 2018*. Manila.

³ ADB. 2018. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Grant to the Kingdom of Cambodia for the Second Urban Environmental Management in the Tonle Sap Basin Project*. Country Economic Indicators (accessible from the list of linked documents in Appendix 2). Manila; and ADB. 2018. *Basic Statistics 2018*. Manila.

⁴ Government of Cambodia. 2015. *Cambodia Industrial Development Policy, 2015–2025: Market Orientation and Enabling Environment for Industrial Development*. Phnom Penh.

4. Nearly 5 million Cambodians have no access to grid electricity and are reliant on car batteries, wood, and other traditional fuels for energy.⁵ For cooking, about 62% of households use firewood, 5% use charcoal, 31% use liquefied petroleum gas, and 2% use electricity.⁶ The traditionally high electricity tariff in the country makes access unaffordable to the poor while constraining economic competitiveness and discouraging investment. Recognizing that expanded access to modern and affordable forms of energy is essential for Cambodia's social and economic advancement, the Government of Cambodia's National Strategic Development Plan (NSDP), 2014–2018⁷ and Industrial Development Policy (IDP), 2015–2025 (footnote 4) prioritize the need to develop the energy sector in an affordable and sustainable manner, while also taking into account the need to minimize adverse environmental and social impacts.

C. Overview of the Energy Sector

1. Primary Energy Supply and Demand

5. The total primary energy supply in Cambodia was about 4.8 million tons of oil equivalent in 2015.⁸ Fuel wood and other biomass accounted for an estimated 44.4% of the total, oil and petroleum products for 38.5%, coal for 10.7%, hydropower for 3.6%, and electricity imports for 2.8%. The share of coal and hydropower in Cambodia's energy supply increased significantly from 2010 to 2015 with the commissioning of new coal and hydropower plants; during this period, the share of coal increased from 0.7% to 10.7%, while the share of hydropower increased from 0.1% to 3.6% (footnote 8).

6. Total final energy consumption in Cambodia grew by an annual average of 6.9% during 2010–2015. Final energy consumption in 2015 was 3.4 million tons of oil equivalent, comprising 50.5% petroleum products, 36.0% biomass, 13.1% electricity, and 0.4% coal. The transport sector is responsible for nearly half (46%) of final energy consumption. In terms of fuel uses, more than 40% of biomass is used in the residential sector for cooking and heating, another 40% is used to produce charcoal (which is also consumed by households), approximately 15% is used in industry, and a small portion contributes to electricity generation. Final consumption of petroleum products is divided by sector as follows: 87% for transport; 6% for industry; 4% for agriculture, service, and residential; and 3% for power generation. Most of the coal consumption is for power generation (97%) while 3% is used in industry. The rapid increase in coal usage is due to the commissioning of two coal-fired power plants in Preah Sihanouk Province in 2014–2017, part of the government's plan to reduce oil-based power generation. Primary energy use increased steadily from 2009 to 2016 due to economic and population growth, but considering the country's stage of economic development, it remains low. At about 480 kilograms of oil equivalent per capita per year in 2016, energy use is about 65% of the Asian average of 740 kilograms, according to the International Energy Agency.⁹

⁵ In 2017, 69% of households had access to grid-connected electricity. Electricity Authority of Cambodia (EAC). 2018. *Salient Features of Power Development in Kingdom of Cambodia*. Phnom Penh.

⁶ World Bank. 2018. *Cambodia—Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework*. Washington, DC.

⁷ Government of Cambodia. 2014. *National Strategic Development Plan, 2014–2018*. Phnom Penh.

⁸ Government of Cambodia, Ministry of Mines and Energy, and Economic Research Institute for Association of Southeast Asian Nations and East Asia. 2016. *Cambodia National Energy Statistics 2016*. Jakarta.

⁹ International Energy Agency. Statistics (accessed 25 September 2018). The Asian average excludes the People's Republic of China.

7. With continuing population growth, economic growth, and urbanization, ADB predicts that the country's energy needs will double by 2030. While hydropower and thermal generation (coal or natural gas) are replacing oil in electricity generation (each is projected to account for roughly half of electricity production by 2030 in the Government of Cambodia's Power Development Plan [PDP], 2015–2030¹⁰), the use of petroleum products is expected to increase with rising demand in the transport, industry, and residential sectors. Demand for oil will be driven primarily by demand for diesel and gasoline as the country becomes more motorized and as the government promotes industrial zones for manufacturing and agro-processing. In the residential sector, use of liquid petroleum gas is expected to increase as kerosene is phased out.

2. Fossil Fuel Resources

8. Cambodia imports all fossil fuels that it consumes, including coal and oil. Preliminary estimates for national coal deposits are small (about 7 million tons) and no commercial-scale mining has begun.¹¹ Cambodia also has very limited oil exploration drilling and no refineries. The country has untapped and mostly unquantified potential for petroleum extraction; however, several geological factors, including similarities to adjacent areas in Viet Nam and Thailand where oil and gas are being produced, point to economically viable oil and gas potential. According to the General Department of Petroleum in the Ministry of Mines and Energy (MME), seismic data show that onshore areas contain three times more potential petroleum resources than offshore areas.¹²

9. There are six offshore petroleum blocks in Cambodian waters (blocks A–F) and 19 onshore blocks (I–XIX) for oil and gas exploration. There are also four more blocks in the offshore Overlapping Claims Area (OCA) with Thailand. This disputed area covers 27,000 square kilometers and it has been estimated to contain up to 11 trillion cubic feet of natural gas and up to 3.6 billion barrels of oil.¹³ The two countries signed a memorandum of understanding in 2001 regarding joint development of the OCA; however, negotiations were stalled in 2006, and the agreement was suspended in 2009, due to political events. Cambodia and Thailand have yet to agree on how to share potential revenue from this area.¹⁴

10. The government uses production sharing contracts to license companies for exploration. All six offshore blocks were awarded (starting with block A in 2002), but only three of the 19 onshore blocks and three of the four OCA blocks were awarded. Only one block, offshore block A, contains proven resources. Oil was discovered in the block's Apsara oil field in 2005. Licenses for the five remaining offshore blocks have been revoked due to lack of progress, owing to low global oil prices and the long duration of negotiations for the first production sharing contract. Similarly, of the three onshore blocks awarded licenses, only one, licensed to the state-

¹⁰ Chugoku Electric Power Co., Inc. 2015. *The Project on Revision of Cambodia Power Development Master Plan*. Presentation prepared for the Government of Cambodia. Phnom Penh. September. Unpublished.

¹¹ Cambodian National Petroleum Authority (retrieved from Open Development Mekong). In March 2014, the Cambodian National Petroleum Authority was integrated into the Ministry of Mines and Energy (MME) as the General Department of Petroleum.

¹² C. Y. Cheang. 2016. OTC 2016: Cambodia Decision on First Oilfield Development by Year End. *Rigzone*. 2 May.

¹³ Nabarro LLP. 2016. Oil and Gas Regulation in Cambodia—Commentary on Prospects for Investors. *CMS Law Now*. 31 October.

¹⁴ V. Sokheng. 2012. Cambodia, Thailand Eye Overlapping Claims Area. *The Phnom Penh Post*. 19 September.

run Vietnam Oil and Gas Group (PetroVietnam), remains active. Provisional concessions in the OCA remain in place, although the maritime border dispute has not yet been resolved. Two have been awarded to a consortium of ConocoPhillips and Idemitsu, and one to Total of France.¹⁵

11. Commercial petroleum resources have been found in offshore block A. Singapore-owned KrisEnergy owns a 95% share in block A, after acquiring Chevron's share in 2014 and buying out the other partners in 2016. The MME owns the remaining 5%. A production agreement was signed in August 2017, and extraction is set to begin in late 2019 or early 2020. KrisEnergy estimates that the project's first platform could recover 8.5 million barrels of oil, and the company is hopeful that additional platforms could provide 30 million barrels of oil over 9 years (footnote 15).¹⁶

12. Cambodia is still drafting the necessary laws and regulations regarding oil and gas production that will update the current legal framework—the 1991 Petroleum Regulations, and the 1995 and 1999 amendments to these; and the 1997 Law on Taxation and its 2003 amendment. Cambodia also uses a model production-sharing contract agreement to establish the terms of employment for contractors in the oil and gas sector. As of April 2018, a draft oil and gas law had been circulated for consultation with nongovernment organizations, the private sector, and other organizations in the sector.¹⁷ There have also been media reports that the government is considering forming a state-owned oil company that would engage in investment and joint venture opportunities in the oil and gas sector.¹⁸ If formed, its functions would be elaborated in the oil and gas law.

13. Cambodia currently has no refinery capacity; however, in May 2017, construction began on a \$2.3 billion refinery project to be located on 365 hectares (ha) in Kampot and Sihanoukville provinces.¹⁹ The refinery will be constructed by the Cambodian Petrochemical Company, a private company, and will have an annual oil capacity of 5 million tons upon completion in 2019. The project received a \$1.67 billion loan from the state-owned Export-Import Bank of China in December 2013, but plans were stalled until May 2016, when the first phase construction contract was awarded to the China National Petroleum Corporation, and subsequently outsourced to the Sino Great Wall International Engineering Group of the People's Republic of China (PRC). The refinery is expected to reduce petroleum imports, lower costs, and improve national energy security, particularly when block A begins producing.

¹⁵ *The Nation*. 2017. Blocks Fall in Cambodia as Oil Interest Dries Up. 9 September.

¹⁶ *Offshore Magazine*. 2017. Report: KrisEnergy, Cambodia Near New Terms for Block A. 20 March.

¹⁷ C. Vannak. 2018. Discussion on Petroleum Law Resumes. *Khmer Times*. 24 April. From 2007 to 2010, ADB provided TA to the Cambodian National Petroleum Authority on developing the new Petroleum Law and economic modeling for production sharing contracts. ADB. 2006. *Technical Assistance to the Kingdom of Cambodia for Institutional Strengthening of the Cambodian National Petroleum Authority*. Manila (TA 4901-CAM).

¹⁸ Open Development Cambodia. 2016. Oil and Gas Resources. 6 January.

¹⁹ H. Kimsay and K. Kotoski. 2017. Ground Broken for Oil Refinery. *The Phnom Penh Post*. 5 May. and K. Kotoski. 2016. Chinese Firm Bags Contract for Oil Refinery. *The Phnom Penh Post*. 5 May.

3. Renewable Energy Resources

14. In 2015, renewable energy accounted for 65% of Cambodia's total energy consumption, according to *Tracking SDG7: The Energy Progress Report* released in May 2018.²⁰ Of this, 46% came from traditional biomass such as wood, charcoal, and dung; 15% from modern biomass such as biogas produced from human and animal waste; and 3% from hydropower. Traditional biomass remains the cooking fuel for 82% of the population (footnote 20).²¹

15. With regard to electricity generation, while large hydropower represented 52% of the the total national electricity capacity (980 megawatts [MW] out of 1,878 MW total capacity) in 2017, Cambodia's uptake of non-large hydrorenewable generation was relatively limited and represented around 30 MW of capacity, consisting mainly of on-grid biomass (sugarcane bagasse), rice husk biomass gasification, and off-grid solar home systems (SHSs) installed by the Rural Electrification Fund (REF), administered by Cambodia's national electricity utility, Electricite du Cambodge (EDC).²² The country's first 10 MW solar power plant came online in 2017.

16. **Hydropower.** Cambodia's technical hydropower potential is an estimated 10,000 MW.²³ Around 50% of hydropower resources are located on the Mekong River, 40% on the tributaries of the Mekong River, and 10% in the southwestern coastal highlands.²⁴ Out of the 10,000 MW, only 980 MW of capacity have been built, 400 MW of capacity are under construction, and another 90 MW of capacity are in the feasibility study stages. Hydropower generation varies greatly between the dry and wet seasons, with reduced electricity generation during the hotter months. In addition, the country has small and micro hydropower potential, but the volumes have not been measured yet.

17. **Biomass.** Cambodia is endowed with considerable biomass energy resources from a variety of sources, including rubber plantation forests; fast-growing tropical trees such as *Gliricidia* and *Acacia*; and agricultural residues such as rice husk, rice straw, corn cobs, wastes from palm oil extraction, cassava stalk, sugarcane bagasse, and cashew nut shells. The country's large-scale processing mills could utilize these by products for power generation. Using 2010 data obtained from the Ministry of Agriculture, Forestry, and Fisheries, ADB estimates that the combined theoretical potential of agricultural residues is about 15,000 gigawatt-hours (GWh) per year.²⁵ By the end of 2016, Cambodia had five biomass generation power plants in operation, representing nearly 18 MW of installed capacity and 42 GWh produced that year. In 2017, two plants representing an additional 21 MW of biomass generation came online.

²⁰ World Bank. 2018. *Tracking SDG7: The Energy Progress Report*. Washington, DC.

²¹ Government of Cambodia, Ministry of Planning. 2016. *Cambodia Socio-Economic Survey 2015*. Phnom Penh.

²² EAC. 2018. *Report on the Power Sector of the Kingdom of Cambodia, 2018 Edition*. Phnom Penh; and MME. 2016. *Current Status of Renewable Energy in Cambodia*. Presentation prepared for the International Renewable Energy Agency's Renewable Energy Statistics Training. Bangkok, Thailand. 12-14 December.

²³ MME. 2016. *Current Status of Renewable Energy in Cambodia*. Presentation prepared for the International Renewable Energy Agency's Renewable Energy Statistics Training. Bangkok, Thailand. 12-14 December.

²⁴ Cambodia National Mekong Committee. 2003. *National Sector Review 2003: Hydropower*. Phnom Penh. Quoted in Open Development Cambodia. Hydropower Dams.

²⁵ ADB. 2015. *Renewable Energy Developments and Potential in the Greater Mekong Subregion*. Manila.

18. Biomass is also used to produce biofuels for transport. These come from jatropha (1,000 ha), palm oil (4,000–10,000 ha), and sugarcane (20,000 ha). In addition, roughly 36 million liters of bio ethanol is produced annually from cassava, under a joint venture with a Korean company, MH Bio-Energy Group. Several projects have demonstrated the potential for using animal waste to produce biogas for cooking and lighting; however, the potential for biogas may be limited to the household level due to small-scale livestock holdings of most farmers.

19. **Solar power.** Cambodia enjoys some of the highest solar resources in the Greater Mekong Subregion (GMS), with solar irradiance measuring on average 1,400–1,800 kilowatt-hours (kWh) per square meter per year throughout the country, for an estimated technical potential of over 8,000 MW. In the middle of Cambodia, including the load center of Phnom Penh, which is responsible for approximately 70% of national electricity demand, the peak solar resource measures over 1,900 kWh per square meter per year. Solar is also a good option for remote rural households that do not currently have access to the grid. By the end of 2017, Cambodia had installed over 60,000 SHSs as part of the SHS program of the REF.²⁶

20. In 2013, the government, with support from development partners, began to seriously consider solar energy. A technical study prepared that year by the Korea Photovoltaic Industry Association for the Ministry of Trade, Industry, and Energy of the Republic of Korea and ADB helped investigate the scope for development of a 100 MW solar power plant in Cambodia.²⁷ In 2015, a United States Agency for International Development-funded study explored the viability of using various solar energy applications to enhance Cambodia's energy security.²⁸ The study found that, at the time, the price of electricity from solar installations above 1 MW was about \$0.12 per kWh, and as low as \$0.10 per kWh if grant financing was available. The study recommended that Cambodia adopt (non-large hydro) renewable energy targets and suggested the following: 100 MW before 2020 (equal to 10% of 2015 peak demand) and 156 MW in 2020 (equal to 10% of 2020 peak demand in the MME's low demand growth forecast). A more ambitious long-term target of 10% electricity supply by 2025 would require 850 MW of solar generation and would help defer development of 220 MW of coal-fired generation planned for 2025.

21. Since 2015, the government has been prompted to explore solar power as a generation option because of the rapid reduction in global prices for renewable technologies such as solar power; Cambodia's excellent solar potential; and the country's ratification of the Paris Agreement, negotiated at the 2015 United Nations Climate Change Conference. In February 2016, the government issued its first large-scale tender for solar power, inviting bids for the supply of 10 MW in Bavet in Svay Rieng Province, to support the development of its special economic zone. Sunseap Group, financed by ADB's Private Sector Operations Department (PSOD), won the bid

²⁶ The installation of 12,000 SHSs through 31 January 2012 was financed under the former Rural Electrification and Transmission Project, funded by the World Bank's Global Environmental Facility Trust Fund.

²⁷ Korea Photovoltaic Industry Association; KC Cottrell Co., Ltd.; and Sun Business Development (for the Ministry of Trade, Industry, and Energy, Republic of Korea; and ADB). Prefeasibility Study in the Kingdom of Cambodia: Identification of Feasible Sites and Conditions for the Development of 100 MW Photovoltaic Power Project. Unpublished.

²⁸ R. de Ferranti et al. 2016. *Switching On: Cambodia's Path to Sustainable Energy Security*. Phnom Penh: Mekong Strategic Partners.

with a tariff of \$0.091 per kWh and achieved financial close in May 2017.²⁹ The project received a 20-year power purchase agreement (PPA) to sell to EDC. It began commercial operations on 1 October 2017.³⁰

22. In 2017, at the government's request, ADB developed a preliminary national solar photovoltaic (PV) grid integration study and road map for EDC. In this study, low, medium, and high solar penetration scenarios were considered. Results show that with currently available technologies, 150 MW of solar can be added to the grid by 2020 (100 MW in Phnom Penh and 50 MW throughout the rest of Cambodia) and up to 350 MW by 2030, with no major impact on the grid and no additional technical upgrades required for the existing transmission system. Solar generation can complement hydropower by helping to meet daytime peak demand and improving hydropower storage performance during the dry season. The study found that uptake of solar will result in savings from avoided thermal generation and imports, as well as the deferred construction or complete avoidance of 300 MW of coal-fired generation by 2030 in medium and high solar PV penetration scenarios (both of which would require grid management and mitigation measures to handle frequency and voltage fluctuations). Following this study, in June 2018, ADB completed a country-wide solar generation master plan for EDC that includes impacts and recommended actions to prepare the grid for solar penetration scenarios of greater than 1,000 MW by 2030. Both the grid integration study and solar generation master plan were prepared for EDC on a confidential basis.

23. Building on the experience of the 10 MW Bavet solar power project and results of the grid integration study and solar generation master plan, ADB is supporting EDC to develop a 100 MW capacity solar power park near the Phnom Penh demand center. ADB's Office of Public-Private Partnership is assisting EDC to design and conduct a competitive tender for procuring the first 60 MW power plant to be built in the solar power park. Additional power plants supplying the remaining 40 MW are expected to be tendered out to the private sector by EDC in a subsequent phase. The National Solar Park Project³¹ is estimated to cost approximately \$26 million and is expected to be financed through a combination of funds from ADB, the Government of Cambodia, and the Strategic Climate Fund under the Scaling Up Renewable Energy Program in Low Income Countries (SREP) (part of the Climate Investment Funds).

24. Cambodia was invited to be a SREP pilot country in 2014. In June 2016, the SREP Sub-Committee approved Cambodia's SREP investment plan and endorsed \$30 million in concessional loans and grants to support a solar energy development program and a biomass generation program. ADB is the sole implementing partner for this investment plan. However, since the SREP has been oversubscribed, the funds currently available to the government total \$14 million. In mid-July 2017, a proposal to revise the SREP investment plan and allocate the full \$14 million to the National Solar Park Project was submitted to the SREP Sub-committee for approval. The revised SREP investment plan was approved in August 2017.

²⁹ ADB. 2016. *Report and Recommendation of the President to the Board of Directors: Proposed Loans and Administration of Loan to Sunseap Asset (Cambodia) Co. Ltd. for the Cambodia Solar Power Project in Cambodia*. Manila.

³⁰ P. Tharakan. 2017. *Experience with Solar PV Deployment in Cambodia*. Presentation for the joint ADB-United States Agency for International Development workshop: Developing a Solar Policy Roadmap and Auction Policies in the Lao People's Democratic Republic (Lao PDR). 17 November.

³¹ ADB. Cambodia: National Solar Park Project.

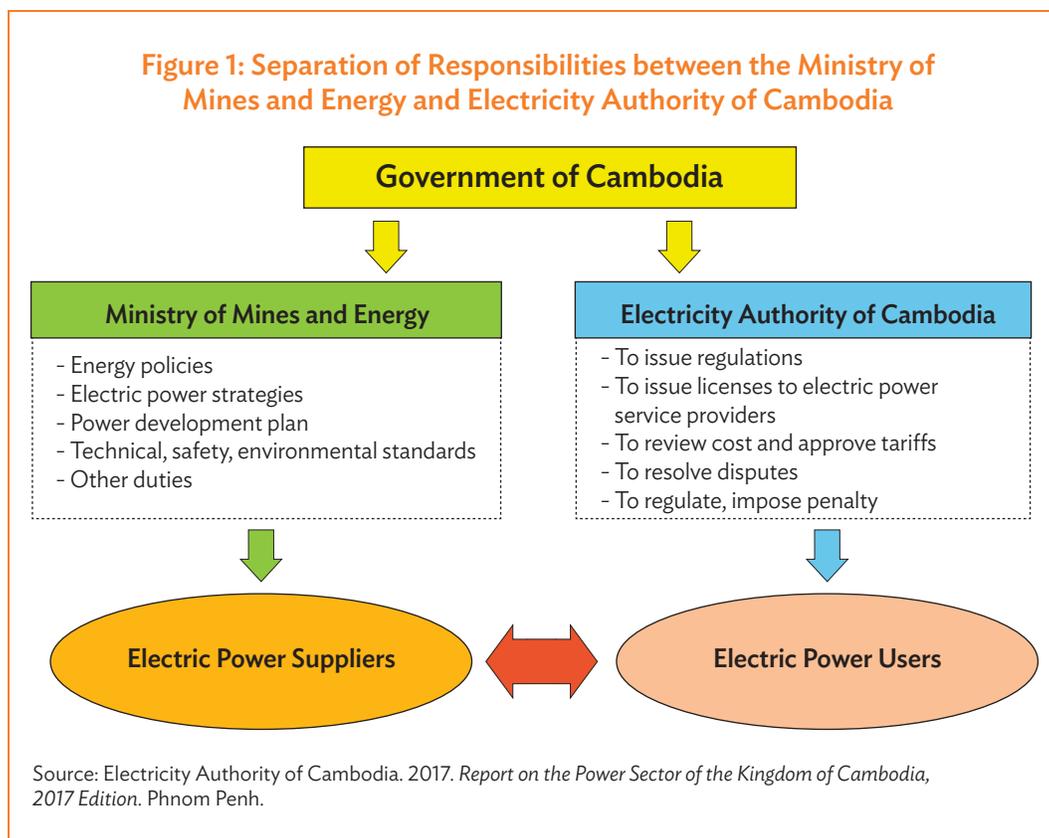
25. In 2017 and 2018, a series of new project announcements was made for business-to-business deals for solar PV plants in several provinces.³² These projects aim to sell electricity directly to businesses in special economic zones or potentially to EDC if an agreement is reached. The projects are at varying stages of development.

26. In anticipation of the use of small-scale distributed solar PV (such as rooftop solar or on-site ground-mounted systems), the Electricity Authority of Cambodia (EAC) issued a regulation on conditions for the installation and connection of distributed solar energy projects to the national grid. The regulation, issued in January 2018,³³ allows large (medium voltage) and bulk (high voltage) consumers to install solar power systems for self-consumption and synchronize with the distribution system of the national grid. The regulation requires that a solar project seeking to connect to the grid must be approved by MME and EDC and must meet certain technical standards and safety conditions. The regulation also includes a two-part tariff system, which comprises charges for consumption and contracted load. Only in exceptional cases may electricity be sold back to the grid; this requires a PPA with EDC and approval from EAC. Solar PV systems designed for self-consumption only and not connected to the grid are also allowed.

27. **Wind.** Localized wind assessments indicate that parts of the country have wind resources of medium intensity that are appropriate for utility-scale turbines. Average wind speeds range from 6 to 9 meters per second per year in the southern regions of Tonle Sap Lake, in the southwestern mountainous areas, and along the coast; however, this represents only 3%–5% of Cambodia’s land area. Given these measurements, Cambodia’s theoretical wind potential is 65 gigawatts, with a potential production capacity of 154 terawatt-hours (TWh) per year (footnote 25). Taking into consideration the ability of the grid to absorb this load, Cambodia’s technical wind potential is estimated to be from 18 MW to 72 MW. A 2015 analysis by ADB finds that wind could potentially be economically feasible in areas with wind speeds greater than 6 meters per second per year that could be reached by the grid, or in small, off-grid applications (footnote 25). A pilot 300-kilowatt wind turbine installed at the port of Sihanoukville in 2010 aims to reduce diesel generation for the harbor grid, but discussions in February 2018 between development partners and ADB suggest the plant is not providing as much power as expected.

³² In September 2017, the joint venture group Global Purify Power, representing investors from Cambodia, the Lao PDR, and Thailand, broke ground on a 15 MW solar plant to serve a special economic zone in Kampong Speu Province. This is the first solar plant project of the company’s total \$400 million investment in the country, anticipated to bring 225 MW of capacity to businesses in Kampong Speu, Kampong Chhnang, and Takéo provinces (M. Kunmakara. 2017. \$400m Solar Project Launched. *Khmer Times*. 11 September.). In October 2017, the French electric utility ENGIE signed a memorandum of understanding with local enterprise Devenco with plans to develop a 30–50 MW solar farm in Kampong Chhnang Province (C. Vannak. 2017. A New Solar Power Partnership Set to Shine. *Khmer Times*. 12 October.). In January 2018, the American firm Omni Navitas announced plans for a 500 MW solar farm in Koh Kong Province (H. Kimsay. 2018. Massive Solar Farm Planned by US Firm. *The Phnom Penh Post*. 1 February.). In October 2018, a joint venture between Cambodian firm SchneiTec Group and PRC-based Jinko Solar announced plans for a 60 MW solar plant in Kampong Speu Province (M. Kunmakara. 2018. Milestone Solar Deal Reached. *Khmer Times*. 24 October.).

³³ EAC Regulation Number 018.sr.18rrk. 2018. On General Conditions for Connecting Solar Generation Sources to the Electricity Supply System of National Grid or to Electrical System of a Consumer Connected to the Electricity Supply System of National Grid. Phnom Penh. 26 January.



4. Key Energy Institutions

28. The organization and regulation of the energy sector in Cambodia follows the 2001 Electricity Law and subsequent amendments of 2007 and 2015.³⁴ The Electricity Law stipulates the separation of responsibilities between the two organizations governing the power sector, the MME and the EAC, and provides for private sector participation in the electricity sector.

29. At the end of 2013, the MME was separated from the Ministry of Industry, Mines, and Energy, which became the Ministry of Industry and Handicraft. The MME takes the lead in developing government policy, strategies, plans, and technical standards for the energy sector. Within the MME, this work is the responsibility of the General Department of Energy and its three departments:

- (i) the Department of Energy Development (which is responsible for energy and electricity planning);
- (ii) the Department of Energy Technology (which covers energy efficiency, technical standards, and non-hydro renewable energy); and
- (iii) the Hydropower Department.

³⁴ EAC. 2018. *Report on the Power Sector of the Kingdom of Cambodia, 2018 Edition*. Phnom Penh.

30. The MME's General Department of Petroleum, also created in December 2013, is responsible for regulating the oil and natural gas sector (both exploration and production), and the wholesale and retail sales of petroleum products. Previously, this responsibility fell under the independent Cambodian National Petroleum Authority; however, this body was dissolved and its responsibilities were subsumed by the General Department of Petroleum.

31. The Ministry of Economy and Finance (MEF), as co-owner of EDC, facilitates its access to long-term and concessional finance and plays an important role in setting energy policy. The MEF is the government's focal point for structural reform, international economic and financial cooperation and integration, lobbying for foreign aid, and preparation of plans for borrowing and repayment of foreign loans.

32. In accord with the requirements of the 1996 Law on Environmental Protection and Natural Resource Management, the Ministry of Environment is given the authority to review and approve the environmental assessments and environmental management plans for all energy projects.

33. The EAC, the electricity regulator, is an autonomous agency with the authority to issue rules, regulations, and procedures on power market operations; award licenses; and set tariffs. The EAC also regularly reviews tariffs and other charges to ensure reasonable end-user prices and adequate returns to investors. The EAC is led by a chairman and two members, who are appointed by the Prime Minister and confirmed by royal decree, and the agency is funded from license applications and fees. All power generators, suppliers, and distributors must be licensed by the EAC.

34. EDC, as the state-owned, vertically integrated power utility, generates, transmits, and distributes electricity in areas assigned to it by the EAC. It is jointly owned by the MME and MEF and is the only public sector licensee of the EAC. Most of EDC's electricity is sold in Phnom Penh and the main provincial towns. EDC's mandate also covers extending and integrating the local grids of private energy producers into one national grid, as well as further extending the national grid to rural areas. To facilitate rural electrification, which involves large capital costs and a low payback, the government provides support and subsidies to EDC.

35. The REF, which was integrated into EDC in August 2012, is the governmental body responsible for subsidizing rural electrification. Its mandate is to (i) promote equitable rural electrification coverage by facilitating the population's access to electricity for economic, social, and household uses at affordable prices, and thus contribute to poverty reduction; and (ii) encourage the private sector to participate in providing sustainable rural electrification services through the economic, technical, and commercial exploitation of well-proven, new, and renewable energy technologies.³⁵

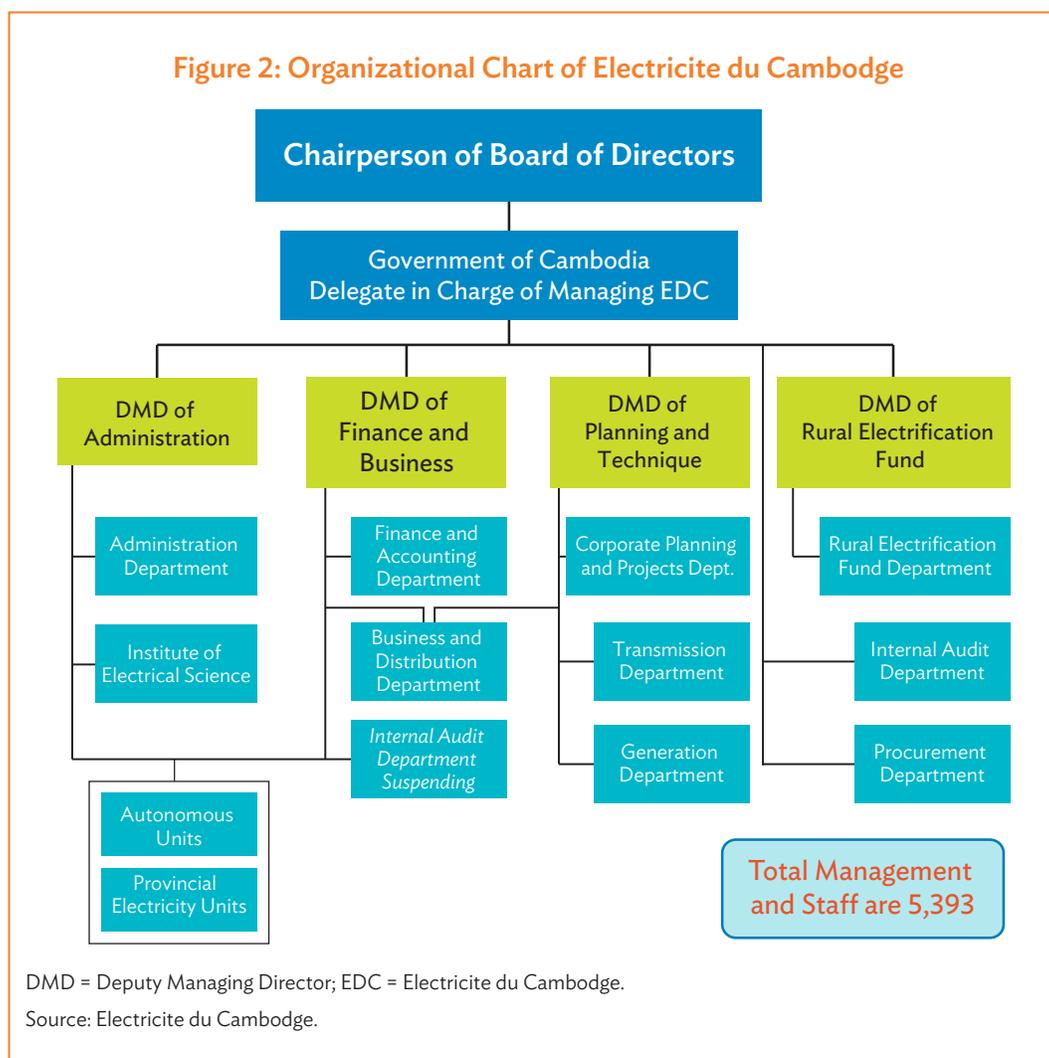
36. The promotion of private participation in electrification, including rural electricity enterprises (REEs), is mandated by Cambodia's 2001 Electricity Law.³⁶ In the past, it was estimated that 600–1,000 REEs provided electricity to off-grid customers, traditionally through diesel

³⁵ EDC, Department of REF. 2017. *Report on Transferring the Benefits Resulting from the Development of Electricity to the Population in Rural Area for the Year 2016*. Phnom Penh.

³⁶ The term "REE" is used broadly in Cambodia to refer to any electricity supplier other than EDC, even if they provide electricity in urban areas.

generation. However, only a few are licensed by the EAC.³⁷ A total of 336 REEs were licensed by the EAC in 2017. With the expansion of the grid, more REEs are being connected to the national grid supply and are no longer reliant on expensive diesel supply. In 2016, 82 licensees received PPAs for supply from the national grid and had their licenses changed from a consolidated license for generation and distribution to a license for distribution only. In 2017, 17 additional licensees were connected to the national grid supply. The REEs have been critical private sector participants in developing, operating, and maintaining the country's electricity distribution system. Private domestic and foreign companies are also encouraged to invest in (i) oil and gas exploration and production; (ii) energy generation from local resources, including hydropower and other renewables; and (iii) expansion of the high-voltage transmission network.

Figure 2: Organizational Chart of Electricite du Cambodge



³⁷ Innovation Energie Développement. 2013. *Final Report: Identifying the Gaps and Building the Evidence Base on Low Carbon Mini-grids*. Francheville, France.

5. Strategic Issues

37. Cambodia is experiencing rapid economic growth, increased electrification rates, and a corresponding growth in energy demand. The country is being challenged to keep up with this rapid demand growth while continuing to expand access to previously unserved areas and addressing issues of energy security, affordability, and environmental sustainability.

38. Cambodia requires a more cohesive energy sector strategy linking policies and physical infrastructure plans (including generation, transmission and distribution) to support further economic growth and competitiveness. The current power development planning process often relies on unsolicited bids and business-to-business arrangements for new power generation, primarily from hydropower and coal. Indeed, the 2015 PDP (footnote 10) forecasts meeting future demand growth through investments in large hydropower and thermal generation (coal-fired in the short-term and both coal and natural gas in the long-term). However, the cost of new renewable energies, such as solar, has dropped significantly and the technologies have improved to allow for higher levels of penetration into the grid from solar parks, rooftop PV and floating solar. Integration of these new renewable sources should be balanced with other sources, such as biomass and quick-responding gas-fired generation, to achieve the optimal mix to increase energy security, reduce costs, and limit the environmental impacts of the sector. Employing a multi-stakeholder approach and building domestic capacity in energy planning will help Cambodia develop a competitive strategy for investment and sector growth.

39. The capacity of EDC to scale up clean energy generation through the private sector and public-private partnerships is limited. The utility needs more experience in conducting competitive tenders in a structured approach, which requires standard tender documents, PPA templates, and established procedures for the review of investment proposals.

40. The traditionally high electricity tariff in the country makes access less affordable to the poor while constraining economic competitiveness and discouraging investment. Since 2015, with the concerted expansion of the high-voltage transmission system and the medium- and low-voltage distribution systems, more and more REE licensees and their customers have been connected to the grid, thereby improving the quality and reducing the cost of electricity supply. In turn, the tariff for consumers has also been reduced (paras. 74–80). Additionally, the reduction in expensive electricity imports has helped reduce the cost of supply. Cambodia needs to continue its grid expansion plans and complete its electricity access agenda to bring modern energy services to the whole population and further lower electricity prices on par with its neighbors.

41. Increased connectivity and cooperation across the GMS could help Cambodia further reduce electricity prices. By allowing open access to transmission lines across the GMS, Cambodia could import bulk power in a way that is cost-effective, rather than through the import of more expensive power transmitted over medium-voltage sub-transmission lines in remote border areas. Cambodia could also explore potential electricity export opportunities, particularly during the rainy season when there is excess generation from hydropower plants.

42. A greater emphasis on energy conservation across the sector—including the use of electricity as well as fuels for transport and cooking—is necessary to contain demand growth, limit the import dependence on coal and other fossil fuels, and set Cambodia on a path of low-carbon development.

D. Electricity Subsector Assessment

43. Electricity in Cambodia is generated by two types of licensees (footnote 34): (i) independent power producers (IPPs) who have a generation license and sell electricity to suppliers or industries through a PPA and (ii) consolidated licensees (EDC and mainly REEs) that generate electricity to supply consumers connected to their distribution networks. Two types of licensees can transmit electricity: (i) the national transmission licensee, EDC, which has the right to transmit electricity to supply any distribution network and bulk power consumers throughout Cambodia;³⁸ and (ii) the special purpose licensees, which have the right to own, operate, and manage identified transmission facilities for delivering and selling electricity in bulk. The consolidated licensees and distribution licensees have the right to own distribution facilities and distribute electricity in their authorized areas.³⁹

44. At the end of 2017, valid licensees totaled 375: 1 consolidated generation, distribution, and national transmission license (EDC); 24 generation licenses to IPPs; 9 special purpose transmission licenses; 8 consolidated licenses consisting of a special purpose transmission and a distribution license; 270 distribution licenses; 5 retail licenses; and 58 consolidated licenses consisting of generation and distribution licenses. The number of licensees grew from 143 in 2006 (footnote 34).

1. Supply, Demand, and Generation Capacity

45. Prior to 2010, Cambodia's power generation capacity was almost entirely based on diesel generators. From 2011 to 2017, there were significant changes to Cambodia's generation capacity. Total installed capacity has substantially increased and become more diversified, with hydro, coal, and solar projects being commissioned. Additions are coming online so rapidly that it is difficult to provide the exact capacity at any given time, and numbers vary by different government sources. At the end of 2017, the EAC reported that the total domestic installed capacity was 1,878 MW, of which 980 MW (52%) was hydropower, 564 MW (30%) was coal-fired, 295 MW (16%) was diesel, 29 MW (less than 2%) was biomass, and 10 MW (less than 1%) was solar (footnote 34). Over 92% of this capacity is owned by IPPs, 6% is owned by EDC, and the rest is owned by other licensees.

46. Annual power generation in 2017 was 8,073 GWh, including approximately 1,440 GWh of imports primarily from Viet Nam (1,095 GWh), Thailand (291 GWh), and the Lao People's Democratic Republic (Lao PDR) (54 GWh). Domestic production increased 21% from 2016. Distributors and REEs are responsible for approximately 31% of electricity sales, the commercial sector for 28%, residential sector for 23%, industry sector for 16%, and the government for 3%.⁴⁰

³⁸ Except if such consumers are within the territories served by isolated systems (REEs).

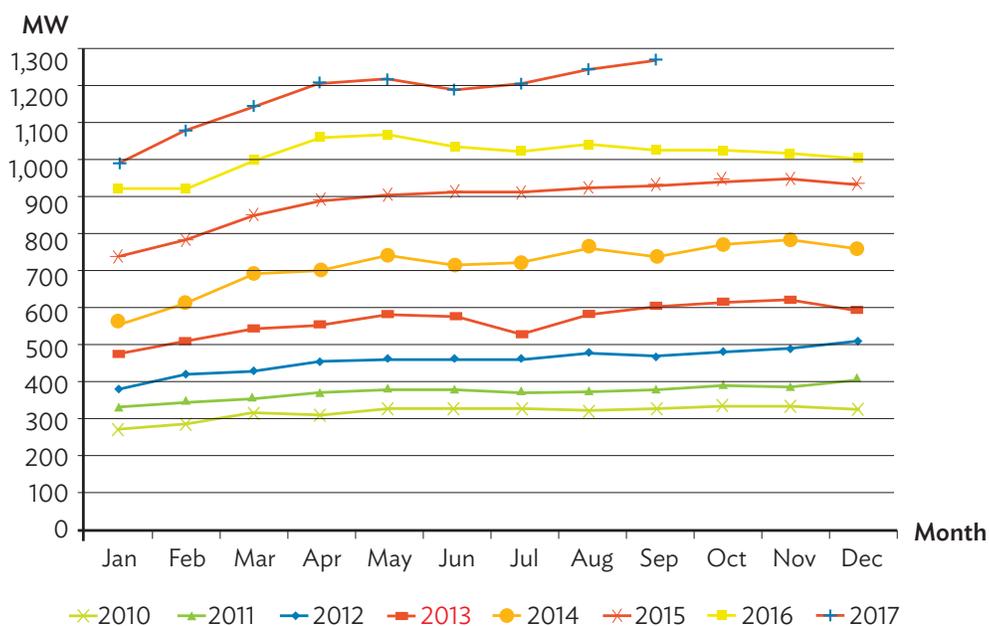
³⁹ While some licensees might operate in multiple areas, each license covers an exclusive distribution area.

⁴⁰ EDC. 2017. *Cambodia Country Presentation*. Presentation prepared for the 23rd Meeting of the Regional Power Trade Coordination Committee (RPTCC). Lao PDR. 13–15 December. The total is more than 100% because of rounding.

Power imports, which have traditionally been a significant source of meeting domestic demand, have been reduced. In 2017, imports from Viet Nam were 1,095 GWh relative to 1,177 GWh in 2016, and imports from Thailand were 291 GWh in 2017 relative to 336 GWh in 2016. A small amount of power is also imported from the Lao PDR to serve the border areas. Overall, imports are further expected to be reduced as additional power plants come online.

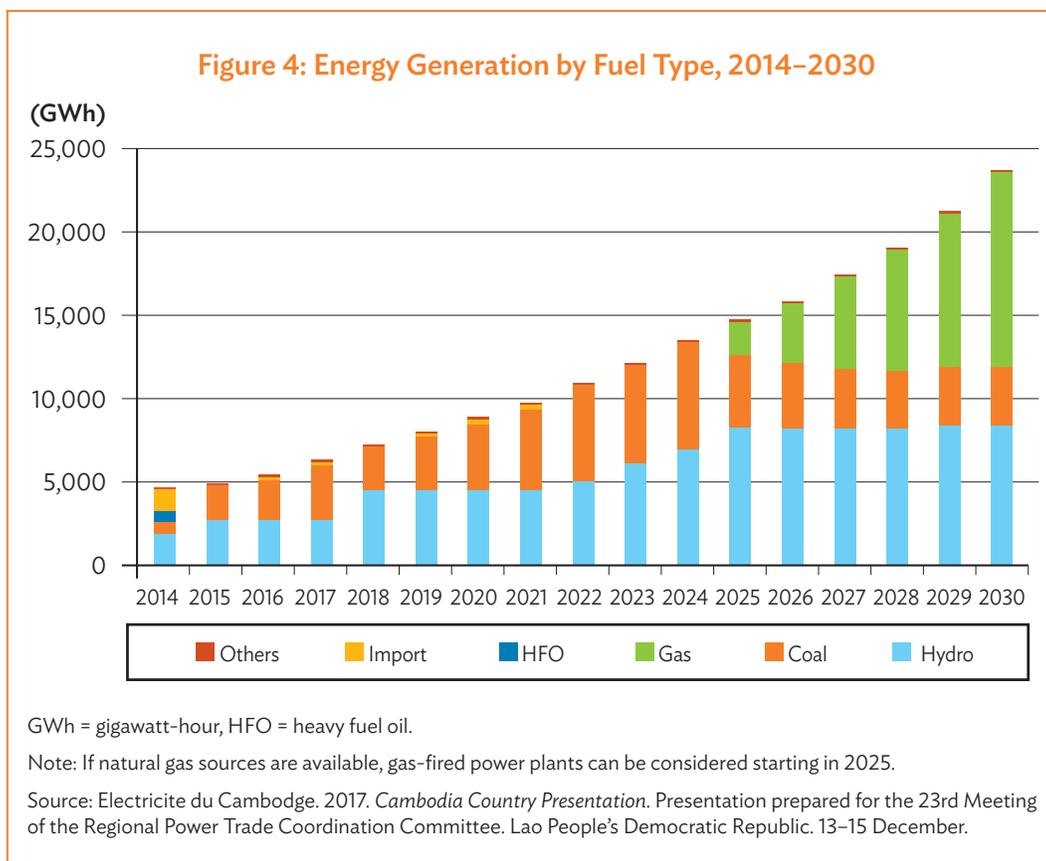
47. From 2011 to 2015, the annual growth of electricity demand averaged 18%. Going forward, the 2015 PDP (footnote 10) in its base case projects an 8.8% compounded annual growth rate in electricity demand to 2030, and Cambodia's energy demand is forecast to rise to 7,700 GWh by 2020 and to 18,000 GWh by 2030, or a greater than threefold increase relative to demand in 2015. This translates to peak demand forecasts of 1,412 MW in 2020 and 3,256 MW in 2030, compared to about 1,000 MW of peak demand in 2016. Of the current peak demand, around 70% is used in Phnom Penh, the capital, where more than 2 million people live, and business and industry are concentrated.

Figure 3: Peak Demand on the National Grid



MW = megawatt.

Source: Electricite du Cambodge. 2017. *Cambodia Country Presentation*. Presentation prepared for the 23rd Meeting of the Regional Power Trade Coordination Committee. Lao People's Democratic Republic. 13–15 December.



48. Total electricity consumption in 2016 was 400 kWh per capita, up from 270 kWh per capita in 2014.⁴¹ Despite the increase, this annual average per capita power consumption was just 38% of the Asian average of 1,040 kWh and 13% of the global average of 3,110 kWh.⁴²

49. From 2013 to 2017, Cambodia saw a surge in new generation facilities.⁴³ Four hydropower facilities representing 722 MW came online during this time as well as 525 MW of coal-fired generation, 10 MW of solar-powered generation, and 21 MW of additional biomass generation. The hydropower plants include the following:

- (i) Kirirom III (18 MW) in Koh Kong Province, owned by the China Electric Power Technology Import and Export Corporation International Hydropower Development Company, which started operating in 2013;
- (ii) Stung Atay (120 MW) in Pursat Province, owned by Cambodia Hydropower Development Company, a subsidiary of China Datang Corporation, which started operating in 2013;

⁴¹ G. Choummit, MME. 2016. *Cambodia Country Presentation*. Presentation prepared for the 21st Meeting of the RPTCC. Cambodia. 8–9 November.

⁴² International Energy Agency. Statistics Database (accessed 1 October 2018). Asian average excluding the PRC.

⁴³ EAC. *Report on the Power Sector of the Kingdom of Cambodia*. Phnom Penh (3 years: 2016–2018); and C. Sokhorng. 2018. Kingdom More Energy Independent. *The Phnom Penh Post*. 5 January.

- (iii) Lower Russei Chrum (338 MW) in Koh Kong Province, owned by China Huadian Lower Russei Chrum Hydroelectric Project (Cambodia) Company, which started operating in 2014; and
- (iv) Stung Tatay (246 MW) in Koh Kong Province, owned by Cambodian Tatay Hydropower Limited (PRC), which began power production in 2014 and started operating in 2015.

50. The coal-fired plants include the following:

- (i) a 120 MW plant operated by Cambodia Energy Limited (a wholly owned subsidiary of Leader Universal Holdings, a Malaysian company) in Preah Sihanouk Province, commissioned in 2014; and
- (ii) a 405 MW plant operated by Cambodia International Investment Development Group and PRC-based Erdos Hongjun Electric Power Co. Ltd., also in Preah Sihanouk Province. At this site, 270 MW of generators were commissioned in 2015 and an additional 135 MW were commissioned in 2017.

51. The biomass plants include the following:

- (i) an 11 MW project in Koh Kong Province, implemented by Kohkong Sugar Industry Limited; and
- (ii) a 10 MW plant at the Rui Feng (Cambodia) International Company Limited (a Chinese-owned firm) sugar mill in Preah Vihear Province, from which EDC plans to purchase 2–4 MW.

52. The country's first utility-scale solar plant with 10 MW of generating capacity, located in Bavet, Svay Rieng Province, was developed by Sunseap Group and commissioned in 2017. Sunseap has a 20-year build-own-operate power purchase agreement with EDC. The project was financed by ADB's PSOD (footnote 29).

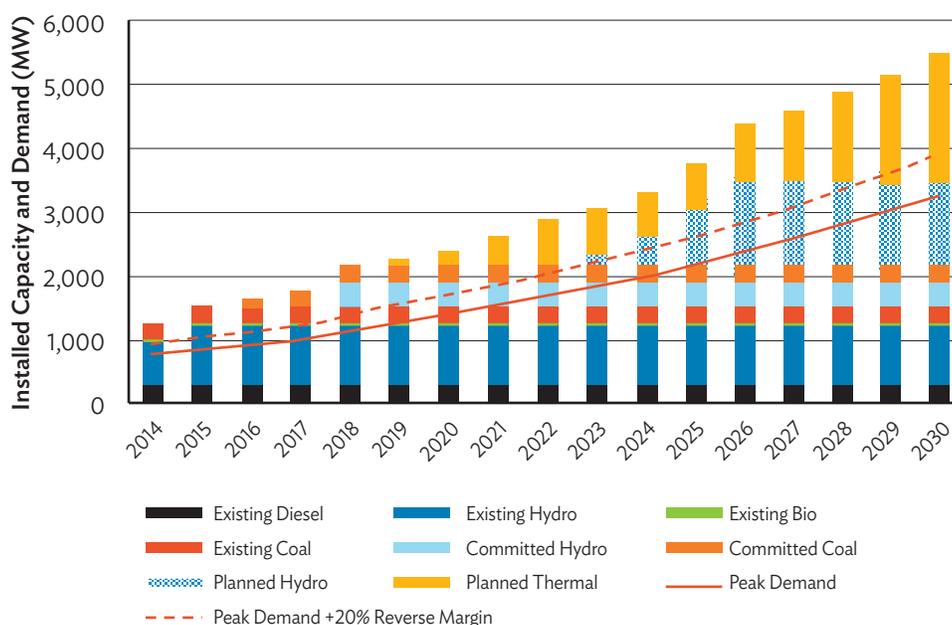
53. Power plants currently under construction include the following:

- (i) A 135 MW coal-fired plant operated by Cambodian Energy II Co. Ltd. (also a wholly owned subsidiary of Leader Universal Holdings, a Malaysian company) and constructed by Toshiba, the first Japanese company to receive a power plant construction contract in the country. This plant in Preah Sihanouk Province is expected to be operational by 2019.
- (ii) The 400 MW Lower Sesan II Hydropower Project, developed by China Huaneng Group and Cambodia's Royal Group. The plant began operating in November 2017 and all eight turbines are expected to be operational by the end of 2018.

54. The Lower Sesan II Project signed a PPA with EDC, which has the monopoly on bulk purchases, including imports, as well as a monopoly on the sale of electricity over the national high-voltage grid. The PPA with Cambodian Energy II is currently being negotiated. The Lower Sesan II Hydropower Project, as with previous hydropower projects, is being undertaken on a build-operate-transfer basis, while the coal power plant is being built as a build-own-operate project. The contracts are for 20 years or more.

55. In addition to electricity plants currently under construction, plans for more are at different stages of development. The Cambodia PDP, prepared by the MME and revised in 2015 (footnote 10), lists an additional 21 power plant projects to be commissioned during 2020–2030 in its base case of projected demand. This includes an additional 750 MW of coal-fired plants; nearly 1,200 MW of hydropower; and 2,100 MW of additional thermal generation (either coal- or gas-fired), with gas-fired generation expected to come online during 2025–2030. By 2030, thermal generation is expected to represent roughly half of the country’s generation capacity. The 21 power projects would be financed mainly by companies based in the PRC and the Republic of Korea, with firms based in Viet Nam and Singapore also considering financing some power plants. A prefeasibility study has been conducted for the proposed Prek Liang Hydropower Project (90 MW).

Figure 5: Cambodia’s Installed Capacity and Demand Forecast, 2014–2030



MW = megawatt.

Source: ADB, based on Chugoku Electric Power Co., Inc. 2015. *The Project on Revision of Cambodia Power Development Master Plan*. Presentation prepared for the Government of Cambodia. Phnom Penh. September. Unpublished.

56. Based on the 2015 PDP (footnote 10), hydropower will dominate electricity supply in the near term while coal power stations based on imported coal will also be a major source by 2022. This new generation capacity has enabled Cambodia to significantly reduce its dependence on oil for the power sector, and therefore to shocks from spikes in external oil prices. This is an important counterweight as well to the rapidly increasing demand for oil in the transport sector. However, the growing use of coal has introduced a number of challenges that need to be managed, in particular increased carbon emissions, increased localized air pollution, management of coal importation facilities in the southwest of the country, and exposure to imported coal at international prices.

57. New sources of generation (hydro and coal) needed to be developed far away from the major load center of Phnom Penh, which has created several operational challenges for EDC's National Control Center in terms of ensuring the power system is operated in a way that avoids power system stability issues. This means that some of the newly commissioned generation resources have not been utilized to their full potential, necessitating the need for additional investments in transmission equipment.

58. In addition, the siting of large hydropower and coal plants is increasingly facing opposition from local communities and civil society, owing to environmental concerns. Recently, the government announced a moratorium on the construction of new hydropower dams until 2020. In particular, the proposed projects at Stung Treng (900 MW) and Sambor (2,600 MW), which would include the construction of two mainstream dams on the Mekong River, have created significant controversy and are no longer considered in the PDP.

2. Transmission and Distribution

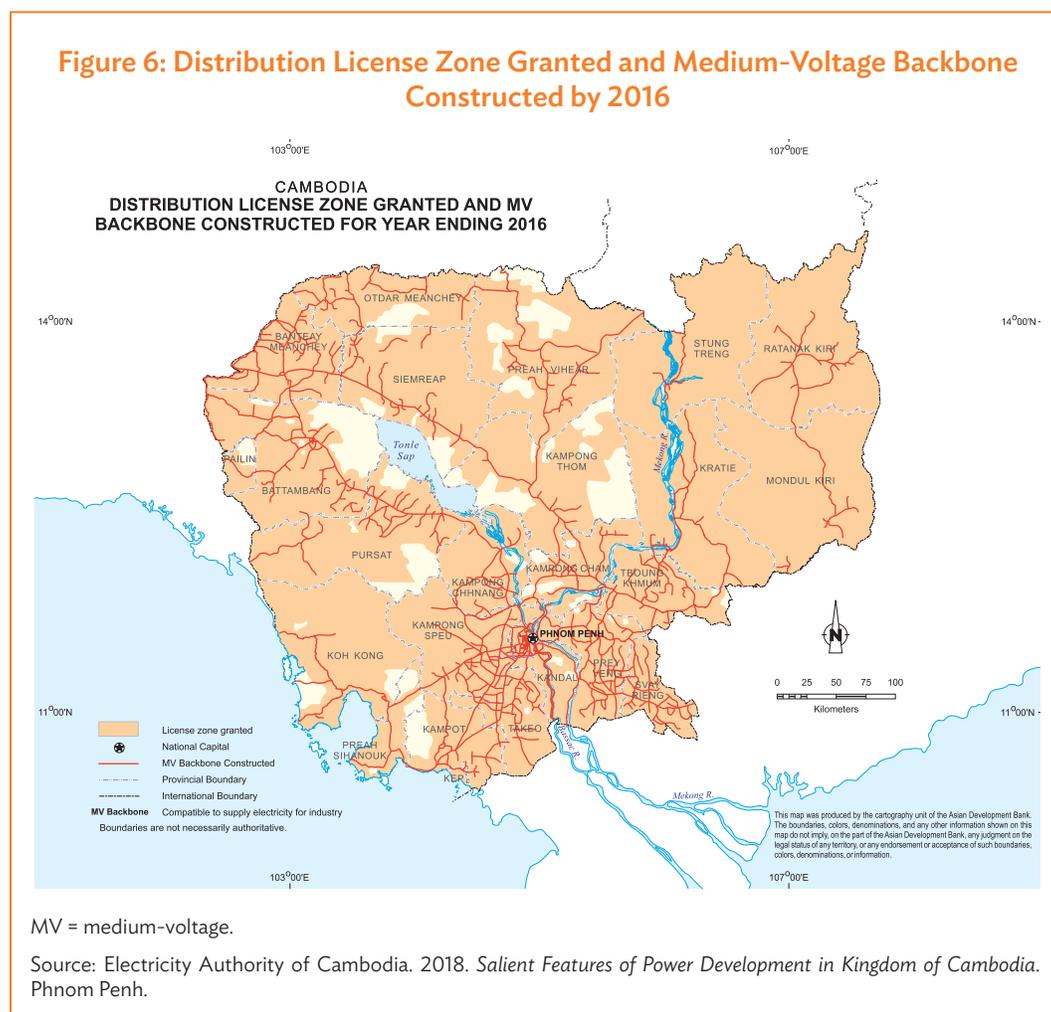
59. In the early 1990s, private IPPs began helping rebuild Cambodia's power sector, which was severely damaged by decades of conflict, civil war, and neglect. Starting in 1994, generating plants powered by diesel and heavy fuel oil were first built in Phnom Penh, Sihanoukville, and Siem Reap, and then in provincial towns, leading to the development of more than 20 isolated provincial grids. Since 2005, the government, with support from international donors, has been linking up power plants with high-voltage 230 kilovolt (kV) and 115 kV transmission lines and medium-voltage 22 kV sub-transmission lines. The government has also been extending the grid to previously isolated areas and supplying them with cheaper imported or domestically-generated power.

60. Since 2015, Cambodia has had a fully integrated high-voltage transmission system in place. The national grid is interconnected to Viet Nam synchronously via a 230 kV line in the southeast. Cambodia also relies on power supplies from Thailand in the northwest and from the Lao PDR in the northeast via separate 115 kV links. The national grid supplies electricity in 19 of 25 provinces in Cambodia via 30 substations: Phnom Penh, Banteay Meanchey, Battambang, Kampong Cham, Kampong Chhnang, Kampong Speu, Kampot, Kandal, Kep, Koh Kong, Kratie, Preah Sihanouk, Preah Vihear, Prey Veng, Pursat, Siem Reap, Stung Treng, Svay Rieng, and Takéo. From these substations, supply is also extended to Kampong Thom, Pailin, Tbong Khumum, Ratanakiri, and Mondulakiri provinces (with the last two provinces connected at the end of 2017) (footnotes 5 and 34). Private licensees supply power to the remaining provinces.

61. Medium-voltage 22 kV sub-transmission lines from the national grid substations (para. 60) supply electricity to local licensees in surrounding areas. In addition, Cambodia imports power at 22 kV from the Lao PDR, Thailand, and Viet Nam to supply areas along the border and extends medium-voltage supply to other licensees through three separate medium-voltage distribution systems. The medium-voltage grid connected to the Viet Nam system supplies power to 18 locations in Kampong Cham, Kampot, Kandal, Kratie, Mondulakiri, Prey Veng, Ratanakiri, Svay Rieng, and Takéo provinces. The medium-voltage grid connected to the Thailand system supplies eight locations in Banteay Meanchey, Battambang, Koh Kong, Oddar Meanchey, and Pailin provinces. The medium-voltage grid connected to the Lao PDR system supplies Stung Treng province. With the recent expansion of all four medium-voltage sub-transmission systems, many areas can now receive electricity from more than one medium-voltage grid at different times of the year (footnote 34).

62. Beyond these supply systems connected to the grid, according to the EAC, in 2017 Cambodia also had 14 isolated distribution grids (mini-grids), with generation capacities ranging from 70 kilowatts to 1.2 MW. In 2017, these mini-grids reached 12,184 consumers and supplied 4.8 GWh. With the concerted expansion of the high-voltage transmission system and the medium-voltage sub-transmission systems, increasing numbers of REE licensees have been connected to the national supply in recent years, thereby improving the quality of supply. For example, during 2015-2017, 120 licensees were connected to the national grid to receive bulk supply.⁴⁴ Currently, 99.5% of electricity consumers are connected to the grid. This has helped to reduce the need for diesel generation, as well as reduce the cost of supply and, therefore, the tariff for consumers (footnote 34).

Figure 6: Distribution License Zone Granted and Medium-Voltage Backbone Constructed by 2016



⁴⁴ EAC. *Report on the Power Sector of the Kingdom of Cambodia*. Phnom Penh (3 years: 2016–2018).

63. Preparing plans for the development of the high-voltage transmission system is the responsibility of the MME, in cooperation with EDC. According to the MME's 2015 PDP (footnote 10), like the power plants, the high-voltage grids may be built and owned by private companies under long-term build-operate-transfer contracts. Grid expansion at the medium-voltage level (i.e., lines connecting the high-voltage grid substations with the rural distribution networks) is the responsibility of EDC, in cooperation with the EAC. Previously, privately owned REEs were also allowed to design and build medium-voltage lines, but this often resulted in uncoordinated, inefficient outcomes. However, in cases where EDC does not have the ability or the intention to develop the medium-voltage grid, the EAC may permit a private licensee to do so. Regarding the low-voltage lines (less than 0.4 kV), distribution licensees are given financial incentives for extending their networks, but if they fail to do so, EDC has the responsibility for grid expansion. Finally, the MME prepares the electricity supply plans for off-grid areas, in cooperation with the EAC and the REF.

64. Cambodia's 2015 PDP includes expanding the transmission network by about 2,600 kilometers (km) to connect all provinces to the national grid by 2020, support the electrification agenda, and reduce the cost of electricity. The high-voltage lines have traditionally attracted foreign investors and have also received donor funding. Beginning in 2014, development partners have also been supporting efforts to expand the medium- and low-voltage grids, which are crucial for bringing grid electricity to the majority of rural Cambodians. During 2014–2015, 115 kV transmission lines from Stung Hav to Sihanoukville, funded by the Japan International Cooperation Agency (JICA), as well as from Chhouk to Banteay Meas, under EDC's own budget, were completed. At the same time, 230 kV lines linking grid substation 6 to grid substation 5, and 115 kV lines linking grid substation 7 with grid substation 2 were commissioned as part of the Phnom Penh Loop Line Phase 1, funded by the Export-Import Bank of China. High-voltage expansions linking Phnom Penh with Bavet (at 115 kV); Kampong Cham with Kratie, Stung Treng, and the Lower Sesan II Hydropower Project (at 230 kV); and from the Lao PDR border to Preah Vihear (at 115 kV), with a total of 486 km of transmission lines, were completed in 2017.

65. Cambodia also needs to expand and strengthen the national grid with investments in a 500 kV backbone. The 2015 PDP includes development of over 300 km of 500 kV transmission lines linking Phnom Penh with neighboring provinces. The first of these lines is to be commissioned in 2019.⁴⁵ The project, which is currently under construction, will connect grid substation Stung Hav in Preah Sihanouk to Phnom Penh. Additional projects include a 500 kV line from the Lao PDR to Stung Treng, double-circuit river crossings at 500 kV to evacuate power from the Lower Sesan II hydropower plant, a 500 kV transmission line from Bek Chan to East Phnom Penh to Soung, and associated high-voltage substations. Cambodia's transmission grid development is also essential for creating an integrated power market in the GMS, a common goal of the GMS countries.

66. Recent additions to Cambodia's distribution networks have been developed under German development cooperation through KfW and the Rural Electrification Project Phase 1, with funding from the Export-Import Bank of China and the Government of Cambodia. These include 5,300 km of medium-voltage lines connecting 278,400 households in 1,600 villages in the southern and western provinces of Banteay Meanchey, Battambang, Kampong Cham, Kampong Speu, Kampot, Oddar Meanchey, Pailin, Preah Sihanouk, Preah Vihear, Prey Veng, Pursat, Svay

⁴⁵ EDC. 2017. *Annual Report 2015*. Phnom Penh.

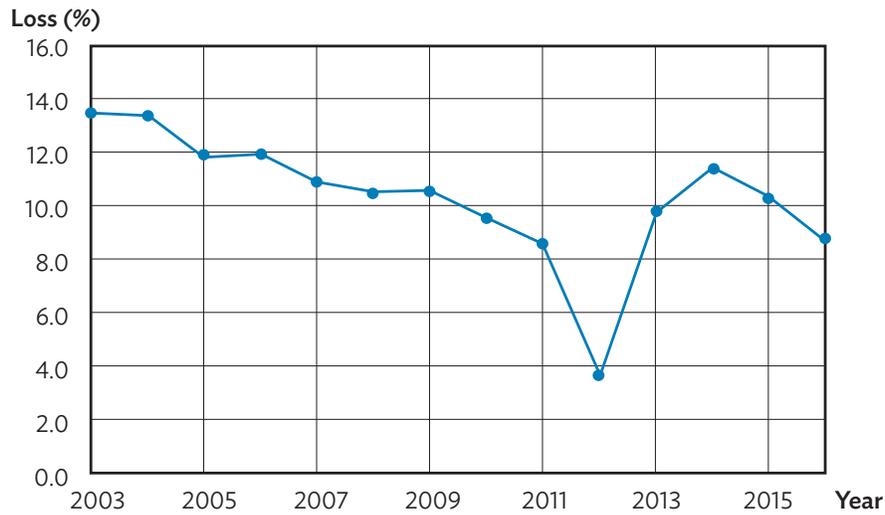
Rieng, and Takéo. An additional 5,800 km of distribution lines to connect 222,000 households in 1,300 villages, with funding from ADB, the Government of Australia, the Government of Cambodia, and the Export-Import Bank of China, is under construction. Another 4,900 km of lines to connect 95,200 households in 570 villages in remaining rural areas are in the pipeline to 2019.

67. As of 2017, approximately 82% of villages received access to grid-connected electricity through the expansion of distribution lines, up from 67% in 2015. An additional 16% of villages are covered by a distribution license zone and are expecting to receive grid-connected electricity in the near future (footnote 5).



68. **System losses.** Overall, since 2013, EDC's system losses—comprising transmission and distribution technical losses and commercial losses—have shown a downward trend, reaching 8.75% in 2016. The reductions in technical losses are attributed to the development of the national high-voltage transmission grid, the connection of REEs to the national grid through sub-transmission lines, and the upgrading of distribution systems by REEs once they are connected. EDC's commercial losses within its own system are low.

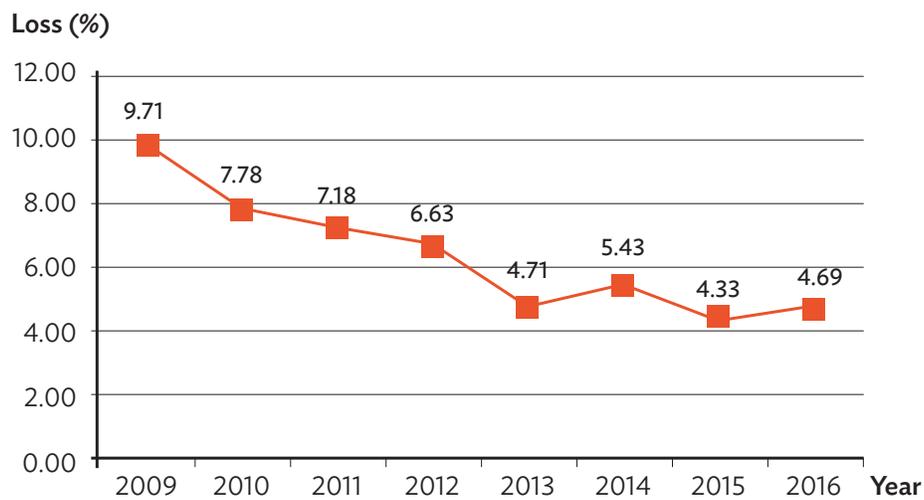
Figure 8: Electricite du Cambodge System Losses, 2003–2016



Note: The 2012 value appears to be a statistical error.

Source: EAC. *Report on the Power Sector of the Kingdom of Cambodia*. Phnom Penh (14 years: 2004–2017).

Figure 9: Electricite du Cambodge Distribution Losses, 2009–2016



Source: Electricite du Cambodge. 2017. *Cambodia Country Presentation*. Presentation prepared for the 23rd Meeting of the Regional Power Trade Coordination Committee. Lao People's Democratic Republic. 13–15 December.

3. Power Market Integration in the Greater Mekong Subregion

69. Regional power market integration in the GMS is an important aspect of electricity sector development in Cambodia, as it enables the country to access more affordable electricity. Cambodia is also exploring the possibility of exporting electricity to Thailand in the rainy season through its current 115 kV connection. In addition, remote border areas of Cambodia, as well as those in the Lao PDR and Viet Nam, benefit from access to power supply from neighboring countries.

70. Energy cooperation, a major pillar of the wider GMS Economic Cooperation Program, is motivated by rapid growth in demand and concerns about energy security throughout the GMS, and is facilitated by the Regional Power Trade Coordination Committee (RPTCC). Established in 2002, the RPTCC focuses on strengthening regional transmission networks, promoting cross-border investments in energy resources, and developing a regional electricity market in a phased manner. The GMS countries have diverse power supply and demand profiles, and gains from the GMS electricity trade are expected to be considerable. As of 2016, the GMS had 11 high-voltage (220 kV, 230 kV, or 500 kV) cross-border power connections with a total capacity of 5,315 MW.⁴⁶ In 2015, the total electricity trade in the GMS was around 47 TWh. The Lao PDR, Myanmar, and the PRC are the region's net exporters, with the Lao PDR as the largest exporter at 15 TWh in 2015. In the same year, Thailand was the largest importer, at 14 TWh.⁴⁷

71. Regional power trade is expected to develop in four phases. The GMS is currently in phase one (bilateral cross-border connections established via PPAs) and transitioning to phase two (grid-to-grid power trading between any two countries, eventually wheeling power through transmission facilities of a third country). The third phase would entail the development of transmission lines exclusively for cross-border trading, while the fourth phase would be a fully competitive regional power market with multiple seller-buyer regulatory frameworks (footnote 46).

72. ADB and the World Bank provide technical support to the RPTCC and its two working groups: the Working Group on Regulatory Issues and the Working Group on Performance Standards and Grid Codes.⁴⁸ The Working Group on Regulatory Issues is in the process of harmonizing regulations regarding open (third-party) access to transmission systems, developing a framework for calculating wheeling charges to use common transmission facilities, and creating a standard template for long-term PPAs. The Working Group on Performance Standards and Grid Codes has developed common performance standards and is currently preparing a regional grid code.

73. Toward 2030, with increased hydropower capacity and an expanded transmission grid, the government is exploring additional opportunities for interconnection with neighboring countries. However, there are limited near-term prospects. An interconnection between

⁴⁶ A. Jeffries. 2017. *Promoting Regional Power Trade Planning, Coordination, and Development in the Greater Mekong Subregion*. Presentation for the GMS 9th Economic Corridors Forum. Ha Noi, Viet Nam. 19 September.

⁴⁷ ADB estimates. The latest figures from the PRC are based on the available data in 2014.

⁴⁸ ADB. 2014. *Technical Assistance for Harmonizing the Greater Mekong Subregion Power Systems to Facilitate Regional Power Trade*. Manila (TA 8830-REG); and ADB. 2007. *Technical Assistance for Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the Greater Mekong Subregion*. Manila (TA 6440-REG).

Cambodia and the Lao PDR that would primarily support export from the Lao PDR to Cambodia is in the early stages of study. The proposed transmission line would connect Ban Hat substation in the Lao PDR's Champasak Province with Chey Sen substation in Cambodia's Preah Vihear Province. The project has generated controversy, as power generation would come from the Don Sahong Dam, a hydropower dam under construction on the lower Mekong mainstream. Nongovernment organizations have stated that construction of this dam would threaten food security and livelihoods for populations in the lower Mekong River basin. While controversial, the governments of the Lao PDR and Cambodia are discussing the possibility of developing the interconnection with their own resources. An even more ambitious proposal, also in the early stages of study, would link the Lao PDR through Cambodia to Viet Nam.

4. End-User Prices and Tariffs

74. Electricity has traditionally been very expensive in Cambodia, and prices have historically been much higher in rural areas than in towns and cities. However, with the reduced reliance on diesel and imports, and with grid extension, the cost of supply has been coming down and tariffs are being stabilized. In addition, in February 2015 the government introduced a strategic plan and subsidy program to reduce the electricity tariff for areas receiving supply from the national grid during 2015–2020 (footnote 5).⁴⁹

75. In 2017, the EDC retail tariff for poor residential customers in provincial towns and rural areas that consume fewer than 10 kWh a month was KR480 per kWh (or about \$0.12 per kWh), reduced from KR820 per kWh (or about \$0.20 per kWh) in 2015.⁵⁰ Residential customers that consume fewer than 50 kWh a month (in Phnom Penh and parts of Kandal Province) are being charged KR610 per kWh (or about \$0.15 per kWh). Customers connected to the national grid that consume above 50 kWh in urban areas, and above 10 kWh in rural areas, are charged KR610–KR790 per kWh (or about \$0.1511 – \$0.1956 per kWh). The tariff for low-voltage consumers of private licensees in areas supplied by the national grid has also been reduced to KR610–KR790 per kWh from KR1,050–KR1,100 per kWh (or \$0.2600 – \$0.2724 per kWh) in 2015.

76. By 2020, rates for high-volume consumers will drop to KR730–KR750 per kWh (or \$0.1808 – \$0.1857 per kWh).

77. In order to incentivize large consumers to shift their consumption to off-peak hours and thereby reduce demand during daytime peak hours while utilizing excess generation produced during nighttime, the government approved a time-of-use tariff in 2014. Large industrial, commercial, and agricultural users can opt for a lower than normal tariff between the hours of 9:00 pm and 7:00 am, and a higher than normal tariff between the hours of 7:00 am and 9:00 pm. The price difference is approximately \$0.04 per kWh (or 20%). However, it appears that the price difference is not large enough to encourage more than a very small number of consumers to switch. In comparison, the time-of-use price difference is \$0.046 per kWh (or 35%) in Thailand and \$0.112 per kWh (or 67%) in Viet Nam.⁵¹

⁴⁹ MME *Prakas* (Order) No. 0094 dated 24 February 2015.

⁵⁰ Using an exchange rate of \$1 = KR4,038.34.

⁵¹ W. Derbyshire. 2015. *Final Report: Cambodia—In Depth Study on Electricity Cost and Supplies*. Bangkok: Economic Consulting Associates.

78. Electricity imports have historically been essential for reducing end-user prices in Cambodia, particularly when local generation is based primarily on diesel and fuel oil. However, with grid extension, and as more (and less expensive) coal- and hydropower-based generation comes online, electricity imports are proving comparatively expensive. ADB estimates the 2017 contract price for power is \$0.09–\$0.10 per kWh from Viet Nam and \$0.10–\$0.11 per kWh from Thailand. Import contracts are typically signed for 1 year at a time.

79. In general, tariffs for the sale of electricity are determined based on the cost of supply for each licensee. However, there are cross-subsidies from larger urban customers to smaller residential customers and to rural customers. These are expected to decrease over time as the total costs of supply fall.

80. The tariff of rural distribution licensees purchasing bulk power from the grid has become stable. It includes incentives, in the form of lower prices, for these licensees to connect to EDC's network at medium-voltage levels, reducing EDC's own investment costs. The tariff for isolated rural distribution licensees generating their own electricity from diesel or oil is related to the cost of fuel and is subject to a fuel cost adjustment mechanism. The EAC changes these tariffs periodically to reflect the cost of diesel.

5. Rural Electrification

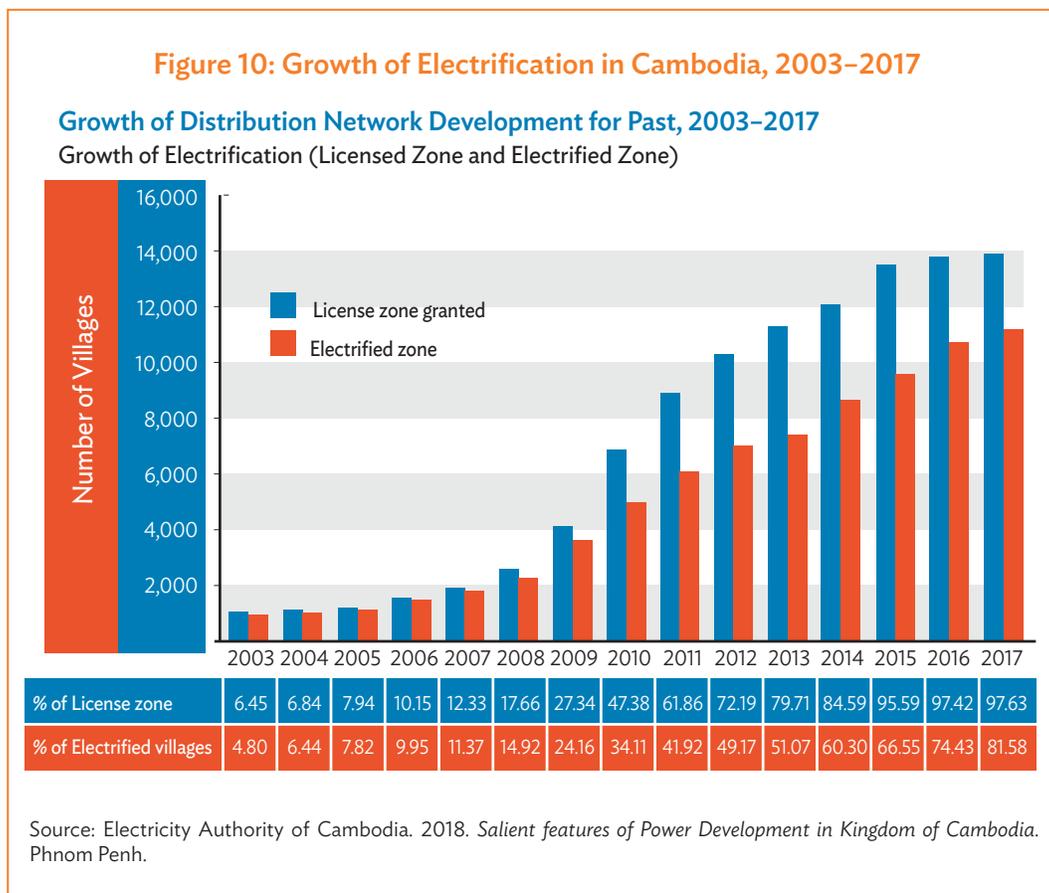
81. In 2007, the government set the following two goals for rural electrification: (i) 100% of villages will have access to electricity of some type by 2020 and (ii) at least 70% of all households will have access to grid-quality electricity by 2030.⁵²

82. According to the EAC, at the end of 2017, approximately 82% of villages received electricity supply via grid connection in a licensed area (national or regional electricity grid), up from 67% in 2015. The household electrification rate reached 69% in 2017, up from 49% in 2015 (footnote 5). Another 16% of villages are located in a distribution license zone where a grid connection is expected in the near future. Despite a clear increase, Cambodia's electrification rate remains the second lowest in Southeast Asia, after Myanmar's.

83. Households in Phnom Penh (with a 99% electrification rate in 2015) and other urban areas (with a 94% electrification rate in 2015) are almost all connected to the grid, while in rural areas, only 58% of households are connected (in 2015). This is a major issue, as almost 80% of the population lives in the countryside. In rural villages, about 30% of households use a car battery for electricity and recharge it at the village's battery charging station. Unfortunately, batteries are a very expensive form of power supply. In addition, just over 5% of rural households use SHSs, and a little over 4% still use kerosene lamps or candles for lighting (footnote 21).

84. To meet the government's targets, EDC is responsible for undertaking the expansion of the high-voltage grid system to all provinces and of the medium-voltage sub-transmission lines into rural areas. The construction of distribution networks—low-voltage lines, transformers, and connection devices—is undertaken by private licensees, but where necessary, the government obligates EDC to invest in these grids.

⁵² In 2017, the household electrification rate reached 69% and it is assumed the 70% target will be achieved soon. The government is currently in the process of revising its electrification target.



85. One of the main reasons for the low electrification rate is that poor households cannot afford the high electricity prices or the high upfront connection costs. These costs comprise utility fees, in-house wiring, and the service line, and can easily total \$100 or more. Grid extension projects have focused mostly on building sub-transmission and distribution lines, while the last step of connecting the house to the grid has received less attention.

86. Another factor challenging the efforts to electrify rural areas is that REEs lack access to affordable finance. In order to extend their grids, the REEs borrow from commercial banks that charge high rates and require substantial collateral, as project and corporate finance structures are not used. Most REEs cannot afford the financing costs and cannot expand their grids, even when consumers can afford the connection costs. Subsidies that support concessionaries in extending their grids to unserved communities are essential for increasing access to electricity in rural areas.

87. In 2012, EDC established the Department of REF to accelerate the development of rural electrification through the promotion of private sector investment in power infrastructure and the management of funds from EDC, other government sources, and donations and grants from external sources for rural electrification efforts.

88. In 2017, EDC provided a grant of \$52 million to the REF. An additional \$2.6 million was provided by KfW to support the REF's programs. The REF is now subsidizing both households and REEs through the following five programs:⁵³

- (i) The Power to the Poor Program is designed to facilitate increased access to grid-supplied electricity for poor households in rural areas by providing them with an interest-free loan to (a) finance the cost for the connection fees of the electricity supplier, (b) cover the deposit fee retained by the electricity supplier, (c) meet the costs for the purchase of materials and labor for the installation of wires from the connection point to the house, and (d) pay for the costs for the purchase of materials and labor for the installation of in-house wiring. The amount of this loan shall not exceed KR480,000 (approximately \$120) per household, and the borrower pays back the loan to the service provider in monthly installments within a set period. During 2013–2017, 7,640 rural households received loans from this program.
- (ii) The SHS Program helps rural families purchase solar panels that supply household electricity in 5 watt-peak (Wp) and 50 Wp packages. The program provides the households an upfront subsidy of \$100 as an interest-free loan for 50 Wp SHSs as well as 5 Wp SHSs as donations. During 2013–2017, 60,040 rural households received SHSs from this program.
- (iii) An REF program also provides assistance to REEs so they can improve existing and/or develop new electricity infrastructure. This program bases the type of assistance on the population density of REEs' concession areas. In densely populated areas, the REF guarantees REEs' loans for power grid investments, while in semi-densely populated areas, the REF provides REEs with interest-free loans. In sparsely populated areas, the REF provides REEs with interest-free loans, plus a grant. During 2013–2017, the REF executed contracts with rural licensees for a total of 7,822 km of transmission lines constructed under this program.
- (iv) A program introduced in 2016 provides a subsidy to licensees connected to the national grid system to enable them to reduce their tariffs in rural areas, as part of the government's subsidy framework for 2015–2020. In 2017, 248 licensees of the 252 licenses connected to the national grid received a subsidy.⁵⁴
- (v) Also in 2016, the REF introduced a time-of-use tariff program to supply electricity for agricultural irrigation uses at reduced prices during off-peak hours. No applications were received in 2016 or 2017.

89. In 2016–2018, ADB provided a \$1 million grant to the REF to pilot an output-based aid program, wherein rural electricity distribution enterprises that connect poor households are reimbursed for a portion of the connection costs. The REF provides a subsidy of \$100 per household connection. As of March 2018, 39 REEs had signed contracts with the REF to install service connections and in-house wiring systems to 9,211 households. The program also helped

⁵³ EDC, Department of REF. 2018. *Report on Transferring the Real Benefits to the Rural Population for the Year 2017*. Phnom Penh.; EDC, Department of REF. 2017. *Report on Transferring the Benefits Resulting from the Development of Electricity to the Population in Rural Area for the Year 2016*. Phnom Penh.; and EDC, Department of REF. *Report on Activities of the Department of Rural Electrification Fund for the Year*. Phnom Penh. (3 years: 2014–2016).

⁵⁴ The remaining four licensees did not provide the requested documentation to receive the subsidy.

the REF design a GIS-based system to identify beneficiaries for connection. Based on the success of the program, EDC is now providing funds to the REF from its own budget to continue offering this subsidy to additional households.

90. In addition to ongoing distribution projects by development partners, EDC has determined that approximately 2,000 km of medium-voltage lines, 13,600 km of low-voltage lines, 520 transformers, and associated metering systems and connection devices are needed to connect the remaining rural households to grid-supplied electricity. ADB estimates that this will require around \$220 million in investments from EDC, private licensees, and/or development partners.

6. Climate and Energy

91. With the country's rapid economic growth, demand for electricity has also increased. From 2011 to 2015, the annual electricity demand growth rate was 18%. By 2030, as annual economic growth is predicted to continue to rise, Cambodia's power consumption is forecast to rise to 18,000 GWh, or a greater than threefold increase relative to demand in 2015 (para. 47).

92. The NSDP, 2014–2018 defines the Government of Cambodia's commitment to mitigate the adverse environmental and social impacts of energy consumption and energy projects, while promoting economic efficiency and the environmental sustainability of each project (footnote 7). The NSDP includes actions to implement the government's priorities related to energy, including (i) developing a legal and regulatory framework for the energy sector to ensure efficient management and use of resources and (ii) encouraging the efficient use of energy with minimal impact on the environment.

93. Cambodia's Nationally Determined Contribution, enshrined in the 2015 Paris Agreement,⁵⁵ commits to a 16% reduction in greenhouse gas emissions from the energy sector from a business-as-usual scenario by 2030.⁵⁶ An additional 7% reduction is to be achieved from the promotion of energy efficiency and renewable energy initiatives in the manufacturing sector; and a further 1% reduction from the promotion of building energy efficiency and improved cookstoves, the use of biodigesters and water filters in waste management, and the use of renewable energy for irrigation and lighting (solar lamps).

94. The MME is committed to increasing energy efficiency as a cost-effective strategy for reducing the high energy costs that hamper economic and social development. In 2017, a National Policy, Strategy, and Action Plan on Energy Efficiency was prepared by the MME in cooperation with the European Union (EU) Energy Initiative Partnership Dialogue Facility and KnowlEdge Srl.⁵⁷ It is expected to be adopted by the MME by the end of 2018.⁵⁸ Under this plan, by 2035, the MME will commit to (i) reducing national energy consumption by 20% compared to business-as-usual projections; and (ii) reducing national carbon dioxide emissions to 3 million tons annually, or 28.5 cumulative million tons from 2017 to 2035, relative to the business-as-usual scenario. In order to achieve these objectives, three sectors have been identified as priority areas (buildings,

⁵⁵ The Paris Agreement entered into force on 4 November 2016.

⁵⁶ Government of Cambodia. 2015. *Cambodia's Intended Nationally Determined Contribution*. Phnom Penh.

⁵⁷ A. M. Bassi and S. Rey. 2017. *National Policy, Strategy, and Action Plan on Energy Efficiency in Cambodia*. Eschborn, Germany: EU Energy Initiative Partnership Dialogue Facility. This is an update to the 2013 draft version of the same name.

⁵⁸ Based on discussions in February 2018.

industry, and transport), and four strategic programming elements will guide activities in each sector (awareness-raising, capacity building, financial incentives, and standards). To reach the overall target, the energy savings of each sector is prescribed as follows: 25% reduction for the building sector, 25% reduction for industry, and 15% reduction for the transport sector. Energy savings will be achieved through the following activities:

- (i) **Building sector.** Introduction of an energy efficiency building code for new buildings, establishment of an energy efficiency performance standard for existing buildings, establishment of a national testing and labeling program for household appliances with associated standards and regulations enacted, and promotion of energy efficient cookstoves.
- (ii) **Industry sector.** Support for the development of energy service companies, implementation of energy efficiency audits and training for accredited auditors, implementation of standards and regulations on industrial energy use and distribution, and provision of financial incentives.
- (iii) **Transport sector.** Support for enhanced vehicle and road maintenance, promotion of integrated public transport systems in main cities, and promotion of bioethanol and biodiesel fuels and the purchase of fuel-efficient and zero-emission vehicles (e.g., hybrid, electric, fuel cell).

95. In 2015, the National Council for Sustainable Development (NCSD) and its general secretariat were created within the Ministry of Environment. The NCSD consolidates the mandates of four previous authorities that are now defunct: the National Council of Green Growth, the National Climate Change Committee, the National Biosafety Secretariat, and the National Biodiversity Steering Committee. The Prime Minister serves as the honorary chair and the minister of environment is the acting chair. The NCSD's membership includes 37 institutions and its main functions are as follows:⁵⁹

- (i) formulating, directing, and evaluating policies, strategic plans, action plans, legal instruments, programs, and projects related to sustainable development;
- (ii) mobilizing resources for sustainable development efforts;
- (iii) fostering partnerships with development partners, the private sector, academia, and other relevant stakeholders aimed at supporting sustainable development; and
- (iv) promoting research, study, education, training, and exchange of technologies relevant to sustainable development.

96. The NCSD's priority focus areas for 2016–2018 include sustainable cities, sustainable energy, climate change response, biodiversity conservation, science and green technology, and finalization and implementation of the National Environment Strategy and Action Plan⁶⁰ and the Environment and Natural Resources Code.

97. The aim of the Environment and Natural Resources Code is to enable sustainable development through protection, management, and restoration of the environment. The latest draft, prepared in July 2017, includes provisions related to climate change, sustainable energy,

⁵⁹ Department of Climate Change. NCSD Roles and Functions.

⁶⁰ Government of Cambodia. 2017. *National Environment Strategy and Action Plan, 2016–2023*. Phnom Penh.

extractive industries, and sustainable cities, among others. The draft code allows for greater natural resources management at the local level and enumerates several dispute resolution procedures. The draft code also aims to ensure that environmental considerations are integrated into the development of future government policies, strategic plans, and programs through a strategic environmental assessment process. The code is expected to be approved by the end of 2018.

98. The guiding framework document for Cambodia's climate change response, currently housed within the NCS, is the Cambodia Climate Change Strategic Plan, 2014–2023.⁶¹ The plan is supported by sector action plans developed by 14 line ministries. The Climate Change Action Plan (CCAP) for Mines and Energy Sectors, 2016–2018⁶² outlines priority policy actions and activities to operationalize the MME's response to climate change adaptation and mitigation. Two key policy objectives of the CCAP include (i) finalizing the National Policy, Strategy, and Action Plan on Energy Efficiency (undertaken by the MME in cooperation with the EU) (para. 94); and (ii) developing a renewable energy promotion strategy and action plan. The second activity is currently being supported by the Cambodia Climate Change Alliance funded by the EU, Swedish International Development Cooperation Agency, and United Nations Development Programme.

99. The CCAP is budgeted at just over \$5 million, and the MME anticipates that a large proportion of the funding will come from multilateral and bilateral development partners or special climate change funds such as the Green Climate Fund. When the MME's CCAP was published, there was no domestic capital budget for the program. However, CCAP actions are to be included in program budgets for cofunding from the national budget, when the MME adopts a program-based budget.

E. Key Subsector Constraints and Development Needs

1. Fragmented Power Grid and Electricity Supply

100. Cambodia's power grid remains fragmented and needs to be integrated into one single nationwide network covering all 25 provinces. This single nationwide network would allow EDC to transmit power seamlessly from point to point and manage the spare capacity as reserve margin to optimally operate the network. More importantly, there is a tariff imbalance between the areas receiving power from the national grid and those that are not. Connecting the isolated sub-transmission systems would help in balancing the power situation across all provinces as well as minimizing tariff disparities.

101. In addition to EDC, there were 336 REEs licensed by the EAC to distribute electricity as of 2017 (para. 36). While the government can oversee their activities through the EAC's licensing procedures and has a goal to reach 100% of villages by 2020, there is no up-to-date least-cost electrification plan for determining the optimal mix of grid extension and off-grid, renewable energy-based solutions.

⁶¹ Government of Cambodia, National Climate Change Committee. 2013. *Cambodia Climate Change Strategic Plan, 2014–2023*. Phnom Penh.

⁶² Government of Cambodia, MME. 2015. *Climate Change Action Plan for Mines and Energy Sectors, 2016–2018*. Phnom Penh.

2. Heavy Reliance on Hydropower and Coal

102. The 2015 PDP (footnote 10) calls for major additions of large hydropower and coal-fired generation plants through 2030. While the replacement of diesel and oil-fired generation is commendable, these large and (in the case of coal) inflexible power plants have their own environmental, social, and operational problems. Coal plants produce increased local air pollution and carbon dioxide emissions responsible for climate change. As Cambodia has no national commercial-scale mining, it is dependent on coal imports for all of its consumption, leaving it vulnerable to global price fluctuations and supply constraints.

103. Hydropower development can have detrimental impacts on freshwater fisheries, nearby agricultural lands, and on local populations forced to relocate. In addition, hydropower reservoirs can be a source of methane gas emissions, another greenhouse gas responsible for climate change.

104. Operationally, reliance on hydropower and coal can cause problems relating to the differences between supply and demand at various times. Hydropower output varies with the season: in the wet season, there is excess generation, while in the dry season, the power system is vulnerable to shortages in supply. Cambodia also experiences reduced demand during nighttime hours. As coal-fired power plants are very inflexible and cannot reduce output without shutting down, excess generation is being produced at night when demand drops. These problems will be exacerbated as new hydro and coal-fired plants come online.

105. Other renewable sources such as solar can complement hydropower by helping to meet daytime peak demand and covering dry season shortages when hydropower reservoirs are low. Additionally, there may be an opportunity to develop floating solar applications on current or planned hydropower reservoirs, reducing the need for large plots of land and new transmission lines and substations for solar farms. Diversifying the electricity supply with local renewable resources can support energy security while also providing technical benefits to the national grid.⁶³

3. Lack of Financial Capacity for Grid Development

106. EDC is primarily responsible for extending the medium-voltage sub-transmission lines. In recent years, it has taken on construction of new high- and low-voltage lines as well, with development partner support. EDC is also exploring opportunities for public-private partnerships in renewable energy generation projects.

107. EDC has recently demonstrated strong financial performance, with its return on equity, pre-tax, exceeding 20% annually from 2013 to 2016. This performance has been helped by access to concessional loans—around half of EDC's capital structure comprises debt with an average interest cost of less than 3%.

108. Despite this, EDC could face significant financing challenges in the future. Continued reductions in tariffs following the government's tariff reduction plan established in 2015 will

⁶³ Technical or ancillary benefits include (i) voltage support during peak loading periods; (ii) reduction of loading levels on transformers; and (iii) reduction of the amount of power that needs to be generated from distant sources (hydro and coal, in particular), and therefore reduction of losses in the transmission system.

reduce revenues to some extent (para. 74). At the same time, the commissioning of major new IPPs will increase EDC's network and PPA obligation costs. This is particularly so given the periodic excess of electricity supply over demand currently seen in Cambodia, which means the capacity expansion is unlikely to deliver much in the way of new electricity sales for some years to come.

109. Any further new generation will be funded by the private sector as IPPs (current estimates are for \$9 billion–\$10 billion required during 2019–2030). ADB estimates that EDC's financing gap for transmission and distribution infrastructure during 2016–2021 is around \$600 million. EDC will need to meet this gap by using its own financial resources, mobilizing additional concessionary financing from development partners, incentivizing private investment, and/or seeking annual budgetary support from the national budget.

110. Financial constraints for grid development also affect the REEs, because many cannot raise the finance needed to expand the low-voltage grid, and they need subsidies to incentivize them to serve rural areas (para. 86). Subsidies are also needed to help poor households pay for the grid connection costs. Through grants to the REF, EDC and development partners, including ADB, are supporting subsidies to rural households and electricity licensees for increased electrification (paras. 87–90).

4. Limited Access and Slow Connection Times to a Reliable Electricity Supply

111. The government has outlined the high cost of electricity and shortages of supply as challenges to industrial growth in its IDP (footnote 4), issues that domestic and foreign investors have identified as barriers for years. Affordable and reliable electricity supply is critical for the diversification of the industry sector, including garments and food processing; and development of new growth engines such as agro-processing, tourism, and light manufacturing.

112. Accessing electricity is also a slow process. According to the World Bank's *Doing Business* 2018 report, it takes 179 days for a newly constructed building to obtain an electricity connection in Phnom Penh.⁶⁴ This contributes to Cambodia's rank of 137 out of 190 economies. EDC requires 75 days to issue a clearance for a new connection and 63 days to complete the external connection work, including meter installation. These long lead times, plus the high cost of an electricity connection, contribute to lower electrification rates than in neighboring countries.

5. Limited Institutional and Human Resource Capacity for Power Sector Development

113. Access to reliable, affordable, and environmentally sustainable electricity is essential for supporting socioeconomic development, including developing economic zones and commercial agriculture, increasing urban–rural equality, attracting more businesses to provincial and district towns, and reducing migration to the capital city. However, the organization and strategy of the electricity sector in Cambodia is fragmented, and the development of physical infrastructure is done in an ad hoc manner (paras. 100–101). To properly develop the power sector, Cambodia needs a coherent strategy and implementation plan that facilitates cost-effective, orderly, and

⁶⁴ World Bank. 2018. *Doing Business 2018: Reforming to Create Jobs*. Washington, DC.

efficient development of generation, transmission, and distribution assets. The strategy should also include associated institutional, legal, and regulatory reforms.

114. The successful implementation of an open and competitive electricity market, both nationally and in the GMS, calls for careful attention to market design. Although private investment in the power sector is necessary, the procurement process should be more structured and transparent. The government needs more experience conducting competitive bidding so that it becomes the norm, with clear criteria for identifying projects and selecting bidders, and standardized, publicly available bidding documents and PPA templates.

115. A key step in electricity sector reform is improving human resource capacity in the EAC, EDC, and MME so that staff can (i) keep pace with expansion requirements and technological innovations; and (ii) develop efficient and cost-effective strategies, policies, processes, and procedures. Key areas for human resource development include strategy development, planning, operations, finance, information technology, and human resources management.

II. SECTOR STRATEGY

A. Government Sector Strategy, Policy, and Plans

116. The government's national strategy for growth is set out in the Rectangular Strategy Phase III, 2013–2018, which applies to the fifth term of the National Assembly, 2013–2018.⁶⁵ The primary document guiding the government is the NSDP, 2014–2018, which was endorsed by the National Assembly on 26 June 2014 (footnote 7). The NSDP targets achievement of the Cambodia Millennium Development Goals,⁶⁶ successful integration into the Association of Southeast Asian Nations economic community, reduction of poverty to about 13% by 2018, and the long-term goal of graduation to upper middle-income country status by 2030.

117. Regarding the energy sector, Cambodia's National Energy Sector Development Policy, established in 1994 (footnote 23),⁶⁷ stipulates the government's main goals for an adequate, affordable, and sustainable energy supply in support of economic development. The NSDP, 2014–2018 emphasizes that although progress has been made in electricity expansion, tariff reduction, and institutional strengthening, further development of the energy sector is essential for increased competitiveness and sustained economic growth. The eight key energy policy objectives of the government in the NSDP are as follows (footnote 7):

- (i) further expanding the capacity of low-cost and high-tech electricity production, especially from new and clean energy sources, along with continued development of all levels of the transmission network aimed at strengthening energy security and ensuring efficient, safe, high-quality, reliable, and affordable electricity supply and distribution to respond to development needs;
- (ii) further encouraging the private sector to invest in electricity generation and transmission and distribution infrastructure by focusing on technical and economic efficiency and minimizing environmental and social impacts;
- (iii) stepping up the implementation of the electrification strategy (paras. 81–90) to meet the goal that all villages in Cambodia will have access to electricity from the national grid or other sources by 2020;

⁶⁵ Government of Cambodia. 2013. *Rectangular Strategy Phase III, 2013–2018*. Phnom Penh. The government has drafted the new Rectangular Strategy Phase IV, 2018–2023, which will guide development of the NSDP, 2019–2023.

⁶⁶ The United Nations Sustainable Development Goals came into effect in January 2016, replacing the Millennium Development Goals, which were to be achieved by 2015. Cambodia is currently developing localized Cambodia Sustainable Development Goals, which will be integrated into future plans and policies, including the NSDP, 2019–2023.

⁶⁷ The United Nations Economic and Social Commission for Asia and the Pacific. 2010. *Assessment Report on Energy Efficiency Institutional Arrangements in Asia*. Bangkok.

- (iv) further supporting the REF to help achieve equitable electricity access for the population through funds from EDC and other government budget allocations, as well as funding support from development partners;
- (v) pursuing rationalization 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 the industry and handicraft sectors;
- (vi) stepping up the exploration and commercialization of the oil and gas sector, which has enormous potential for ensuring energy security and will provide valuable resources for Cambodia's economic development in the long term;
- (vii) further strengthening institutional capacity, human resources, and planning and management of the energy sector; and
- (viii) continuing active involvement in energy cooperation under the GMS regional framework.

118. Similarly, the government's IDP recognizes that insufficient coordination and investment in physical infrastructure, including electricity and clean water, are holding back the adoption of manufacturing and other value-added industries. In line with the IDP's 2018 target, the government has reduced the price of electricity for specific industrial zones and expanded transmission networks to improve reliability of supply. The IDP also calls for a review of the forecast of long-term electricity demand, the 2015 PDP, and energy supply options to better align with the country's goals for economic and industrial development (footnote 4).

119. Cambodia does not yet have a comprehensive energy strategy. Instead, the government has adopted, or is preparing, various sector strategies and action plans. The MME's PDP, which was prepared in 2007 for the period 2008–2020 and updated in 2015 for the period 2015–2030 (footnote 10), includes investment plans for generation and transmission expansion. With regard to distribution expansion and rural electrification, the MME, in cooperation with the EAC and REF, sets the goals.

120. Apart from generally encouraging the use of renewable energy and setting aspirational goals for rural electrification through renewable sources, Cambodia has not yet set a clear national renewable energy target. However, a National Policy, Strategy, and Action Plan on Energy Efficiency in Cambodia was developed by consultants funded under the EU Energy Initiative Partnership Dialogue Facility, and is expected to be adopted by the end of 2018 (footnote 57). A strategy and action plan for the promotion of renewable energy, including a target percentage of renewable energy in the energy mix, is to be undertaken as part of the MME'S CCAP, 2016–2018 (footnote 62). In addition, Cambodia's Nationally Determined Contribution targets a 24% reduction in emissions from renewable energy and energy efficiency initiatives (footnote 56). Preparation of the Nationally Appropriate Mitigation Actions required to meet this target and establish an emissions management approach for the sector are also part of the MME's CCAP.

121. Moving forward, the government will need to formulate a consolidated energy sector strategy and implementation plan that specifies sector priorities, timelines, and responsible agencies for different initiatives and activities. Consolidating the various thematic strategies and plans should facilitate more organized and efficient development of the energy sector, including the development of physical infrastructure and required legal, regulatory, and institutional frameworks.

B. ADB Sector Support Program and Experience

122. ADB's CPS for Cambodia, 2014–2018, approved in November 2014, reflects the priorities outlined in the Rectangular Strategy Phase III, 2013–2018 and the NSDP, 2014–2018.⁶⁸ The overall impact of the CPS will be the reduction of poverty and vulnerability. To achieve this, ADB operations are focusing on (i) inclusive economic growth, (ii) environmentally sustainable growth, and (iii) regional cooperation and integration. Public–private partnerships and strategies to strengthen partnerships with cofinanciers are also being supported to help mobilize resource flows.

123. The CPS, 2014–2018 identifies two strategic pillars that underpin ADB activities in Cambodia: (i) rural–urban–regional linkages and (ii) human and social development. Public sector management acts as a facilitating cross-cutting strategic pillar. The first pillar helps address the challenges of (i) industrial transformation; (ii) competitiveness; (iii) value chain promotion, including in the agriculture sector; (iv) rural energy and sustainable rural job creation; (v) urban and rural infrastructure along national and subregional economic corridors and rural arteries; and (vi) related logistics improvements. These challenges are also addressed in the IDP (footnote 4). ADB energy sector initiatives, which include ongoing loans, grants, and TA activities, support outcomes under the first pillar of the CPS. No new generation investments were identified in 2014 and 2015, as the government had been targeting funds from export credit agencies and the private sector for generation projects. In 2016–2017, ADB reintroduced its support to the sector through an initial phase of investments and TA in solar energy.

124. Since 1994, ADB has awarded \$190 million in loans and grants to Cambodia's energy sector and provided nearly \$5 million in TA. ADB funding has focused on (i) projects to build high-voltage (230 kV and 115 kV) and medium-voltage (22 kV) transmission lines to connect the isolated systems that supply most provincial towns and expand electricity access, (ii) the creation of a 230 kV backbone across the country, and (iii) capacity building for energy sector institutions. Currently, ADB is supporting the development of renewable energy generation, particularly solar, to assist the country in meeting its growing demand while addressing its climate change targets.

Table 1: ADB Approved Loans and Grants for the Energy Sector, 1994–2016

Project Number	Project Name	Type of Assistance	Date Approved	Amount Approved (\$ million)	Distribution (\$ million)
50248-001	Cambodia Solar Power Project	ADB and private sector loans	7 Dec 16	9.55	ADB loan = 6.85; private sector loan = 2.70
45303-001	Rural Energy Project (formerly Rural Energy Pilot Project)	Grant	15 Jan 13	6.10	

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⁶⁸ ADB. 2014. *CPS: Cambodia, 2014–2018*. Manila.

Table 1 continued

Project Number	Project Name	Type of Assistance	Date Approved	Amount Approved (\$ million)	Distribution (\$ million)
42361-013	Medium-Voltage Sub-Transmission Expansion Sector Project (formerly Rural Electrification Project)	Grant and loans	14 Dec 12	56.00	
42100-012	Capacity Building for the Cambodian National Petroleum Authority	TA grant	16 Dec 10	0.40	
42361-012	Rural Electrification Project	TA grant	29 Nov 10	1.30	
40914-014	(Cambodia) Power Transmission Lines Co., Ltd., Power Transmission Project	Private sector loan and equity	27 Jun 07	32.00	ADB loan = 8.00; private sector equity and cofinancing = 24.00
40079-012	Institutional Strengthening of the Cambodian National Petroleum Authority (formerly Oil and Gas Regulatory Framework)	TA grant	18 Dec 06	1.00	
37041-013	Second Power Transmission and Distribution Project	Loan	4 Oct 06	20.00	
34390-012	Power Distribution and Greater Mekong Subregion Transmission Project (formerly Provincial Power and Transmission Project)	TA grant	10 Jan 03	0.73	
34390-013	Greater Mekong Subregion Transmission Project	Loan	15 Dec 03	44.30	
28191-013	Provincial Power Supply	Loan	5 Dec 00	18.60	
28191	Power Rehabilitation II	TA grant	20 Aug 96	0.45	
28113	Power Rehabilitation Project	Loan	15 Dec 94	28.01	

continued on next page

Table 1 continued

Project Number	Project Name	Type of Assistance	Date Approved	Amount Approved (\$ million)	Distribution (\$ million)
28188	Power Sector Manpower Development and Training	TA grant	15 Dec 94	0.50	
26636	Strengthening the Institutional and Legal Framework for the Energy and Mineral Sectors	TA grant	14 Dec 94	0.60	

ADB = Asian Development Bank, TA = technical assistance.

Source: ADB.

125. ADB has supported the construction of transmission and distribution systems through public and private sector investments, including

- (i) 109 km of a 230 kV transmission line from Viet Nam via Takéo to Phnom Penh, with associated substations and distribution systems, which was cofinanced by the World Bank and the Nordic Development Fund (the GMS Transmission Project, completed in 2010);⁶⁹
- (ii) 221 km of 115 kV transmission lines from Thailand to Banteay Meanchey, Battambang, and Siem Reap, with associated substations, which was supported by ADB's PSOD (the [Cambodia] Power Transmission Lines Co., Ltd. Power Transmission Project, completed in 2007);⁷⁰ and
- (iii) 82 km of 230 kV transmission lines from Kampot to Sihanoukville, completed in March 2013, and construction of a 115 kV substation and associated distribution lines in Sihanoukville town, completed in June 2014, which was cofinanced by JICA (the Second Power Transmission and Distribution Project, completed in 2015).⁷¹

126. The Medium-Voltage Sub-Transmission Expansion Sector Project (formerly the Rural Electrification Project),⁷² the Rural Energy Project (formerly the Rural Energy Pilot Project),⁷³ and the Cambodia Solar Power Project⁷⁴ are ongoing or recently completed.

127. The Medium-Voltage Sub-Transmission Expansion Sector Project is expanding the supply of reliable and cost-effective grid electricity in Banteay Meanchey, Kampong Cham, Kampong Thom, Kandal, and Siem Reap provinces through the construction of 2,110 km of 22 kV sub-transmission lines. The project also supports improved operational effectiveness and

⁶⁹ ADB. Cambodia: GMS Transmission Project.

⁷⁰ ADB. Cambodia: [Cambodia] Power Transmission Lines Co., Ltd. Power Transmission Project.

⁷¹ ADB. Cambodia: Second Power Transmission and Distribution Project.

⁷² ADB. Cambodia: Medium-Voltage Sub-Transmission Expansion Sector Project.

⁷³ ADB. Cambodia: Rural Energy Project.

⁷⁴ ADB. Cambodia: Solar Power Project.

efficiency of EDC and includes a grant component to the REF to finance service connection costs for poor households in the project provinces (para. 88). The project closing date is expected to be 31 December 2019.

128. The Rural Energy Project was funded by a \$6.1 million grant from the Government of Australia. The project addressed both power and non-power energy supply in rural Cambodia by (i) electrifying 10,000 households in Svay Rieng Province by extending the medium-voltage line and the low-voltage network and installing meters; (ii) promoting the use of 90,000 higher-efficiency cookstoves in rural areas in Kampong Cham Province;⁷⁵ and (iii) developing the capacity of the EAC. In addition, the project trained 12 traditional cookstove producers in Kampong Cham and Tboung Khmum provinces to produce the improved cookstove, and carried out awareness-building campaigns to distributors and end users, who are typically women. To develop capacity, in March 2015, the EAC hosted an in-house training on electricity regulation and tariff design. In early 2018, the EAC conducted a four-part training related to regulatory aspects surrounding the proposed deployment of solar PV rooftop projects and solar farms. The project was closed on 31 August 2018.

129. Under the Cambodia Solar Power Project, ADB's PSOD provided a \$9.55 million debt package to finance the development of the country's first 10 MW solar power plant in Bavet, Svay Rieng Province. The plant was built by Sunseap and began commercial operations on 1 October 2017.

C. ADB Self-Evaluation

130. **Self-evaluation.** ADB's most recent country assistance program evaluation for Cambodia was conducted in 2009 and covers 1998–2008.⁷⁶ It noted that energy sector development was considered crucial in all ADB operational strategies for Cambodia and rated energy sector assistance as *relevant, effective, likely sustainable, and substantial in impact*. However, the evaluation and subsequent project completion reports, as well as the latest CPS, 2011–2013 final review, identify efficiency problems that have resulted in delays in implementation.

131. These delays can be attributed partly to EDC's limited human resources and partly to its limited operating efficiency with regard to (i) recruiting implementation consultants, (ii) handling procurement, and (iii) implementing environment and resettlement plans. But delays have also resulted from the institutional arrangements between the MEF and EDC, whereby the MEF reviews EDC procurement processes in detail.

132. The Independent Evaluation Department's validation report of the CPS, 2011–2013 final review,⁷⁷ conducted in 2014, noted the effectiveness of recent programs in the energy sector while highlighting the inconsistency of resource allocations in the energy sector with CPS objectives.

⁷⁵ In December 2013, after project approval and general elections in Cambodia, the province of Kampong Cham was divided into two provinces by royal decree: Kampong Cham and Tboung Khmum. A revision to the cookstoves project component was made to maintain the original target area, which is now spread across the two provinces.

⁷⁶ Independent Evaluation Department. 2009. *Country Assistance Program Evaluation for Cambodia: Growth and Sector Reform*. Manila: ADB.

⁷⁷ Independent Evaluation Department. 2014. *Validation Report: Cambodia: CPS, 2011–2013 Final Review Validation*. Manila: ADB.

Although the energy sector was included in the CPS results framework, it was not one of the five priority sectors. However, during the CPS, 2011–2013 period, three energy sector programs were approved, representing \$61.1 million in lending, or 11% of the 2-year CPS program.

133. The validation report noted that the energy sector projects contributed to expanding transmission lines and creating substation capacity in project corridors, and that institutional capacity building for EDC led to improved performance of the utility. Specifically, the report noted the GMS Transmission Project achieved results despite delays in implementation (footnote 69). For future programming, the validation report suggested electricity tariffs should be adjusted to contribute to the sustainability of project outcomes. In general, capacity building to further strengthen executing and implementing agencies is also needed, according to the validation report.

134. The project completion report for the Second Power Transmission and Distribution Project, which was validated in December 2016, rated the project *successful*.⁷⁸ The project completion report for the GMS Transmission Project, which was validated in May 2014, rated the project *successful* overall, highlighting that the project has a *highly significant* impact on Cambodia.⁷⁹

135. Both project completion reports noted implementation delays, especially in achieving loan effectiveness, recruiting implementation consultants, preparing feasibility studies, and awarding civil works contracts. Both project completion reports also recommended that ADB should continue to assist EDC in evaluating complex turnkey contracts in line with ADB guidelines and procedures to avoid major procurement delays. The project completion report for the GMS Transmission Project recommended that ADB should continue to provide assistance for rural electrification projects to enable the government to increase the electrification rate, especially for the rural poor.

136. **Lessons learned.** Based on the information presented in paras. 130–135, the following lessons are relevant to the energy sector:

- (i) Affordable electricity tariffs are critical for achieving the government’s rural electrification goals and improving the country’s economic competitiveness. EDC, with support from development partners, needs to continue to invest in transmission and distribution network expansion and connect more licensees to the grid, which will reduce the overall cost of supply and electricity tariffs for consumers. Continued financial support to REEs and households through the REF for distribution line extensions and household connections is crucial to increase access to electricity in rural areas.

⁷⁸ ADB. 2016. *Completion Report: Second Power Transmission and Distribution Project in Cambodia*. Manila.

⁷⁹ ADB. 2012. *Completion Report: GMS Transmission Project in Cambodia*. Manila.

- (ii) With the ongoing reduction in renewable energy generation costs globally and abundant renewable energy resources, Cambodia is well placed to integrate significant amounts of renewable energy, particularly solar, into its generation mix. Diversifying Cambodia's hydropower and coal base load supply with the addition of solar would help lower the cost of supply while also helping to implement the emission reduction targets set in Cambodia's Nationally Determined Contribution to the Paris Agreement (footnote 56).
- (iii) ADB's experience assisting EDC with the 10 MW solar power plant in Bavet, Svay Rieng Province and with prior transmission projects shows that EDC needs additional experience structuring transparent, competitive procurement for private sector-led power projects and negotiating contracts with private developers. ADB procurement support can help build technical capacity in EDC as well as an awareness within EDC of the costs, operational requirements, and actual performance of solar PV plants.
- (iv) It is also imperative that Cambodia develop a consolidated sector strategy and power development plan to help guide energy programs and investments.

D. Other Development Partner Support

137. Traditionally, development partners have primarily focused on financing power infrastructure, particularly the expansion of high-voltage transmission lines. Since 2014, development partners have broadened their support to national grid expansion (including medium- and low-voltage sub-transmission and distribution lines and associated facilities), rural electrification, and capacity building. Table 2 lists ongoing development partner projects and programs.

Table 2: Ongoing Development Partner Projects and Programs

Development Partner	Name of Project	Description	Project Type	Year Approved	Amount (\$ million)
JICA	Southern Economic Corridor Distribution Expansion Project	Support for the construction of distribution lines and facilities in Svay Rieng, Banteay Meanchey, and Koh Kong provinces	Grant	2016	9.0
	Phnom Penh City Transmission and Distribution System Expansion Project (Phase 1)	Upgrading of transmission lines, substations, and distribution lines in the Phnom Penh metropolitan area	ODA loan	2014	65.0
	Phnom Penh City Transmission and Distribution System Expansion Project (Phase 2)	Support for the construction of the transmission and distribution network in Phnom Penh, including introducing newly updated technologies	ODA loan	2015	130.0

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Table 2 continued

Development Partner	Name of Project	Description	Project Type	Year Approved	Amount (\$ million)
	Power Economic and Planning Adviser	Support for and policy advice on power generation plan, rural electrification plan and human resources development	Technical cooperation	2016	...
	The Project for Enhancement of Operation and Management of Cambodia Transmission System	Capacity building to EDC for planning, operating, and managing the transmission system to improve security and stability	Technical cooperation	2017	...
AFD	EDC grid extension	Expansion of the transmission network to areas currently not connected to the grid in three provinces (Koh Kong, Kratie, and Kampong Cham)	Loan	2015	87.0
	EDC capacity building program	Capacity building in finance and risk, engineering, supervision of works and maintenance, SCADA, procurement, and environment and social safeguards management	TA grant	2015	1.3
	REEs' Access to Finance	Support for rural electrification strategy through the promotion of financing of REEs and removing barriers for sustainable access to commercial loans	Loan and TA grant	2014	15.0 loan and 3.7 grant
	Green Microfinance Program (Good Solar Initiative)	Support to the solar PV industry through promotion of labeling program and support to MFIs	Loan and TA grant	2014	7.5 loan and 2.5 grant
	Modernization study for EDC	Feasibility study on grid modernization, extension, and promotion of energy efficiency	TA grant	2017	...
	Potential for energy efficiency measures in biomass consuming industries	Feasibility study on the potential for energy efficiency measures in biomass consuming industries	Grant	2017	...

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Table 2 continued

Development Partner	Name of Project	Description	Project Type	Year Approved	Amount (\$ million)
KfW	Energy Efficiency in Rural Grids Cambodia	Feasibility study on options to (i) improve efficiency and reliability within the existing distribution systems and (ii) support new grid-based electricity access for consumers in Kampong Thom, Oddar Meanchey, Preah Vihear, and Siem Reap provinces	TA grant	2017	...
DFAT	Investing in Infrastructure	Provision of (i) grant cofinancing to REEs to expand household distribution networks and (ii) support to the Government of Cambodia for renewable energy policy, including preparation of a renewable energy master plan	Grant	2016	37.0
USAID	Clean Power Asia Program	Capacity building and policy advice for renewable energy integration	...	2016	16.0
World Bank Energy Sector Management Assistance Program	Multitier framework survey	Conducting of a multitier framework survey for measuring energy access in Cambodia
EUEI PDF	Capacity development for independent evaluation and update of energy efficiency strategies in the Kingdom of Cambodia	Capacity building on data analysis of energy efficiency measures and support for updating the National Policy, Strategy, and Action Plan on Energy Efficiency	TA grant	2016	0.08

... = data not available, AFD = Agence Française de Développement, DFAT = Australia's Department of Foreign Affairs and Trade, EDC = Electricite du Cambodge, EUEI PDF = European Union Energy Initiative Partnership Dialogue Facility, JICA = Japan International Cooperation Agency, MFI = microfinance institutions, ODA = official development assistance, PV = photovoltaic, REE = rural electrification enterprise, SCADA = supervisory control and data acquisition, TA = technical assistance, USAID = United States Agency for International Development.

Sources: Asian Development Bank and Agence Française de Développement, Australia's Department of Foreign Affairs and Trade, European Union Energy Initiative, KfW, Japan International Cooperation Agency, and United States Agency for International Development's Clean Power Asia Program.

138. Agence Française de Développement (AFD) is engaged in TA and financing energy projects. Current TA programs are focused on capacity building for EDC, REEs, the Foreign Trade Bank of Cambodia, microfinance institutions, and SHS manufacturers. Current AFD investment support is focused on expansion of transmission lines and facilities. In addition to ongoing programs, AFD is preparing a new transmission extension project for EDC and a second phase

of the REEs' Access to Financing project, both for approval in late 2018, as well as conducting a feasibility study for a new project on the potential for energy efficiency measures in biomass consuming industries. AFD is also exploring a possible power interconnection between Cambodia, the Lao PDR, and Thailand. A prefeasibility study has been conducted.

139. JICA's focus in the energy sector is on financing power infrastructure (including the expansion of the national grid and small hydropower development) and capacity building in power system planning and operation. Through the Phnom Penh City Transmission and Distribution System Expansion Project, JICA is supporting EDC with the construction of high- and medium-voltage transmission lines, and associated substation facilities. The Southern Economic Corridor Distribution Expansion Project is supporting the construction of distribution lines and facilities in Banteay Meanchey, Koh Kong, and Svay Rieng provinces.

140. JICA is also funding a technical adviser to the MME to assist the MME, EDC, and EAC with energy planning, including updating the 2015 PDP (footnote 10) and the forthcoming Strategy and Plan for Development of Rural Electrification. An additional technical cooperation project for capacity building of EDC in transmission system planning and maintenance began in December 2017.

141. The EU facilitates the distribution of grants through the Asia Investment Facility to other development partners active in the country such as AFD. In addition, the EU Energy Initiative Partnership Dialogue Facility supported the government with the development of a National Policy, Strategy, and Action Plan on Energy Efficiency. Preparation of the plan involved training three ministries in energy efficiency data collection and analysis. The draft version was released in May 2013. An updated version was approved by the technical working group on energy efficiency in August 2017 and is expected to be adopted by the government by the end of 2018 (para. 94).

142. KfW has previously provided financing for transmission lines and sub-transmission lines, as well as support to the REF for rural electrification (paras. 66 and 88). Currently, KfW is preparing a project on energy efficiency in rural grids to (i) improve efficiency and reliability within the existing distribution systems and (ii) support new grid-based electricity access to consumers in Kampong Thom, Oddar Meanchey, Preah Vihear, and Siem Reap provinces. Additionally, KfW is exploring opportunities to support solar PV projects.

143. Australia's Department of Foreign Affairs and Trade is providing a A\$45.3 million grant for the Investing in Infrastructure Program, a flexible investment finance program aimed at accelerating private investment in small-scale rural infrastructure. One of the program's two main interventions is providing grant cofinancing to REEs to expand household distribution networks. The program is also supporting renewable energy policy development by the MME. In June 2018, a technical working group was formed to draft a Renewable Energy Master Plan.

144. In partnership with ADB, the United States Agency for International Development's Clean Power Asia Program is undertaking renewable energy-focused TA work in Cambodia. In March 2017, a joint workshop on solar PV policy development was held with representatives from the EAC, EDC, MME, and NCSD. The Clean Power Asia Program continues to provide capacity building support to the EAC on a range of issues, including regulation of utility-scale and distributed solar PV applications.

145. The World Bank, with support from the Energy Sector Management Assistance Program, conducted a multitier framework survey for measuring energy access in Cambodia in 2017. The objective of the survey was to provide a multidimensional approach to data collection on energy access that captured both quantitative and qualitative aspects. The results of the survey in Cambodia were published in March 2018 (footnote 6).

E. ADB Sector Strategy

146. Going forward, ADB is adapting to the evolving requirements in Cambodia's energy sector, particularly the country's commitment to a clean energy transition with provision of reliable, affordable, and sustainable energy for all. ADB's sector strategy, which will be integrated into the CPS, 2019–2023, includes supporting the government to increase the sustainability and affordability of the generation mix through the development of clean energy sources, particularly solar power, and to improve the reliability of supply through grid strengthening.

147. ADB's sector strategy will focus on preparing Cambodia for a clean energy transition through capacity building in solar PV generation at every stage of the process, including conducting solar park planning, preparing the grid and regulatory framework for solar integration, tendering solar PV plants to the private sector, and operating and maintaining the latest technologies to support solar PV (including battery storage). This will be achieved with a combination of TA, transaction advisory support, and hands-on learning through investments in solar generation and transmission expansion. ADB's strategy seeks to employ a coordinated "One ADB" approach, fostering collaboration between public and private sector operations to support Cambodia in developing a more robust and sustainable energy sector.

F. Lending and Nonlending Program and Resource Needs

148. Following the sector strategy in paras. 146–147, ADB proposes that its assistance program to Cambodia for 2019–2023 focuses on the following thematic areas: high-voltage grid expansion, renewable energy, investment planning, capacity building and institutional reform, and development of a comprehensive energy sector strategy and power development plan. In addition, Cambodia will benefit from the ADB GMS program on regional power trade, which provides TA for the six countries in the GMS (footnote 48). The program will include both lending and nonlending products, as detailed in the Energy Sector: Road Map and Results Framework, 2019–2023 (section III).

1. Lending Products

a. High-Voltage Grid Expansion

149. **Grid expansion.** ADB plans to continue funding new grid expansion projects, in line with EDC and the MEF's requirements. An investment project scheduled for 2020 titled the Grid Reinforcement Project for Expanded Renewable Energy Generation aims to support upgrades and expansion of a series of 115 kV and 230 kV transmission lines and associated substations in the greater Phnom Penh and Sihanoukville areas, in order to strengthen the power transmission network to provide increased supply and improved system reliability.

b. Renewable Energy

150. **Solar parks.** Under the National Solar Park Project (footnote 31), scheduled for 2019, ADB is supporting EDC to develop a 100 MW capacity solar park and tender out development of the first solar generation plant to the private sector. The project aims to demonstrate the ability of large-scale solar parks to improve the electricity supply, provide technical benefits to the national grid, and substitute for planned fossil-fuel and hydropower generation in the future. This project will increase awareness within EDC of the costs, operational requirements, and actual performance of solar PV plants, which will inform further policy development and give EDC knowledge and experience in (i) structuring a transparent, competitive procurement for private sector-led power projects (complete with standardized bidding documents, evaluation criteria, and PPA templates); and (ii) negotiating with private developers. Along with the recent 10 MW solar power plant at Bavet, these pioneering solar projects will develop the capacity of grid operators to manage the variable power produced by solar PV projects. A prefeasibility study of the National Solar Park Project was prepared in August 2017 and the feasibility study was completed in August 2018.

151. In addition to the National Solar Park Project, the government is keen to scale up the deployment of solar parks throughout the country. ADB is currently supporting EDC to develop a solar generation master plan. In line with this plan, and as part of the Grid Reinforcement Project for Expanded Renewable Energy Generation, ADB will provide support for the development of one or two additional solar parks, including common infrastructure for the parks, pooling substations, and associated transmission lines.

2. Nonlending Products

152. **Investment planning.** TA will be provided for stocktaking of the energy sector status and future investment opportunities, particularly in renewable energy and energy efficiency. A TA activity for \$1.4 million, Support for a Sustainable Power Sector,⁸⁰ is scheduled for 2019 to support the government to develop a comprehensive energy sector strategy and power development plan.

153. The TA will help build capacity of the MME and EDC in system planning. It will assist the MME to develop a pipeline of priority projects for strategic investments in power generation, transmission, and distribution networks, as well as prefeasibility studies for select projects. ADB will support the MME in exploring business models and identifying innovative sources of investment for renewable energy and energy efficiency projects.

154. **Renewable energy.** Through an additional TA project attached to the National Solar Park Project, ADB will support wide-ranging capacity development to EDC and EAC in solar PV technology; solar park planning; energy storage systems; and development of grid codes for solar energy and grid integration challenges, including environmental and social safeguards. The \$500,000 TA is scheduled for 2019.

⁸⁰ TA activity under the Facility TA REG: Southeast Asia Energy Sector Development, Investment Planning, and Capacity Building Facility.

155. **Capacity building and institutional reform.** In addition to the TA activities in paras. 152–154, ADB will provide TA to the MME, EDC, and other relevant government entities for institutional strengthening and capacity building. ADB suggests the following activities for consideration:

- (i) Although EDC is a relatively small utility, going forward, it could explore a road map for establishing a holding company with a separate generation company and transmission and distribution company. This could be implemented by 2025 or 2026. The region is envisaged to change considerably by 2026 as more transmission line interconnections emerge. This could begin with functional unbundling to better account for the separate costs of the generation, transmission, and distribution functions.
- (ii) Strengthening EDC's capacity in negotiating with its counterpart utilities in neighboring countries on cross-border interconnections and tariff setting is needed.
- (iii) As more generation comes online, EDC will need to examine how it could export its surplus power from hydropower during the wet season and possibly from solar parks.
- (iv) As more 230 kV and 500 kV transmission lines and associated substations are being built in the coming years, EDC's capacity in its operation and maintenance of these networks needs to be enhanced.
- (v) The MME could examine the potential for floating solar parks on Tonle Sap Lake close to load centers near Siem Reap and/or in existing hydropower reservoirs.
- (vi) The MME's capacity in promoting energy efficiency programs needs to be strengthened.

156. **Regional cooperation.** ADB strongly supports regional economic cooperation and power trade in the GMS. Work is underway toward harmonizing technical standards and grid codes for intercountry connections, enabling the region to work toward establishing a GMS power market. ADB is also supporting prefeasibility studies for a number of priority interconnection projects, which may include opportunities for Cambodia to export power (paras. 69–73; and footnote 48).

157. ADB can help Cambodia prepare to play a bigger role in GMS power trade by enabling the use of its existing and planned transmission lines to evacuate power to load centers in southern Viet Nam or in northeast Thailand. Cambodia needs to be able to anticipate regional changes that are likely to happen from 2019 to 2023, with hydropower plants coming online in the Lao PDR and demand growth at load centers in Thailand and Viet Nam necessitating export through Cambodia. Cambodia can position itself to take advantage of this situation and play a vital role in evacuating power within the GMS while also earning foreign exchange through wheeling tariffs.

3. Risks and Assumptions

158. In developing the proposed ADB strategy to support the energy sector in Cambodia, the main assumption is that the new government, which was installed following the national elections on 29 July 2018, will design and implement the next (fourth) phase of the Rectangular Strategy and the NSDP, 2019–2023, with targets for the provision of reliable, affordable, and sustainable energy. As the country still lacks a comprehensive national energy policy, ADB's

energy sector strategy for Cambodia is based on the 2015 PDP, the IDP, and national climate change commitments.

159. Mobilizing substantial financing is a key challenge the government must overcome if it wishes to meet its plans and targets for the energy sector. ADB is positioned to support the government in leveraging public and private sector funding as outlined in the lending and nonlending programs in paras. 148–157. Another key assumption is that other development partners will also continue to support the government through their respective energy sector programs and in collaboration with ADB.

160. ADB's proposed support for Cambodia's energy sector is subject to two main risks: (i) limited institutional capacity in clean energy projects and (ii) continued reliance on unsolicited, business-to-business deals from private developers. Improved human resources are required to identify and appraise potential projects, assess social and environmental impacts, and implement and manage projects. In addition, greater interest of private developers seeking projects in Cambodia may encourage government agencies to select unsolicited bids for projects from familiar contractors without supporting fair competition, considering financial impacts, or mitigating the associated environmental and social impacts.

161. ADB's proposed strategy emphasizes building the capacity of MME and EDC staff to effectively and transparently evaluate and procure potential clean energy projects. Well-trained and experienced staff will be able to competitively tender power projects and choose the most technically, environmentally, and socially sound projects based on international best practice. Once projects are selected, skilled staff will monitor and advise project developers in meeting technical specifications of the national grid to ensure network reliability, as well as fulfilling the standards of ADB's social and environmental safeguards. The proposed ADB strategy includes nonlending program support for capacity building to mitigate the two risks mentioned in para. 160.

III. ENERGY SECTOR: ROAD MAP AND RESULTS FRAMEWORK, 2019–2023

Country Sector Outcomes		Country Sector Outputs		ADB Sector Operations	
Sector Outcomes with ADB Contribution	Indicators with Targets and Baselines	Sector Outputs with ADB Contribution	Indicators with Incremental Targets	Planned and Ongoing ADB Interventions	Main Outputs Expected from ADB Interventions
<p>Increased grid-electricity consumption by more people and businesses for promoting economic growth and social development</p> <p>Improved connectivity of physical energy assets and strengthened institutional, regulatory, and human resource capacity to provide reliable and sustainable power supply</p>	<p>Power demand increases to 1,827 MW by 2023 (2016 baseline: 876 MW)</p> <p>Village electrification rate increases to 100% by 2020 (2017 baseline: 82%)</p> <p>Household electrification rate increases to 70% in 2030 (2017 baseline: 69%)^a</p> <p>All 25 provinces connected to the national grid by 2023 (2017 baseline: 19 provinces)</p> <p>Human resource capacity for effective energy policy formulation and planning in EDC and the MME established by 2023 (2017 baseline: Not applicable)</p>	<p>Electricity transmission and distribution system expanded and reliability improved</p> <p>Institutions and human resource capacity for renewable energy and energy efficiency established</p> <p>Increased renewable energy capacity and practice of energy efficiency</p>	<p>At least 150 MW of installed solar capacity added by 2023 (2017 baseline: 10 MW)</p> <p>1,850 km of additional high-voltage transmission lines constructed by 2021 (2017 baseline: 1,957 km)</p> <p>10,500 km of additional medium-voltage sub-transmission lines constructed by 2021 (2017 baseline: 28,975 km)</p> <p>9,000 km of additional low-voltage distribution lines constructed by 2021 (2017 baseline: 27,862 km)</p>	<p>Planned key activity areas</p> <p>Grid infrastructure extension</p> <p>Support for Cambodia's first set of utility-scale, solar energy-based generation parks for the national grid</p> <p>Energy sector policy, regulatory, and institutional support</p> <p>Pipeline projects with estimated amounts</p> <p>National Solar Park Project (2019: \$7.64 million concessional OCR, \$14 million SREP)</p> <p>Grid Reinforcement Project for Expanded Renewable Energy Generation (2020: \$80 million concessional OCR)</p> <p>Support for a Sustainable Power Sector (2019: \$1 million CEF-CEFPF, \$0.4 million CTFBDF)</p>	<p>Pipeline projects</p> <p>Improved operating efficiency of EDC</p> <p>Strengthened capacity of the EAC and EDC to regulate and operate solar power generation in the national grid</p> <p>Increased demand for electricity services through increased economic activities</p> <p>71 km of transmission lines and associated substations in Phnom Penh and Sihanoukville constructed</p> <p>Ongoing projects</p> <p>2,110 km of transmission lines in five provinces to expand the national grid</p> <p>Capacity building for EDC</p> <p>Effective transfer of low-carbon systems and practices within the GMS</p>

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Table continued

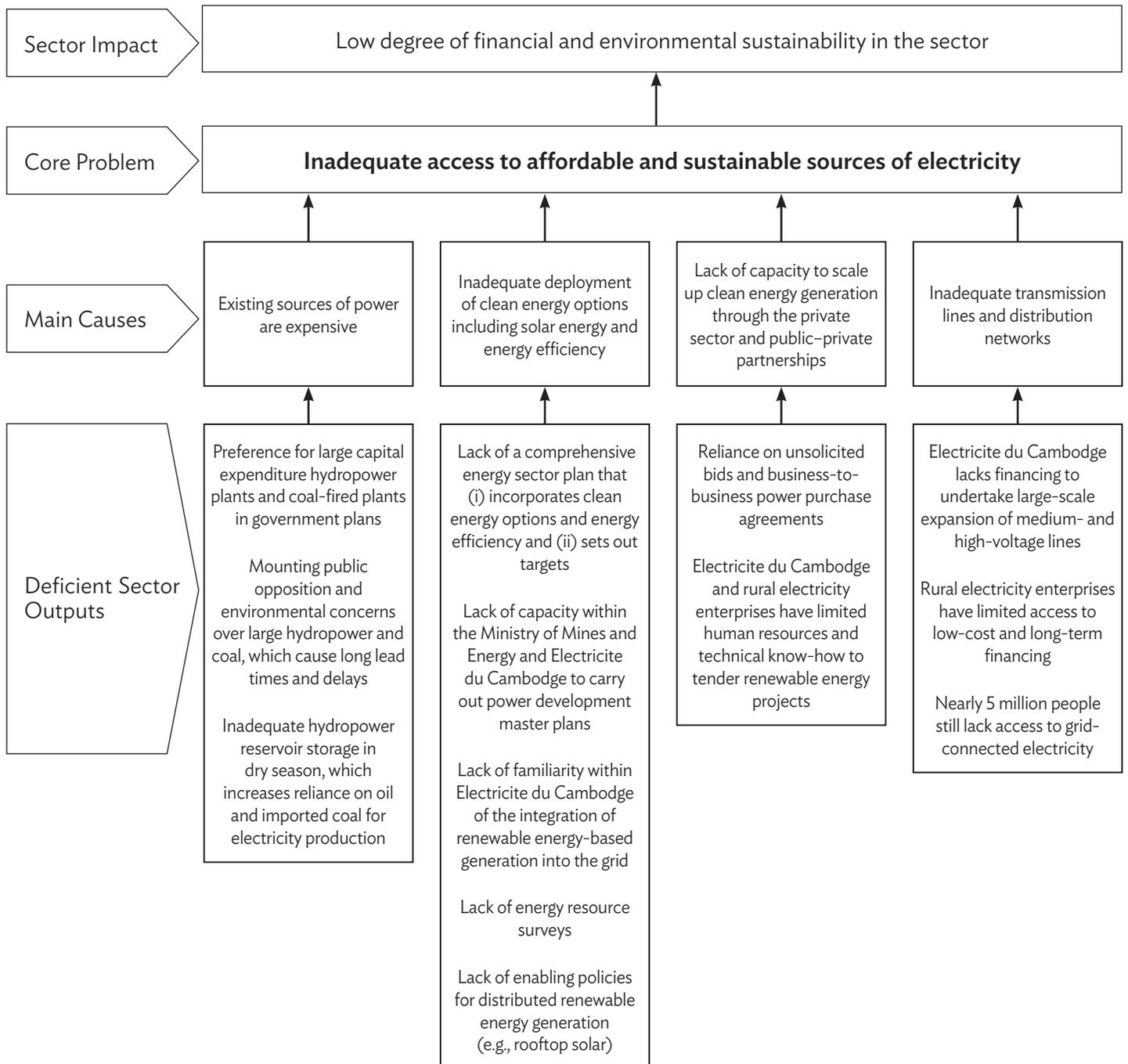
Country Sector Outcomes		Country Sector Outputs		ADB Sector Operations	
Sector Outcomes with ADB Contribution	Indicators with Targets and Baselines	Sector Outputs with ADB Contribution	Indicators with Incremental Targets	Planned and Ongoing ADB Interventions	Main Outputs Expected from ADB Interventions
	<p>Effective institutional framework for tendering generation projects established by 2023 (2017 baseline: Not applicable)</p> <p>Renewable energy and energy efficiency targets and frameworks established by 2023 (2017 baseline: Not applicable)</p>			<p>Solar PV Capacity Building (2019: \$500,000 e-Asia and Knowledge Partnership Fund)</p> <p>Ongoing projects with approved amounts</p> <p>Medium-Voltage Sub-Transmission Expansion Sector Project (Loan 2979, \$45 million, ADF; Loan 8264, \$10 million, OFID; Grant 0468, \$1 million, CEFPP)</p> <p>Promoting Energy Efficiency, Renewable Energy, and Clean Fossil Fuel Energy in the GMS (CDTA 7679-REG)</p>	

ADB = Asian Development Bank, ADF = Asian Development Fund, CDTA = capacity development technical assistance, CEF-CEFPP = Clean Energy Fund under the Clean Energy Financing Partnership Facility, CTFBDF = Clean Technology Fund Business Development Facility, EAC = Electricity Authority of Cambodia, EDC = Electricite du Cambodge, GMS = Greater Mekong Subregion, km = kilometer, kV = kilovolt, MME = Ministry of Mines and Energy, MW = megawatt, OCR = ordinary capital resources, OFID = Organization of the Petroleum Exporting Countries Fund for International Development, PV = photovoltaic, SREP = Scaling Up Renewable Energy Program in Low Income Countries.

^a In 2017, the household electrification rate was 69% and it is assumed the 70% target will be achieved soon. The government is currently in the process of revising its electrification target.

Source: ADB.

IV. APPENDIX: ENERGY SECTOR PROBLEM TREE



Cambodia Energy Sector Assessment, Strategy, and Road Map

This publication focuses on the strategic investment priorities of the Asian Development Bank (ADB) in the energy sector of Cambodia. It highlights sector performance, priority development constraints, government plans and strategies, and ADB's past and future support. The sector assessment, strategy, and road map is aligned with ADB's Strategy 2030 and will inform its country partnership strategy for Cambodia, 2019–2023, which is currently under development. It seeks to help provide sector background information for investment and technical assistance operations.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 67 members—48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

