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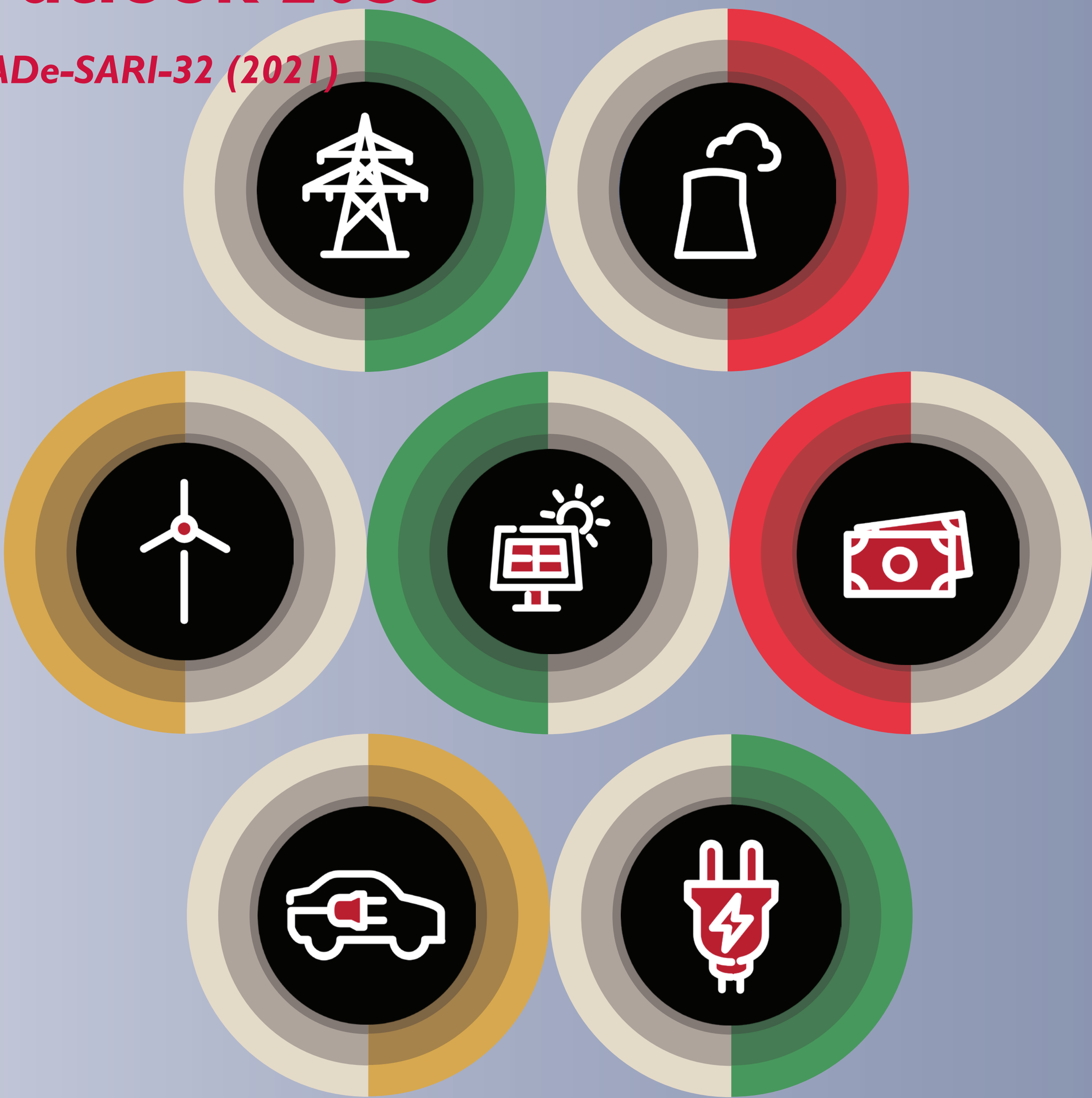
SOUTH ASIA REGIONAL INITIATIVE
FOR ENERGY INTEGRATION (SARI/EI)

BIMSTEC Energy Outlook 2035

IRADe-SARI-32 (2021)



SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY INTEGRATION (SARI/EI)

BIMSTEC ENERGY OUTLOOK – 2035

IRADe-SARI-32 (2021)

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IRADe-SARI-32 (2021)

Preface

We are pleased to present the report on the "**Second Edition of BIMSTEC Energy Outlook 2035**". This report is a biennial edition and developed under the South Asia Regional Initiative for Energy Integration (SARI/EI) program, supported by the USAID and implemented by Integrated Research and Action for Development (IRADe).

Based on a request of the BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation), earlier in the year 2018, the first edition of the BIMSTEC Energy Outlook 2030 was also developed by the SARI/EI team, and the same was released in the inaugural session of the BIMSTEC's conference, held on 20th March 2018 in Dhaka, Bangladesh.

The BIMSTEC Energy Outlook report constitutes, a futuristic outlook towards 2035, covering the following points:

a) Past, present, and future trends in the energy value chain comprising power, gas, and oil;
b) Comprehensive energy modeling of BIMSTEC countries for forecasting; and
c) Reforms, policy, and regulatory frameworks in the energy sector.

The report aims to provide understanding among the member states of BIMSTEC about the long-term energy outlook, and ongoing energy transitions that may help them to plan further for regional cooperation efforts as well as towards betterment of the economy and environment in the BIMSTEC region.

I hope that this report will be a useful reference point for facilitating enriching discussions on the energy outlook in the region. I am grateful to USAID for their continued support in the preparation of this report. I would like to acknowledge the members of M/s Deloitte Touche Tohmatsu India LLP, India team, Mr. John Smith-Sreen, Director, Indo Pacific Office, USAID/India, Ms. Monali Zeya Hazra, Regional Energy and Clean Energy Specialist, Indo Pacific Office, USAID/India, and the research team at SARI/ EI secretariat at IRADe, for their valuable inputs on the outlook, through sustained efforts in ensuring that the study report is completed despite the restrictions posed by the lockdown.

Dr. Jyoti Parikh
Executive Director
Integrated Research and Action for Development (IRADe)

Foreword

The U.S. Agency for International Development (USAID) has been working to enhance regional energy cooperation in South Asia since the year 2000, through its South Asia Regional Initiative for Energy (SARI/E) program. The first three phases of the program during the period 2000-2012, focused on building trust, raising awareness, and assessing potential transmission interconnections. The current and fourth phase of the program, called the South Asia Regional Initiative for Energy Integration (SARI/EI), which was launched in the year 2012, focuses on three developmental outcomes: coordination of a policy, legal and regulatory framework; advancement of transmission systems interconnection; and establishment of a South Asia regional electricity market.

As a part of its engagement, SARI/EI partnered with key regional institutions such as BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation), a regional organization comprising of seven member states including Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka, and Thailand across South and Southeast Asia. As a part of this collaboration, SARI/EI produced the "BIMSTEC Energy Outlook 2035", a biennial publication, with the objective to enhance energy knowledge and support energy cooperation among BIMSTEC member states.

The "Outlook" covers country-level energy data, regional economic and energy analysis, sectoral analysis, and the energy and investment outlook through 2035 for BIMSTEC countries. The energy sector analysis focuses on the region's economies and conventional and non-conventional energy resources, while also listing key issues faced by the different countries in the region. The report comprehensively covers all the energy interconnections in the BIMSTEC region for oil, gas, and electricity.

I would like to take this opportunity to acknowledge the excellent work done by the SARI/EI team at IRADe and Deloitte India in developing this second edition of the "BIMSTEC Energy Outlook 2035". I hope this report will be useful for all BIMSTEC countries and for those interested in the region's energy sector.

Sincerely,

John Smith-Sreen

John Smith-Sreen
Director, Indo-Pacific Office
USAID/India

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1.1 Introduction

Figure 1: BIMSTEC Member States

The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC) is a regional organization comprising seven Member States (Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand) lying in the littoral and adjacent areas of the Bay of Bengal constituting a contiguous regional unity.

BIMSTEC Member States coordinate with each other, within and outside the BIMSTEC framework on energy related matters including cross border energy trade. The Member States may be interested to understand about the long term energy outlook, and ongoing energy transitions that may help them to plan further for regional cooperation efforts. This report aims to act as such a reference point for the stakeholders.

1.2 BIMSTEC Regional Profile

1.2.1 Economy, trade and investment

Overall, the total GDP (at current price, USD) of the BIMSTEC region was 3.7 Trillion USD in 2019 up from 2.5 Trillion USD in 2011. This makes the grouping's contribution to global GDP at 4.2%, as compared to 3.4% in 2011. India, Thailand and Bangladesh are the three topmost economies in terms of GDP in the region. While specific share of countries in total GDP varies, BIMSTEC region countries have succeeded in strengthening their economy in the last five years.

Between 2011 and 2019, the growth rate of BIMSTEC GDP at current price was 4.5%. If we restrict to the recent period of 2015-2019, this has increased to 6.3%.

$			
3.7 Trillion USD	**4.2%**	**4.5%**	**6.3%**
Total GDP, 2019 (at current price)	Share of world GDP, 2019	GDP growth in 2011-2019	GDP growth in 2015-2019

Source: The World Bank, Government reports [1]

Except for Thailand, all other countries in the BIMSTEC region maintain a trade deficit, and import more than what they export. The exports as % of imports is low in the case of Nepal, Bhutan and Bangladesh. In comparison, the variation between exports and imports is low for countries such as Thailand and India. In 2019, the imports formed 1017 billion USD, against exports of 954 billion USD in the region. [2]

Intra-regional trade among BIMSTEC countries are estimated to be only 7% of the global trade.[3] In spite of the low share compared to global trade, BIMSTEC region has still seen a significant boost in the level of trade between its countries as well. The intra-regional trade in BIMSTEC region was 83.90 billion USD in 2017 up from 72 billion USD in 2016 and 37 billion USD in 2014. [4]

60.01	**24.03**	**7%**
Imports (USD Billions), 2019	Exports (USD Billions) , 2019	Intraregional trade as % of global trade

In terms of investment, the total FDI inflows to BIMSTEC in 2019 was USD 60 billion as against the FDI outflows of USD 24 billion from the region. India has the largest FDI inflows and outflows, followed by Thailand. In 2019, out of the total FDI inflows to BIMSTEC region, 84% was to India and 7% to Thailand.

60.01	**24.03**	**1.53%**	**0.61%**
FDI Inflows (USD Billions), 2019	FDI Outflows (USD Billions) , 2019	FDI inflow as % of GDP, 2019	FDI outflow as % of GDP, 2019

Source: UNCTAD [5]

1.2.2 Energy resource potential

The BIMSTEC region is endowed with abundant natural resources comprising of 331 billion tonnes of coal, 718 million tonne of oil, 76 Trillion Cubic Feet (TCF) of natural gas, 386 GW of large hydropower and renewable energy of 1359 GW potential.

377 billion tonnes of coal	**718 million tonnes of oil**	**76 trillion cubic feet of natural gas**	**386 GW of hydropower**	**1359 GW of renewable energy**

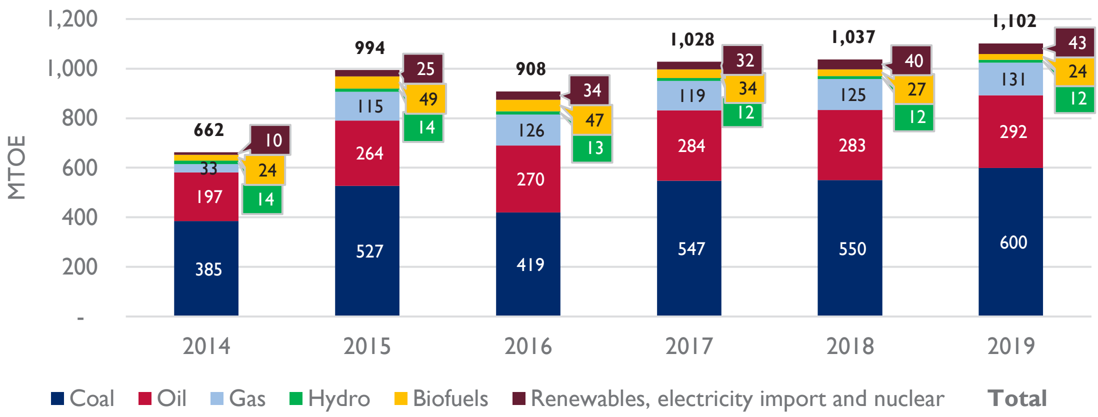
Source: BP Statistical Review, SAARC, Bangladesh Ministry of Petroleum, Investment Board of Nepal, Bhutan Statistical Bureau, Asian Development Bank, Food and Agricultural Organization, Central Electricity Authority, Bangladesh Power Division, Government of Myanmar, NITI Aayog, India Ministry of Power, India Ministry of Statistics and Program Implementation, European Journal of Sustainable Development Research [6]

Bulk of the hydropower potential is in India, Myanmar, Nepal and Bhutan. India also has the highest coal reserves in the region, and the largest renewable energy (solar and wind) potential. India, Myanmar, Thailand and Bangladesh has substantial gas reserves also. There is also the case of Sri Lanka, where exploration activities are underway for oil and gas fields, and therefore there could be discoveries of proven reserves in the future.

1.2.3 Energy supply scenario

Primary Energy Supply (PES) in the BIMSTEC is primarily dependent on Coal and Oil Products with Hydro and Renewable Energy share also gradually increasing. Coal (54%) and oil (27%) together contributed to 81% of the primary energy supply in the region in 2019. Only biofuels show a downward trend in growth, whereas supply from all other sources have been increasing. If the energy transition, especially in rural areas continue, the use of biofuels and waste for energy requirements may further reduce.

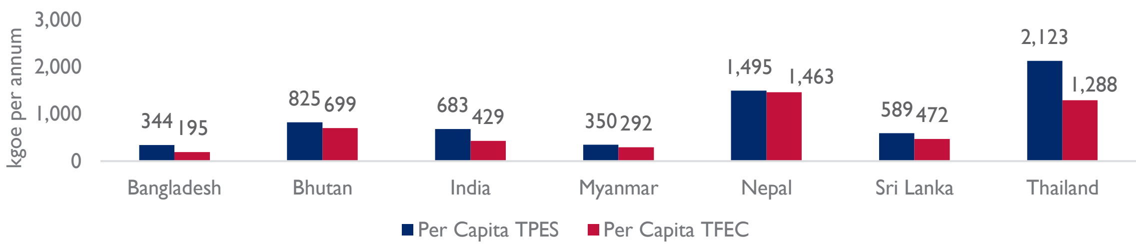
Figure 2: BIMSTEC - Source wise primary energy supply



For some of the countries, as data from government sources is not available for some years, the same have not been included.
Source: Statistical departments of respective governments. Detailed source provided in chapter 5

India has the highest share of total PES amongst all BIMSTEC country members followed by Thailand and Bangladesh. Between 2014 and 2019, the energy supply in the region has grown at an average rate of 10.72%. The per-capita energy supply and consumption details are provided below. The per-capita energy is highest in the case of Thailand and lowest in the case of Bangladesh and Myanmar.

Figure 3: Per capita energy supply and consumption - 2019

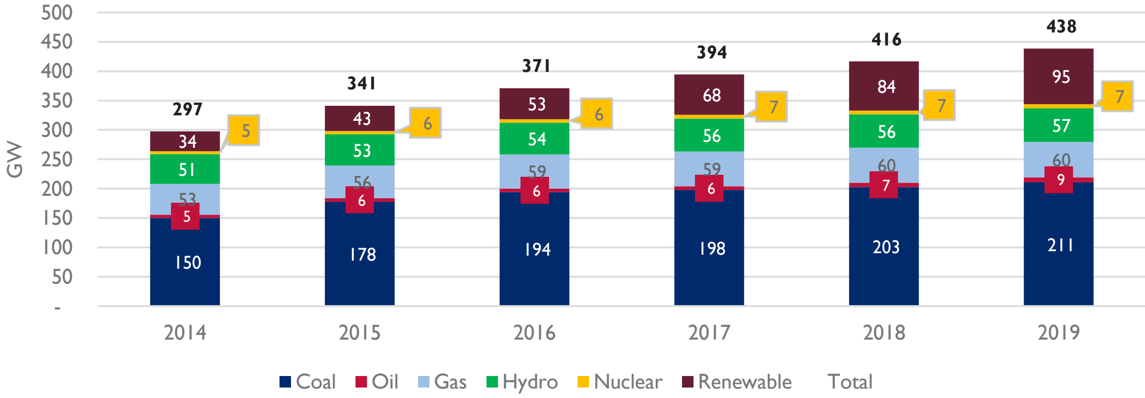


For some of the countries, as data is not available for 2019, latest available data has been used.
Source: Statistical departments of respective governments. Detailed source provided in chapter 5

1.2.4 Electricity scenario

The installed capacity of electricity in BIMSTEC region increased by 47% between 2014 and 2019, from 297 GW in 2014 to 438 GW in 2019. The CAGR of installed capacity during this period was 8%. The steepest growth rate was for renewables, which increased at a CAGR of 23%. In absolute terms, the highest capacity addition was for coal power plants, where 60.5 GW was added between 2014 and 2019.

Figure 4: BIMSTEC - Growth of electricity capacity

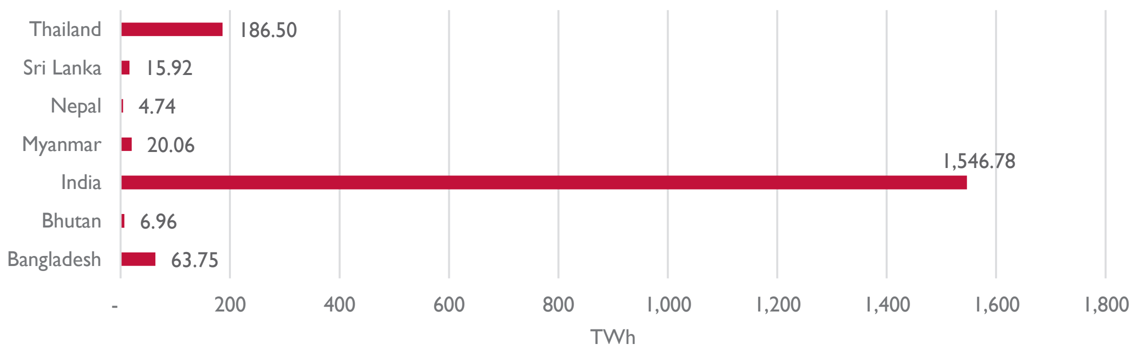


For Myanmar, 2018 values are taken for 2019 also. Import capacities are not considered, to avoid double counting.

Source: Annual reports of respective utilities or ministries

The installed capacity of electricity is highest in the case of India (367 GW), followed by Thailand (40 GW). The share of India and Thailand in total installed capacity in the region is 93%. In terms of generation, India has the largest share of 84% (1547 TWh), followed by Thailand with 10% (187 TWh).

Figure 5: BIMSTEC electricity generation – 2019

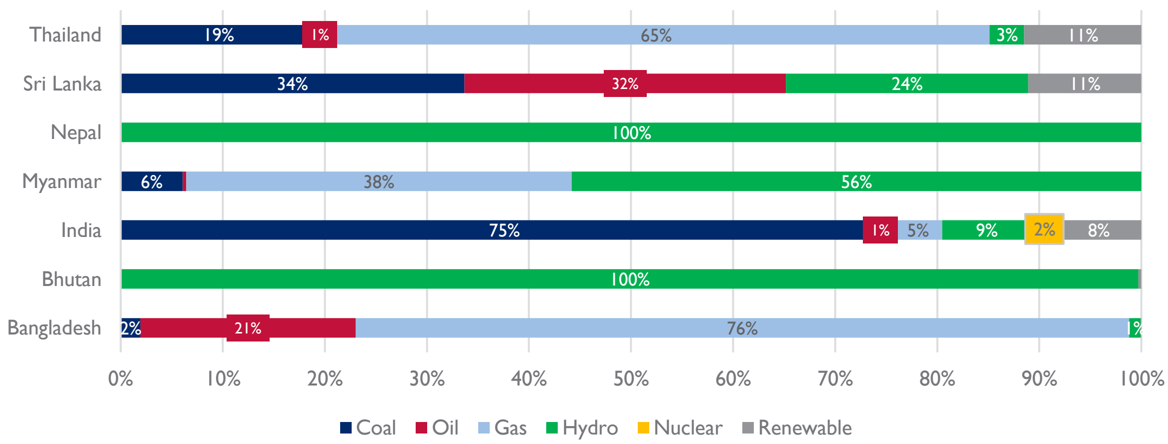


For Myanmar, 2018 values are taken. Import capacities are not considered, to avoid double counting.

Source: Annual reports of respective utilities or ministries

The electricity generation mix clearly shows the specific energy source dominance in various countries, as can be observed in case of coal in India, hydro in Nepal and Bhutan and gas in Bangladesh and Thailand.

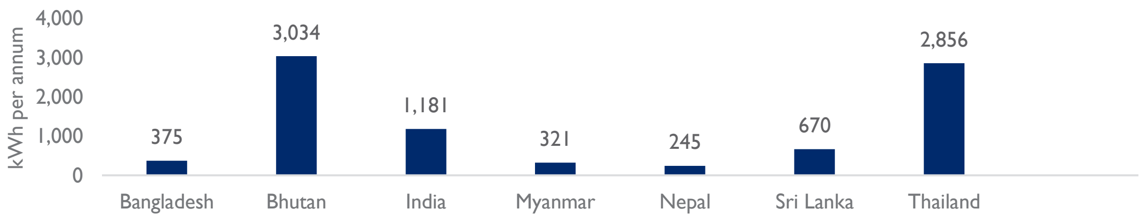
Figure 6: BIMSTEC electricity generation mix - 2019



For Myanmar, 2018 values are taken. Source: Annual reports of respective utilities or ministries

There is a wide variation in per capita electricity consumption among BIMSTEC Member States. The per capita consumption of countries such as Thailand and Bhutan are more than twice to that of other countries. Even in case of Thailand and Bhutan, the per capita electricity consumption is still low, if compared to advanced economies such as European Union (6,100 kWh) and USA (12,900 kWh). [7]

Figure 7: BIMSTEC Per-capita Electricity Consumption – 2019

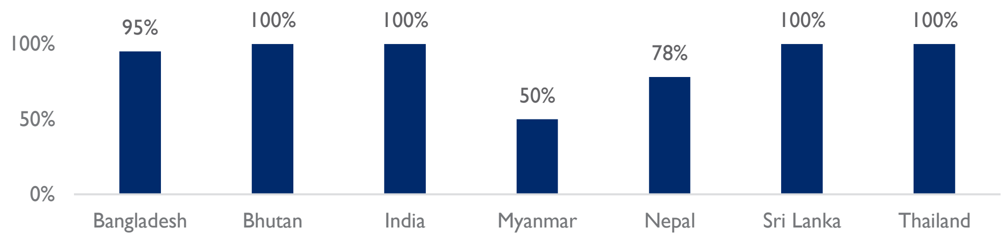


All values pertain to CY/FY 2019 other than Myanmar where 2018 values are used.
Values for Bhutan and Myanmar are calculated from sales and population.

Source: Multiple sources [8]

In terms of Electricity Access, Sri Lanka, India and Thailand has achieved 100% or near to 100% access. Bhutan has also reported 100% access, though the same includes access through off-grid sources.[9] Similarly, Nepal has also reported 78% access.[10] Bangladesh has managed to improve its rural electrification coverage, which stands at 95% as on end of June 2019.[11] Myanmar's electrification ratio stands at 50%.[12]

Figure 8: Electricity Access



Source: Bangladesh Power Development Board, Bhutan Power Corporation, Rural Electrification Corporation, Myanmar office of President, Nepal Electricity Authority, Sri Lanka Ministry of Power, The World Bank[13]

1.2.5 Regional energy cooperation

BIMSTEC Member States have a long history of bilateral cooperation in electricity sector. There are cross border transmission interconnections and cross border power trade between many of the Member States. This includes the export of power from hydropower plants in Bhutan to India, and the import of power from India, by Bangladesh, Nepal, and to a very small extent, Myanmar. In some cases, there is also transmission interconnection and trade with outside the region, such as in the case of Myanmar (with China) and Thailand (Laos, Malaysia). The summary of cross border power trade in BIMSTEC is provided below.

Table 1: Cross border power trade in BIMSTEC, in Million Units

Countries	2014	2015	2016	2017	2018	2019	2020*
Bhutan to India	5,555	5,109	5,557	5,864	5,611	4,657	6,311
India to Bangladesh	1,448	3,272	3,654	4,420	4,809	5,690	6,988
India to Myanmar				3	5	7	9
India to Nepal	840	997	1,470	2,021	2,389	2,799	2,373
Myanmar to China	2,532	1,463	1,239	2,381	#	#	#
South East Asia to Thailand	10,193	12,148	18,389	23,321	25,576	22,665	21,779

** India related numbers are for April 2019 – March 2020. Thailand's value for 2020 is prorated based on seven month data. # - Not available*

Source: POSOCO, Government of Myanmar, EPPO[14]

In comparison to cross border power trade, gas grid interconnections and trade within BIMSTEC are still at a very nascent stage. The only cross border pipelines that are currently operational are the pipelines that supply gas from Myanmar to Thailand and China. These include the following:

1. Pipelines for transfer of gas from Yadana, Yetagun and Zawtika gas fields in Myanmar to Thailand[1].
2. 771 km Myanmar-China gas pipeline, commissioned in 2013, from Madè Island on the west coast of Myanmar to Ruili in the southwestern Chinese province of Yunnan .

[1] *Petroleum Economist, Gas Exports Up and Running - https://www.petroleum-economist.com/articles/misc/misc/2001/gas-exports-up-and-running*

3. 793 km Myanmar-China crude oil pipeline, commissioned in 2017, from Ramree Island on the western coast of Myanmar to Ruili in China's Yunnan Province.[15]

There is also a petroleum pipeline between Motihari in India and Amlekhgunj in Nepal, which was commissioned in 2019.

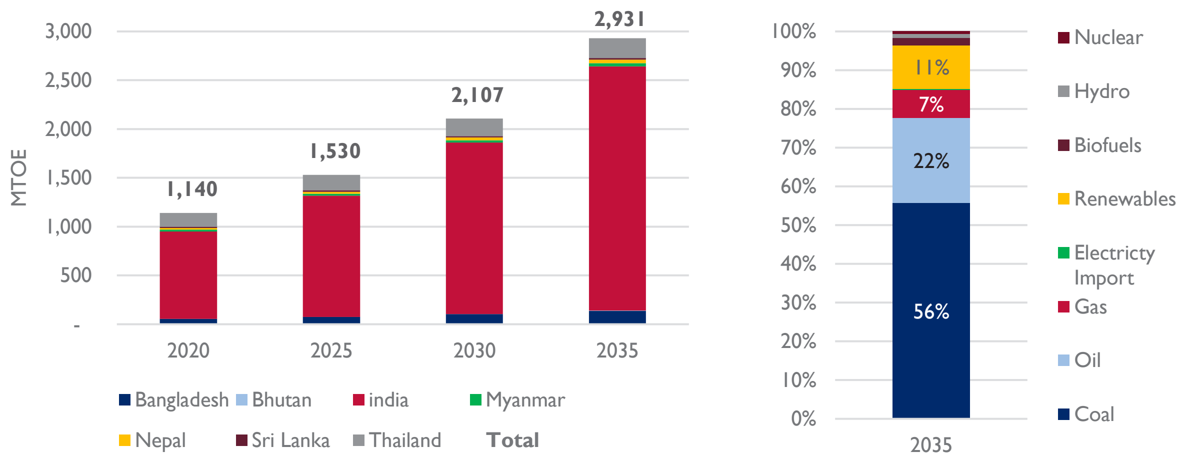
1.3 BIMSTEC Energy Outlook 2035

The below estimates of BIMSTEC energy outlook for 2035 uses the future outlook data of utilities / Governments wherever they are publicly available. However, in the absence of such information, the outlook is estimated using a set of assumptions which are detailed in chapter 7 of the report.

1.3.1 Energy outlook

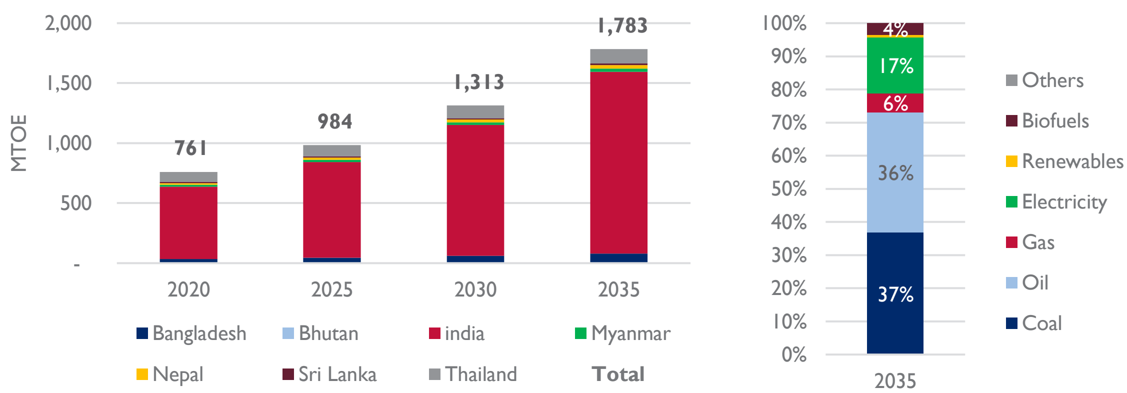
The Total Primary Energy Supply (TPES) is expected to grow at 6.5%, from 1140 MTOE in 2020 to 2931 MTOE in 2035. An increase in share of renewables, and decrease in share of gas is anticipated by 2035. However, the overall dominance of fossil fuels in the total energy supply is not expected to reduce significantly, coal, oil and gas in total is still expected to contribute to 85% of primary energy supply in 2035.

Figure 9: BIMSTEC – Total Primary Energy Supply, 2035



The aggregate of country outlooks of Total Final Energy Consumption (TFEC) is illustrated below, which depicts TFEC increasing at a compound annual growth rate of 5.8%. The share of coal is expected to increase, whereas that of traditional biofuels are expected to decrease. India is the dominant country in terms of energy, followed by Thailand.

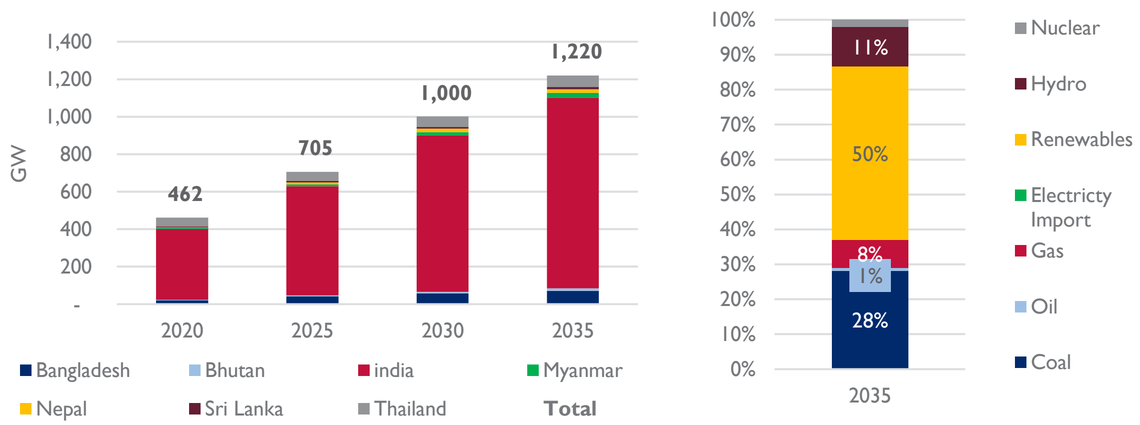
Figure 10: BIMSTEC - Total Final Energy Consumption, 2035



1.3.2 Electricity outlook

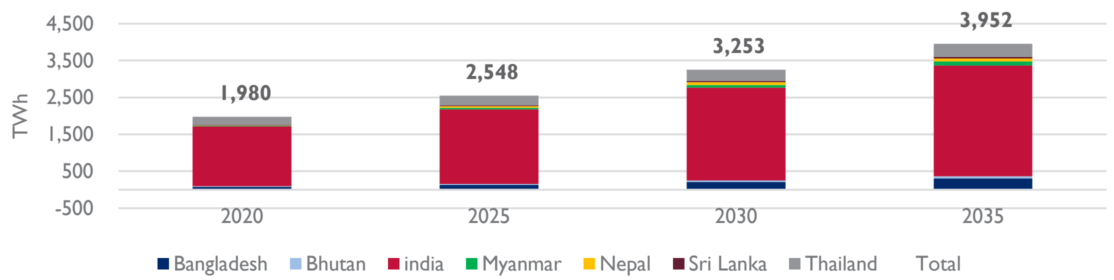
The capacity of electricity generation in BIMSTEC is estimated to increase at a compound annual growth rate of 6.7%, reaching 1220 GW by 2035. Similar to energy scenario, India has the highest capacity. The energy transition is clearly evident here, with renewables increasing the share to 50% in 2035, from 22% of 2020.

Figure 11: BIMSTEC - Electricity installed capacity – 2035



The electricity generation is expected to grow at a CAGR of 4.7%, reaching 3952 TWh in 2035.

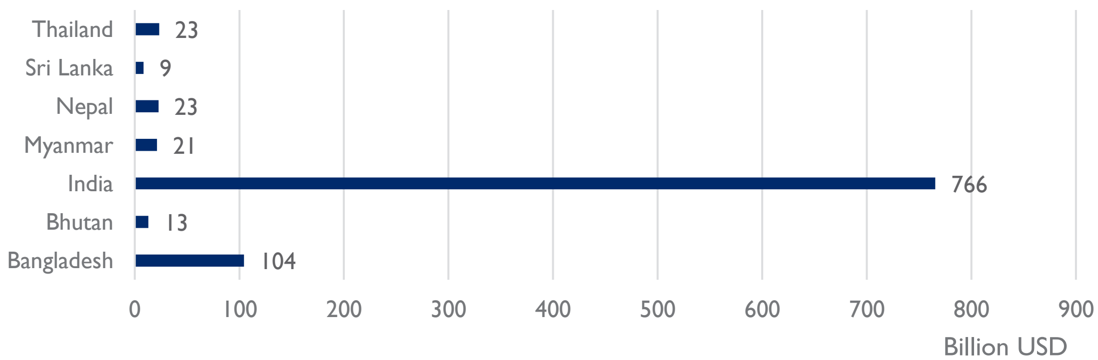
Figure 12: BIMSTEC - Electricity generation outlook 2035



1.3.3 Investment opportunities

The planned electricity generation augmentation, and corresponding investment requirement till 2035 has been considered, by considering estimates of investment made by respective governments / utilities wherever the same is available. In other cases, the estimated capacity addition, along with benchmark investment costs are considered. In total, the investment requirement for the sector for 2021-2035 is estimated at 958,428 Million USD. India and Thailand accounts for nearly 80% of the investment requirements.

Figure 13: Summary of generation investment requirement



In addition, there will be need for transmission investments, which will be a combination of expansion of transmission network within the country and for cross border infrastructure. Due to variation in geography, length to nearest grid network etc., it is not practical to estimate transmission investment requirement on an aggregate basis. However, rough estimates based on average can be attempted. For example, in Nepal, the transmission investment cost is assessed at 6038 Million USD for 38 GW of installed capacity, i.e. 0.159 Million USD/MW. If we extend the same benchmark to installed capacity addition of 767,603 MW, the total transmission investment requirement will be 122 billion USD.

1.3.4 Outlook for cross border electricity trade (CBET)

An estimate for CBET within BIMSTEC by 2035 was developed, by considering the country wise domestic surplus / deficit, and the existing plans for CBET expansion. The respective governments / utilities in BIMSTEC have identified a few key project / set of projects, for future CBET. This includes the following:

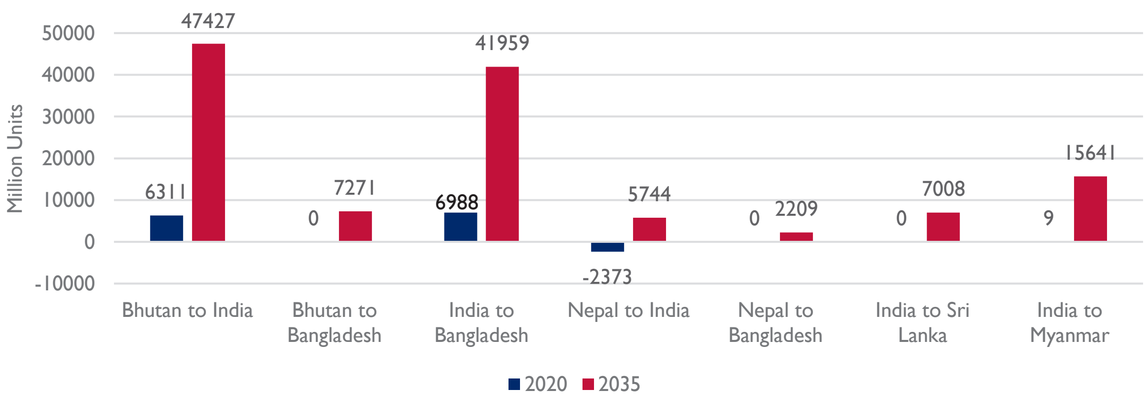
- Under an intergovernmental agreement, Government of India has agreed to assist Royal Government of Bhutan in developing a minimum of 10,000 MW of hydropower and import the surplus electricity from this to India.[16]
- Bhutan has identified 1125 MW Dorjilung HPP as one of the potential power plants for supply to Bangladesh.[17] There are also talks about export of power from 404 MW Nyera Amari HPP.
- India already exports close to 1200 MW of power to Bangladesh.
- India has agreed to import power from the 900 MW Arun-III hydropower project in Nepal.
- Bangladesh has agreed to import 500 MW of power from the 900 MW Upper Karnali hydropower project in Nepal. Considering the involvement of Indian developer, rest of the power may be considered to be off taken in India. Bangladesh's PSMP envisages new import of 1496 MW in 2022, and additional 4500 MW of import between 2023 and 2035, and another 4500 MW of import between 2036 and 2041.

In addition to the above, to check viability of CBET, the following avenues were also explored:

1. In Myanmar, the additional energy to be procured through new power plants in 2030-2035 is estimated as 15,641 MU. It can be considered instead as a potential option for import from other countries.
2. In Sri Lanka, considering the ongoing discussions on transmission interconnection of up to 1000 MW with India, corresponding energy can also be assessed as a potential option, instead of generating the same domestically.

Based on the above assumptions, considering the committed CBET transactions, and considering a cost optimization logic for the remaining potential CBET, it is estimated that CBET in BIMSTEC region has the potential to increase up to 7 times, from 15,618 MU in 2020, to 127,259 MU. This will be equivalent to trade of 14.5 GW on Round-the-Clock basis in 2035.

Figure 14: CBET in BIMSTEC, in 2020 and estimate for 2035

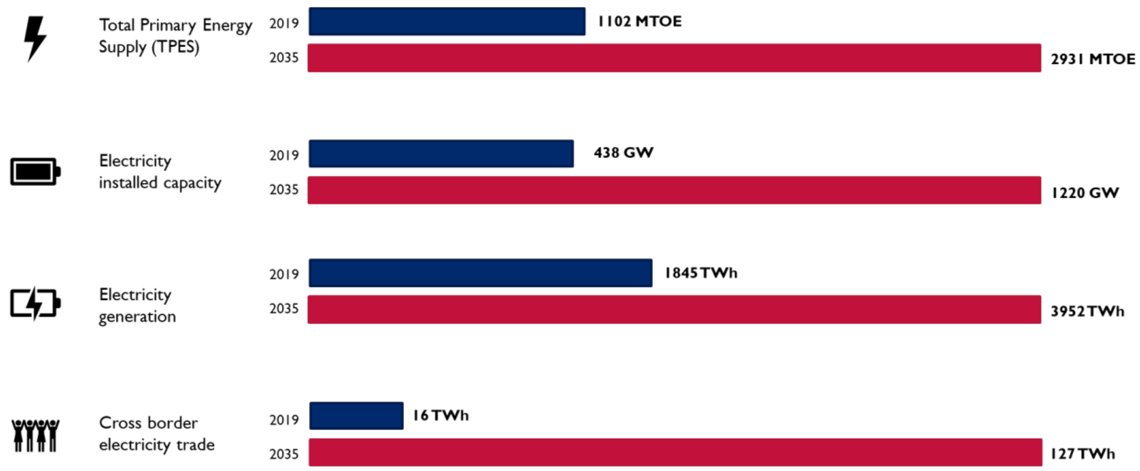


It may be noted that the above analysis is considerably sensitive to cost parameters, and therefore any variation in assumed costs could change the results of the analysis substantially. A reduction in generation costs could open up more trade such as increased export of power from Nepal, or CBET between Thailand and South Asia. More importantly, the intended message is the potential for BIMSTEC Member States to cooperate on energy sector, in a mutually beneficial manner.

1.4 Summary and observations

The energy sector within BIMSTEC is expected to grow considerably from the present state, by 2035. A comparison of some of the key energy statistics for 2019 and 2035 is provided below. Parameters such as primary energy supply, installed capacity of electricity, and electricity generation is expected to increase by more than 100%, by 2035. While TPES and electricity generation is expected to become slightly more than double, the electricity installed capacity is expected to increase by two times from the 2019 level, and the cross border electricity trade is expected to increase by more than 7 times, from the 2019 level.

Figure 15: BIMSTEC – Energy parameters - 2019 and 2035



The anticipated energy scenario raises various questions and challenges, such as the following.

1. The investment requirement in electricity generation itself, if spread equally across of 2021-2035 will be 64 billion USD per year. While some portion of this may as well be private investment, the Governments will still have to be ready to invest at least in a portion in this. In addition, there will be costs for transmission evacuation, system balancing etc.
2. The commercial potential of a South Asia – South East Asia interconnection, between Myanmar and India/Bangladesh is there, if competitive power can be made available. Will BIMSTEC Member States be able to develop cheaper projects, in comparison to other countries in the region, such as Laos?
3. Cross border interconnections in oil and gas are prominent in Thailand and Myanmar, though not widely adopted in rest of BIMSTEC. The possibilities in wider energy cooperation can be explored.
4. There is a wide variation in renewable energy potential, most of which is located in India. Out of the 1359 GW of renewable energy potential in the region, 1242 GW is in India. In comparison, the anticipated installed capacity of renewable energy in India for 2035 is only 574 GW. Thus, there is a possibility of developing untapped RE potential in countries such as India, for use in smaller countries or countries with limited available land in the region.
5. There are cost arbitrage opportunities, in terms of displacing costly domestic power with cheaper imported power, However, it is the policy maker's prerogative to arrive at the desired trade-off between economics, energy security and flexibility.

6. In addition to the anticipated CBET of 127 TWh in 2035, there is an additional available power of over 230 TWh. This opens the possibility of either restricting the generation expansion plans to slightly lesser levels, or to also explore CBET opportunities even beyond BIMSTEC.
7. Some of the cross border trade was analysed in spite of anysolid proposals for cross border transmission line, such as in the case of potential CBET between India and Myanmar. The overall assumption was that once the parties decide on undertaking CBET, the transmission arrangements can be quickly put in place. However, there is another viewpoint on whether the visibility of interconnection plans in the near future accelerate the efforts for regional energy integration.
8. The installed capacity of renewable energy in the region is expected to reach 50% by 2035. Such a large share of RE requires flexible generation sources, which may not necessarily be available in the countries where such generation is located. This opens up a potential possibility of planning for regional RE balancing resources, or power plants offering flexible power through CBET.

While the potential opportunities and key questions are considered by the policy makers, the institutional aspects will also require attention. BIMSTEC as a regional grouping can play an important role in channelling the country level initiatives to provide a platform for securing affordable, sustainable and reliable supply of energy/electricity by integrating the energy resources vis-à-vis socio-economic development of the region.

The existing success stories in CBET, energy efficiency measures and renewable capacity additions need to be replicated across the region. To materialise these investment a conducive and cooperative political, economic and investment friendly environment is required in the BIMSTEC region. There are certain initiatives which can be taken up for enhanced energy cooperation in BIMSTEC region, such as:

1. Strengthening of existing MoUs on energy cooperation through a separate BIMSTEC-Comprehensive Plan for Energy Cooperation (BIMSTEC-CPEC);
2. Development of detailed master plans for energy cooperation, identifying the regional level projects and implementation modalities; and
3. Commence the operations of regional coordination institutions such as BIMSTEC Grid Interconnection Coordination Committee (BGICC) and BIMSTEC Energy Center (BEC).

Once these basic aspects are implemented, the next phase of regional coordination, including the development of a seamless energy market will be easier to getadopted and implemented, as supporting policy, institutional and physical framework will already be available. In parallel to the efforts for BIMSTEC energy grids and energy markets, the BIMSTEC Member States can also cooperate among each other on sharing of leading practices and successful strategies for implementation of energy efficiency measures, distributed generation, smart grid initiatives, fuel cell, clean coal technologies, energy storage, electric mobility and renewable energy integration.

2 About the study

The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) is a sub-regional, international organization comprising of the following seven countries from South Asia and South East Asia:

1	Bangladesh	3	India	5	Nepal	7	Thailand
2	Bhutan	4	Myanmar	6	Sri Lanka		

The main objective of BIMSTEC is to enhance technological and economic cooperation among South Asian and South East Asian countries along the coast of the Bay of Bengal. There are 14 areas of cooperation among the BIMSTEC nations, out of which energy is also one of the areas.

The idea of BIMSTEC Energy Outlook camedURING a meeting of the SARI/EI delegation with Honourable Secretary General of the BIMSTEC on 20 October 2016. During the meeting, it was suggested that considering energy literacy is very limited among BIMSTEC member countries, there is a need to have a report on "BIMSTEC Energy Outlook "a biennial flagship publication which will not only improve the energy literacy among the BIMSTEC member states but also support cohesion and sustenance on the Energy/Electricity cooperation initiative among the BIMSTEC member states.

Based on the request, SARI/EI developed the first edition of the BIMSTEC Energy Outlook 2030 which was released in the inaugural session of the Conference on "BIMSTEC at its 20: Towards a Bay of Bengal Community" held on 20 March 2018 at BIMSTEC Secretariat in Dhaka, Bangladesh.

BIMSTEC Energy Outlook 2030 was a first of its kind report in the BIMSTEC region, which covered substantial data, provided sectoral analysis, identified investment required, projected demand and supply up to 2030, and suggested institutional structure and energy security considerations related to energy/electricity covering all the seven BIMSTEC countries.

This study report constitutes the second edition of the BIMSTEC Energy Outlook, this time with a futuristic outlook towards 2035, covering the following:

1 Past, present and future trends in energy value chain comprising of power, gas and oil;

2 Comprehensive energy modelling of BIMSTEC countries for forecasting; and

3 Reforms, policy and regulatory frameworks in the energy sector.

The Outlook relies on published reports and publications on the respective BIMSTEC countries to assess the current scenario and project the overall energy outlook for the region up to 2035. The document covers country-level energy data, regional level energy and economic data and investment outlook up to 2035. The report also covers comprehensively all the energy interconnections in the BIMSTEC region for oil, gas and electricity.

The respective countries' power/energy sector master plans, system planning documents, publications, annual reports of the utilities and other relevant studies available in the public domain have been used in this study to arrive at the future outlook. Various assumptions used for the outlook estimation are detailed in chapter 7. The report also covers the energy sector institutional structure, and latest developments in the energy market, including initiatives related to renewable energy, energy efficiency, smart grids and electric vehicles.

3 The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC)

3.1 Introduction

The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC) is a regional organization comprising seven Member States (Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand) lying in the littoral and adjacent areas of the Bay of Bengal constituting a contiguous regional unity.

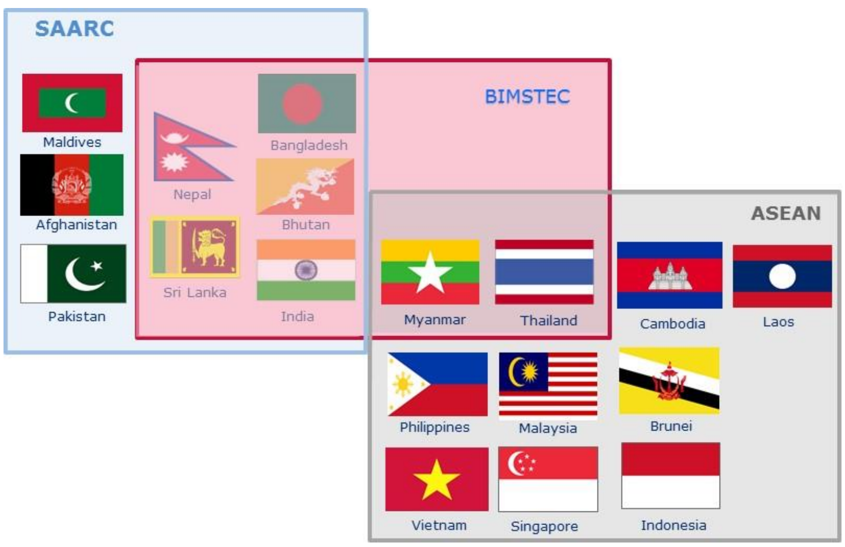
BIMSTEC Member States coordinate with each other, within and outside the BIMSTEC framework on energy related matters including cross border energy trade. The Member States may be interested to understand about the long term energy outlook, and ongoing energy transitions that may help them to plan further for regional cooperation efforts. This report aims to act as such a reference point for the stakeholders.

3.2 Background

Figure 16: BIMSTEC Member States

BIMSTEC was established in June 1997 through the Bangkok Declaration. Initially, the economic bloc was formed with four member states with the acronym 'BIST-EC' (Bangladesh, India, Sri Lanka and Thailand Economic Cooperation). Following the inclusion of Myanmar on 22 December 1997 during a special Ministerial Meeting in Bangkok, the Group was renamed 'BIMST-EC' (Bangladesh, India, Myanmar, Sri Lanka and Thailand Economic Cooperation). With the admission of Nepal and Bhutan at the 6th Ministerial Meeting (February 2004, Thailand), its name was changed to the 'Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation'.

Figure 17: BIMSTEC and other groupings in the region



The regional group constitutes a bridge between South and Southeast Asia and represents a reinforcement of relations among these countries. BIMSTEC has also established a platform for intra-regional cooperation between the South Asian Association for Regional Cooperation (SAARC) and the Association of Southeast Asian Nations (ASEAN) members.

The objectives of BIMSTEC, as stated in its Declaration[18] are to:

1. Create an enabling environment for rapid economic development through the identification and implementation of specific cooperation projects in the sectors of trade, investment and industry, technology, human resource development, tourism, agriculture, energy and infrastructure and transportation.
2. Accelerate the economic growth and social progress in the sub-region through joint endeavours in a spirit of equality and partnership.
3. Promote active collaboration and mutual assistance on matters of common interest in the economic, social, technical, and scientific fields.
4. Provide assistance to each other in the form of training and research facilities in the educational, professional and technical spheres.
5. Cooperate more effectively in joint efforts that are supportive of and complementary to the national development plans of Member states, which result in tangible benefits to the people in raising their living standards, including generating employment and improving the transportation and communication infrastructure.
6. Maintain close and beneficial cooperation with existing international and regional organizations with similar aims and purposes.
7. Cooperate in projects that can be dealt with most productively on a sub-regional basis and make the best use of available synergies among BIMSTEC member countries.

3.3 Evolution of BIMSTEC – An Energy Sector Perspective

BIMSTEC has identified 14 priority areas of cooperation, with a lead country identified for each of the areas. The areas and the corresponding lead country are summarized below.

Table 2: BIMSTEC priority areas and lead country

Country	**Priority areas led by the country**			
Bangladesh	Trade and Investment	Climate Change		
Bhutan	Cultural Cooperation			
India	Counter terrorism and transnational crime	Transport & Communication	Tourism	Environment and Disaster Management
Myanmar	Energy	Agriculture		
Nepal	Poverty Alleviation			
Sri Lanka	Technology			
Thailand	Fisheries	Public Health	People-to-People contact	

Energy has been one of the sectors that BIMSTEC focuses for regional co-operation, right from its inception. In the First BIMSTEC Summit held in Bangkok on 31 July 2004, energy was identified as one of the sectors for focussed cooperation. Cost effective reliable electricity supply is critical for socio-economic development of nations. As BIMSTEC Member States are endowed with diverse natural resources, regional cooperation for energy and cross border energy trade can help in addressing the common regional challenges like energy access, optimized utilization of natural resources, and institutional capacity building. To institutionalize the energy cooperation process in BIMSTEC, it was decided to establish a BIMSTEC Energy Centre, during the first ministerial conference on Energy Cooperation in 2005. The centre was envisaged to coordinate, facilitate and strengthen cooperation in the energy sector in the BIMSTEC region by promoting experience sharing, capacity building and best practices.

Some of the key initiatives taken so far by BIMSTEC in the energy sector are explained below.

3.3.1 Oil and Gas Sector

BIMSTEC initiated various cooperation activities in the oil and gas Sector. The Trans BIMSTEC Gas Pipeline Project was identified as one of the key project under BIMSTEC. Thailand conducted feasibility study for Trans BIMSTEC Gas Pipeline Project and organized a Task Force meeting in Bangkok, Thailand in March 2001 and a pre-feasibility study was completed in late 2004. A Task Force meeting to decide Terms of Reference for the study on Trans BIMSTEC Gas Pipeline (s) was also held in Bangkok, Thailand on 28-29 June 2006 together with a Workshop on Petroleum Reserves in BIMSTEC Region. The energy security concern of key BIMSTEC countries drove the need for a BIMSTEC gas grid.

3.3.2 Electricity Sector

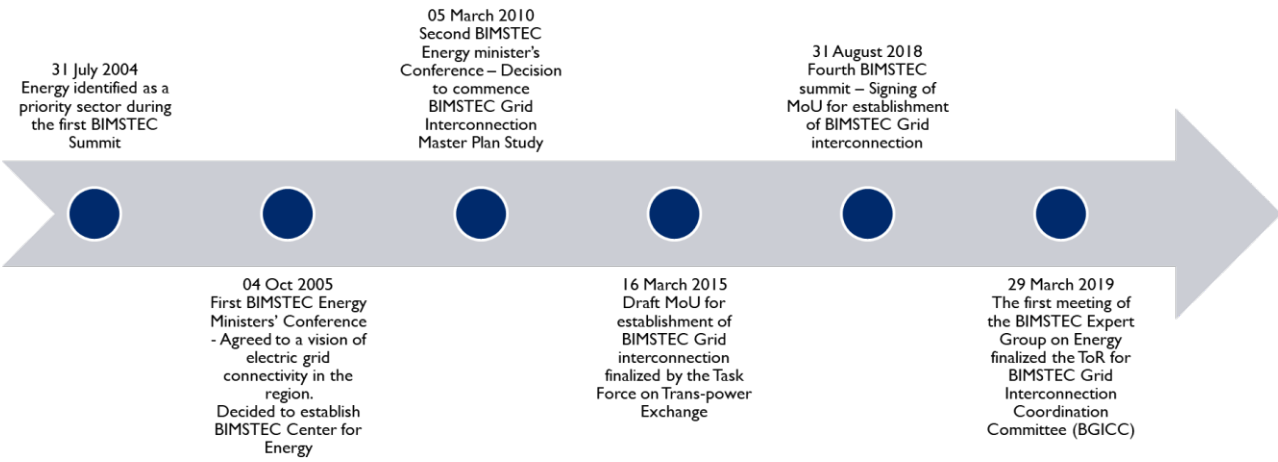
BIMSTEC initiated various cooperation activities in power/ electricity Sector. The BIMSTEC Trans Power Exchange and Development Project was identified as part of the "Plan of Action for Energy Cooperation in BIMSTEC", which was formulated in the first BIMSTEC Energy Ministers' Conference held in New Delhi on 4 October 2005. Thailand was assigned to coordinate a Task Force to initiate the projects, starting preparations of Terms of Reference for the Task Force and to draft the MoU to be signed among the member countries. In order to establish the BIMSTEC Trans Power Exchange and Development Project, a workshop on Harmonization of Grid Standards was held on 6 February 2006 in India. With emphasis on remote area electrification, India also hosted a workshop on 'Sharing Experiences in Developing Hydro Project' in October 2006. Thailand also hosted a regional workshop and study visit on 'Biomass gasification for power production' under BIMSTEC cooperation on 13-14 May 2008.

Between 2005 and 2016, several meetings of the Task Force for BIMSTEC Trans Power Exchange and Development were held. A key outcome of these meetings was that the draft MoU for establishment of BIMSTEC Grid Interconnection was finalized on 16 March 2015. The MoU for establishment of the BIMSTEC Grid Interconnection was finally signed on 31 August 2018 at the fourth BIMSTEC Summit held in Kathmandu, Nepal[19]. The objectives of grid interconnections for the trade in electricity under the MoU are for all parties to:

1. Coordinate and cooperate in the planning, development, and operation of interconnected systems to optimize costs while maintaining satisfactory reliability and security;
2. Fully recover the costs and share benefits equitably, resulting from the reductions in investments on generation, transmission systems and fuel cost;
3. Provide reliable, secure, and economic electricity supply to the parties;
4. Develop transmission tariff framework for trading of electricity among the Parties; and
5. Open up new avenues of cooperation to promote electricity trade.

To implement these objectives, an appropriate institutional arrangement and other policy measures are to be implemented. It has been proposed that the BIMSTEC Grid Interconnection Coordination Committee (BGICC) will be set up to actively coordinate for successful implementation of grid interconnections and trade in electricity. The first meeting of the BIMSTEC Expert Group on Energy held in Nay Pyi Taw, Myanmar on 28-29 March 2019, finalized the draft Terms of Reference (TOR) of BGICC.

Figure 18: BIMSTEC - Timeline of key energy related initiatives



3.3.3 Non-Conventional Sources of Energy

In the fourth BIMSTEC Summit Declaration of August 2018[20], BIMSTEC member countries recognized the potential of energy resources in the region, particularly renewable and clean energy sources. The countries also agreed to expedite their efforts to develop a comprehensive plan for energy cooperation by working closely with each other within the region and decided to constitute an intergovernmental group of experts to enhance energy cooperation including in hydro-power and other sources of renewable energy. The countries have also committed to exploring a possibility to establish an Inter-governmental expert group to develop a plan of action for collective response to climate change for the region and to reaffirm commitments to operationalize the Paris Agreement.

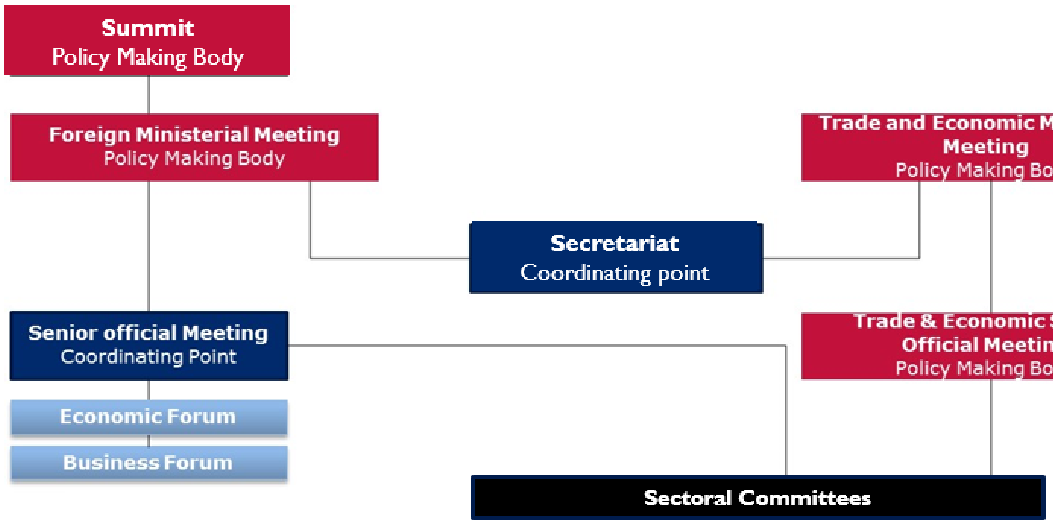
3.4 Structure and Institutional Mechanisms of BIMSTEC

The BIMSTEC declaration provides the following institutional mechanisms:

- Annual Ministerial Meetings, to be hosted by the Member States on the basis of alphabetical rotation;
- Senior Officials Committee, to meet on a regular basis as and when required;
- BIMSTEC Working Group, the lower tier of the BIMSTEC process comprising Ambassadors/Representatives from Member States to carry on the work in between Annual Ministerial Meetings; and
- Specialized Task Forces and other mechanisms as deemed necessary by the senior officials to be coordinated by Member States, as appropriate.

BIMSTEC has been organizing inter-governmental interactions through summits, ministerial meetings, senior officials meetings and expert group meeting. The country holding the chairmanship of BIMSTEC is responsible for the conduct of regular meetings, including the BIMSTEC Summit, Ministerial Meeting, Senior Officials Meeting and BIMSTEC Working Group Meeting. [21]

Figure 19: BIMSTEC institutional structure



The main working mechanism of BIMSTEC is explained below:

BIMSTEC Summit: BIMSTEC Summit is the highest policy making body in the BIMSTEC process. As per the decision of the 6th BIMSTEC Ministerial Meeting held in Thailand on 8th February 2004, the Summit should preferably be held every two years. A total of four meetings have been held till 2018. The first Summit Meeting of the Heads of the BIMSTEC Countries was held in Bangkok, Thailand on 31 July 2004. Nepal held the chairmanship from March 2014 to August 2018. Currently, Sri Lanka has the Chairmanship of BIMSTEC.

Ministerial Meetings: Ministerial Meetings (MM) consists of Foreign Ministerial Meetings and Trade and Economic Affairs Meetings. While the Foreign Ministerial Meeting acts as prime mover determining the overall policy, as well as recommendations for the Leaders' Summit, the Trade/Economic Ministerial Meetings (TEMM) monitors the progress in the Trade and Investment Sector as well as FTA policy.

Trade/Economic Ministerial Meetings (TEMM): The Trade/Economic Ministerial Meetings consists of the Trade/Economic Ministers of the Member States, assisted by the Senior Trade/Economic officials Meeting that provides input to the MMs. TEMMs are mandated to follow up and accelerate the implementation of economic activities.

Senior Officials' Meetings (SOM): The Senior Officials Meetings is divided into the area of foreign affairs (SOM) and the area of trade and economic affairs (STEOM). Permanent secretaries of the foreign affairs and that of trade and economic affairs are the delegations to their respective forum.

The SOM precedes the Ministerial Meeting and is represented by the senior officials of the Foreign Ministries of the Member States at the Foreign Secretary Level. A representative from the Ministry of Commerce/Trade is also inducted in the delegation. The SOM helps the Ministerial Meeting in monitoring and providing overall direction to the BIMSTEC activities. It is therefore the most important policy level organ of the BIMSTEC Grouping reporting ultimately to the Ministerial organ.

Senior Trade/Economic Official's Meetings (STEOM): The Senior Trade/Economic Officials Meeting is an operational body under BIMSTEC comprising of Senior Officials of the Trade/Commerce Ministry of the Member States and representative from Ministry of Foreign Affairs. This meeting precedes the Ministerial Meeting and reports to the TEMM.

Business Forum and Economic Forum: Two forums i.e. Business Forum and Economic Forum under the STEOM has been formed to allow active participation of the private sector. In the Business Forum, private sector representative from the BIMSTEC Member States meet and discuss various issues. Results from the Business Forum will be forwarded to Economic Forum where the private sector private sector have an opportunity to discuss freely with representatives from the public sector from Member States. The Economic Forum then reports the outcomes of its meeting to the STEOM.

Secretariat: Permanent Secretariat of BIMSTEC was established in Dhaka, Bangladesh on 13 September 2014. Secretariat is headed by a Secretary General. Secretariat has five Divisions, each being managed by a Director: (i) Administration and Coordination Division (ii) Cultural Division, iii) Connectivity and Security Division, (iv) Development Division and (v) Social Affairs Division. The Secretariat serves as the main coordinating body for BIMSTEC.

Expert Group Meeting: The Lead Countries of the 13 priority sectors of cooperation and 15 sub-sectors hosts the expert group meeting of their responsible sectors regularly and report the result to SOM.[22]

3.5 BIMSTEC Regional Profile

BIMSTEC region brings together over 1.65 billion people, and a combined GDP of US$ 3.7 trillion. The brief profile of the constituent countries in the BIMSTEC region is presented in following table.

Table 3: BIMSTEC regional profile - 2019

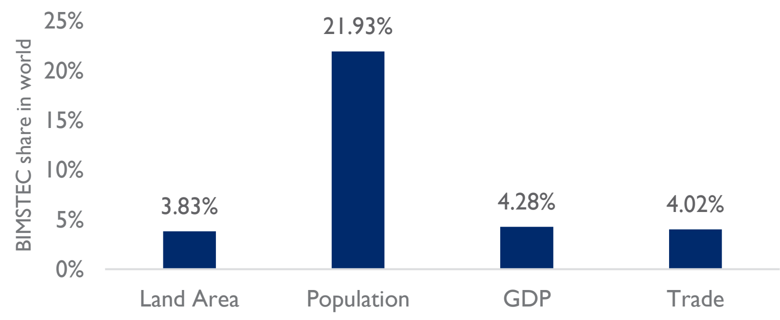
Country	Total land area Square KM	Total population Million	GDP at current prices US$ Billion
Bangladesh	147,570	166	300
Bhutan	38,394	1*	2*
India	3,287,469	1,327	2,695
Myanmar	676,553	53*	76
Nepal	147,181	30	35
Sri Lanka	65,610	22	84
Thailand	513,120	67	522
BIMSTEC	**4,875,897**	**1,665**	**3,714**

** 2018; All other figures related to CY/FY 2019*

Source: Statistical year books and data sources of respective countries, The World Bank [23]

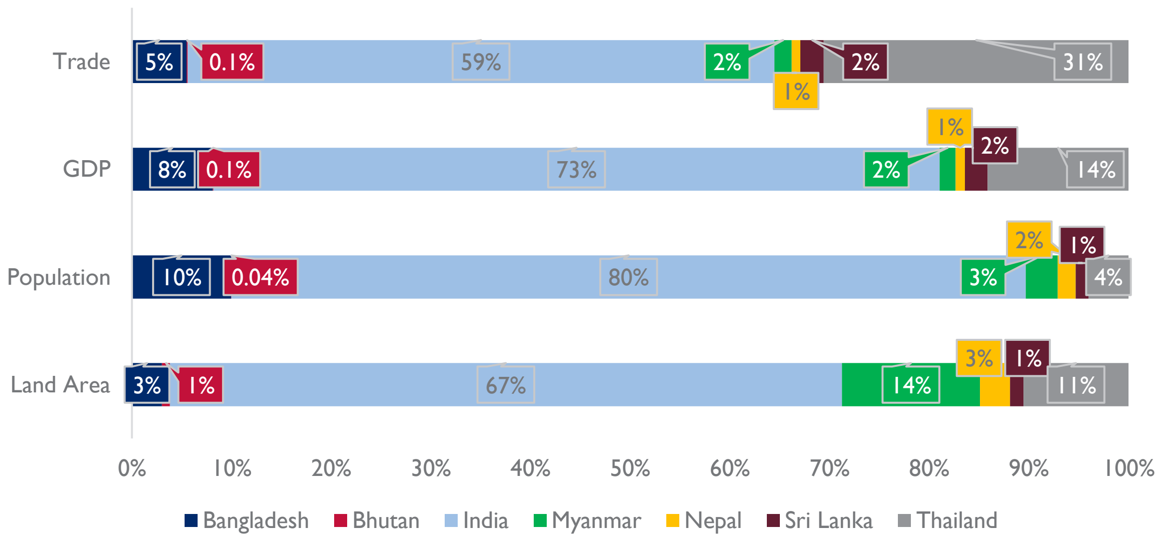
The BIMSTEC region is also significant in terms of its scale globally. Even though the region's share of land area in the world is only 3.8%, the region hosts 21.9% of the world's population, generates 4.3% of world GDP and has a 4% share in global trade. In other words, any positive interventions in the BIMSTEC region in terms of energy or economy has the potential to impact 21.9% of the world's population.

Figure 20: BIMSTEC as % of World



Source: The World Bank [24]

Figure 21: Comparison of BIMSTEC countries



Source: The World Bank [25]

India is the largest country in the region, in terms of geography (67% of the region's area), population (80% of the region's population) and GDP (73% of the region's GDP). Thailand is the second largest in terms of GDP; Myanmar, the second largest in terms of area and Bangladesh the second largest in terms of population in the region.

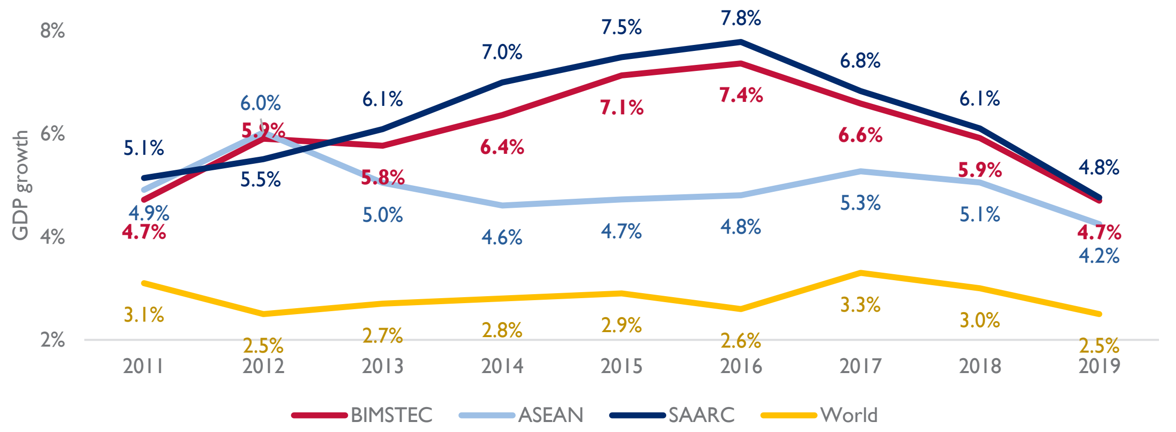
4 BIMSTEC Regional Economic Scenario

4.1 Macroeconomic overview and indicators

In terms of economic growth, BIMSTEC region performed similar to economies in the SAARC region, and better than the world average, over the past decade. Annual GDP growth rate in the BIMSTEC region ranged between 4.7 to 7.4 percentage, which is very close to the SAARC region where it varies from 4.8 to 7.8 percentage respectively. Both regions performed better in comparison to the ASEAN region where the annual GDP growth rate was between 4.2 to 6 percentage. All three regions performed better than the global average economic growth.

Irrespective of the overall performance, the trends in GDP growth in the region is a cause of concern, as the growth rate has been slowing from 2017. The growth rate in BIMSTEC for 2019 is at its lowest in the last nine years.

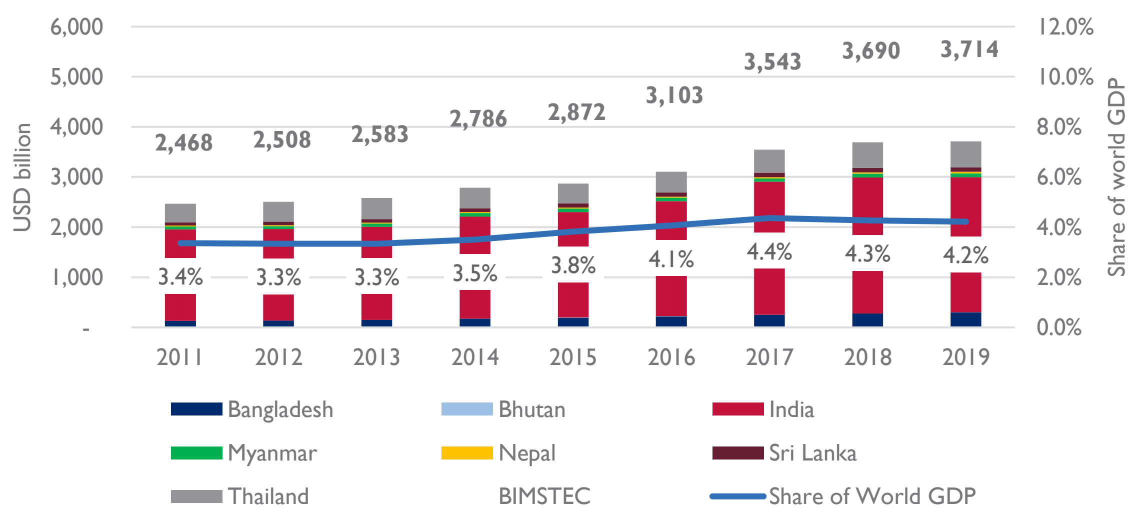
Figure 22: BIMSTEC GDP growth compared to other groupings



Source: The World Bank [26]

Overall, the total GDP (at current price, USD) of the BIMSTEC region was 3.7 Trillion USD in 2019 up from 2.5 Trillion USD in 2011. This makes the grouping's contribution to global GDP at 4.2%, as compared to 3.4% in 2011. India, Thailand and Bangladesh are the top most three economies in terms of GDP in the region. While specific share of countries in total GDP varies, BIMSTEC region countries have succeeded in strengthening their economy in the last five years.

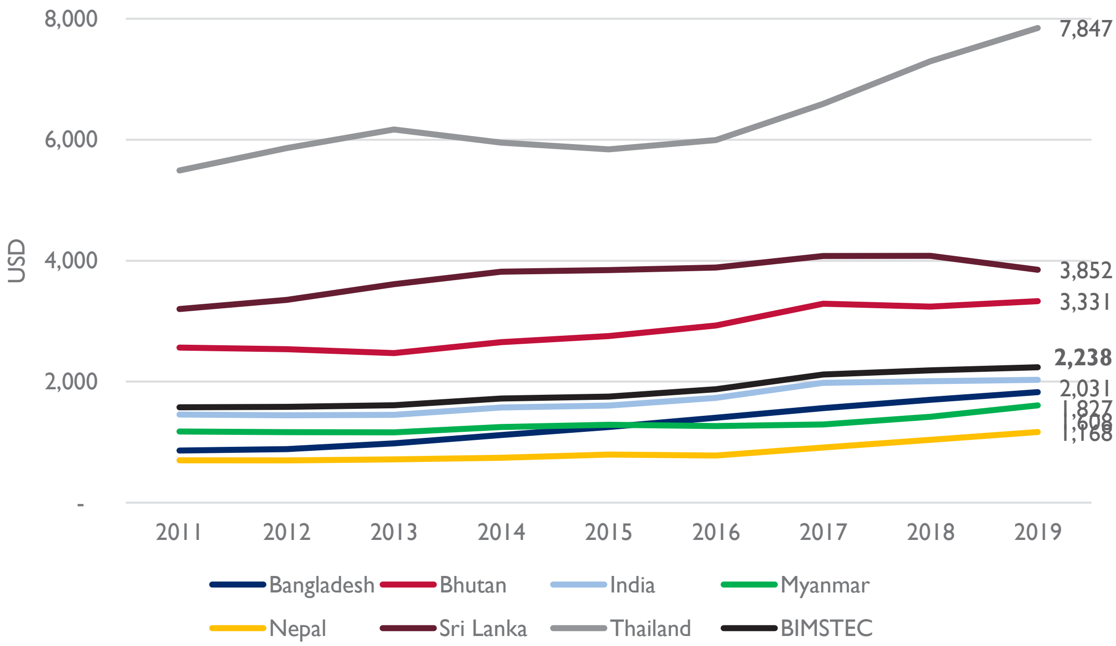
Figure 23: BIMSTEC GDP (Current Price)



Source: The World Bank, Government reports [27]

BIMSTEC countries are in the developing phase. Thailand has the highest per capita income, which is followed by Sri Lanka, Bhutan and India.

Figure 24: BIMSTEC Per-Capita GDP (Current Price)



Source: The World Bank, Government reports [28]

A few key country level economic indicators for 2019 are listed below. Bangladesh is the fastest growing economy (in terms of GDP growth). In 2019, global economy grew at the rate of 2.9 per cent.[29] Four out of seven countries of BIMSTEC region grew at faster rate than this rate.

Table 4: Key Country-level Indicators - 2019

Country	GDP (Current Price) Per Capita	GDP (Constant Price) Growth Rate	Consumer Price Inflation	Average Exchange Rate for National Currency	
	US$	(%)	(%)	Per US$	Local Currency
Bangladesh	1,827	8.13%	5.6%	84.5	Taka
Bhutan	3,331#	3.03%#	2.7%	70.4	Ngultrum
India	2,031	6.80%	7.7%	70.4	Indian Rupee
Myanmar	1,608	2.89%	8.8%	1518.3	Kyat
Nepal	1,168	2.28%	5.6%	112.6	Nepali Rupee
Sri Lanka	3,852	2.30%	3.5%	178.7	Sri Lankan Rupee
Thailand	7,847	3.10%	0.7%	31	Baht
BIMSTEC	**2,238##**	**6.16%###**			

 # - CY/FY 2018; All other figures related to CY/FY 2019
- Weighted average with population as the weight ### - Weighted average with total current GDP as the weight

Source: Statistical year books and data sources of respective countries, The World Bank [30]

The larger GDP growth of countries such as Bangladesh allows them to improve their per-capita GDP also. A consistently good economic growth has resulted in substantial improvement of per-capita GDP in the case of such countries. If regional energy cooperation initiatives can also bring additional growth, the overall economic indicators in the region are also expected to improve substantially.

Between 2011 and 2019, the growth rate of BIMSTEC GDP at current price was 4.5%. If we restrict to the recent period of 2015-2019, this has increased to 6.3%.

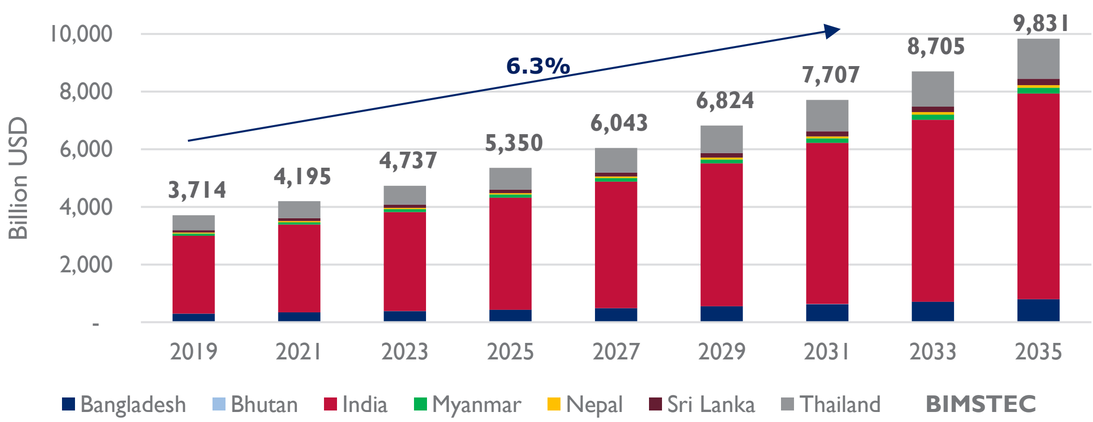
Table 5: Trends in GDP growth, at Current Prices

Country Name	2011-2019	2015-2019
Bangladesh	9.8%	10.0%
Bhutan	3.3%	4.9%
India	4.2%	6.0%
Myanmar	4.0%	5.7%
Nepal	6.6%	10.2%
Sri Lanka	2.3%	0.1%
Thailand	4.6%	7.7%
BIMSTEC	**4.5%**	**6.3%**

Source: The World Bank [31]

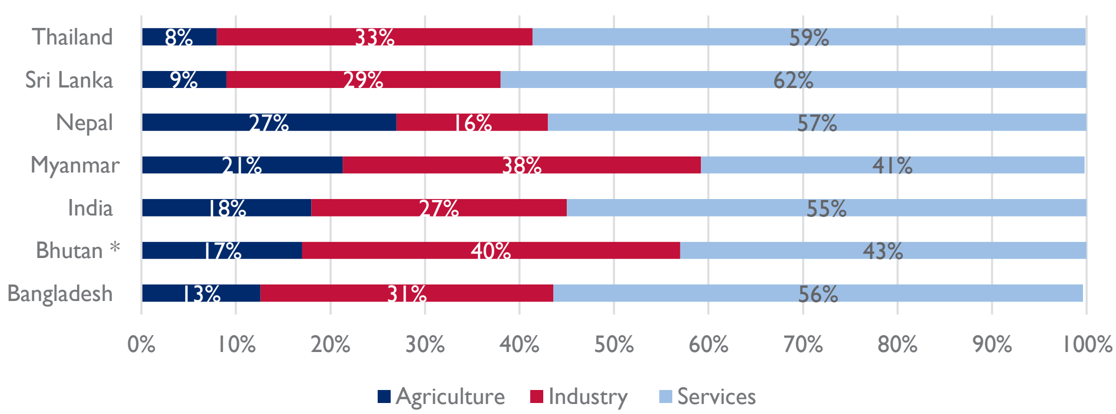
If this rate of 6.3% was taken for the future also, BIMSTEC would have become a 9.8 trillion USD economy by 2035. However, with the impact of COVID and associated aspects, such growth remains uncertain.

Figure 25: GDP (Current price) forecast for BIMSTEC



The current sector-wise breakup of the GDP shows that the service sector contributes over half of the total GDP in the region, with a third coming from industry, and rest being agriculture. Nepal has the highest contribution from the agriculture sector in its GDP while Bhutan's economy has a higher share of industry and Sri Lanka has the highest contribution from the services sector.

Figure 26: Sector-wise GDP breakup, 2019

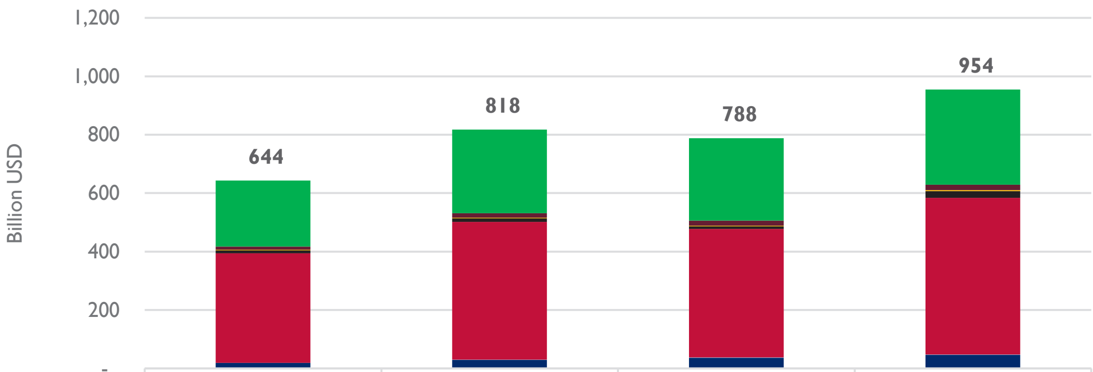


** 2018. All other data for 2019.*   *Source: World Bank* [32]

4.2 Key trade indicators

During 2019, the member countries together had a total merchandise export value of USD 954 billion. The exports have grown by an annual rate of 4.47% between 2010 and 2019.

Figure 27: BIMSTEC exports



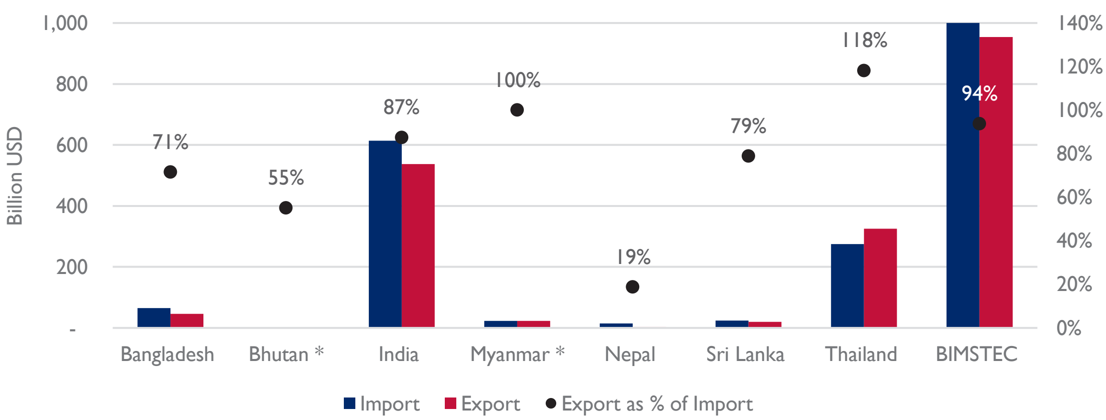
	2010	2013	2016	2019
BIMSTEC	644	818	788	954
Thailand	227	286	282	325
Sri Lanka	11	15	17	19
Nepal	2	2	2	3
Myanmar	10	12	9	23
India	375	472	440	537
Bhutan	1	1	1	1
Bangladesh	18	29	37	46

Bangladesh Bhutan India Myanmar Nepal Sri Lanka Thailand BIMSTEC

** Myanmar and Bhutan – 2018 data used instead of 2019*   *Source: World Bank* [33]

Except for Thailand, all other countries in the BIMSTEC region maintain a trade deficit, and import more than what they export. The exports as % of imports is low in the case of Nepal, Bhutan and Bangladesh. In comparison, the variation between exports and imports is low for countries such as Thailand and India. As a region, BIMSTEC imports more than it exports.

Figure 28: BIMSTEC - Imports and Exports - 2019



** 2018. All other data for 2019.*   *Source: World Bank* [34]

The table below shows further details of the major merchandise trends of BIMSTEC countries. In absolute terms, for both export and import, the top three countries are India, Thailand and Bangladesh respectively. However, when the exports and imports are viewed as relative to GDP, the share of exports in GDP is highest in the case of Thailand and Bhutan, whereas the share of imports in GDP is highest in the case of Bhutan and Thailand. The total exports and imports in the region are 50% of the total GDP.

Table 6: Key trade indicators - 2019

	Exports of goods and services (Billion USD)	Imports of goods and services (Billion USD)	Total trade (current USD)	Exports of goods and services (% of GDP)	Imports of goods and services (% of GDP)	Total Trade (Imports + Exports) (% of GDP)
Bangladesh	46	65	111	15%	21%	37%
Bhutan *	1	1	2	31%	56%	87%
India	537	614	1,151	19%	21%	40%
Myanmar *	23	23	46	30%	30%	61%
Nepal	3	14	17	9%	46%	55%
Sri Lanka	19	25	44	23%	29%	52%
Thailand	325	275	600	60%	51%	110%
BIMSTEC	**954**	**1,017**	**1,971**	**24%**	**26%**	**50%**

** 2018. All other data for 2019. Source: World Bank [35]*

4.3 Investment Trends

Foreign Direct Investment (FDI) and trade are often seen as important catalysts for economic growth in the developing countries. The inflow of investments is considered as a key driver for accelerating the economic growth through employment generation, global capital, global technology transfer, product markets and distribution network. The total FDI inflows to BIMSTEC region in 2019 was USD 60 billion.

The below table compares the flow of FDI across various regions in the world. It can be observed that the share of FDI inflow into the BIMSTEC region is small in comparison to the FDIs to the other regions of the world, particularly the developed nations. BIMSTEC's share in world FDI inflows in 2019 was 4%, compared to 10.4% of ASEAN, and 20.1% of BRICS. However, the region's trade share is higher than that of SAARC / South Asia region (3.7%).

Table 7: FDI Inflows in Select Regional Trade Groupings

Grouping	FDI Inflows (USD Billions) 2018	Share in world FDI (%) 2018	FDI Inflows (USD Billions) 2019	Share in world FDI (%) 2019
ASEAN	148.93	10.0%	155.80	10.4%
BRICS	258.94	17.3%	300.13	20.1%
BIMSTEC	61.41	4.1%	60.01	4.0%
SAARC	49.85	3.3%	55.92	3.7%

Source: UNCTAD [36]

The total FDI inflows to BIMSTEC in 2019 was USD 60 billion as against the FDI outflows of USD 24 billion from the region. India has the largest FDI inflows and outflows, followed by Thailand. The table below provides FDI trends for member countries and contribution to the respective country's GDP.

Table 8: FDI trends in BIMSTEC, 2019

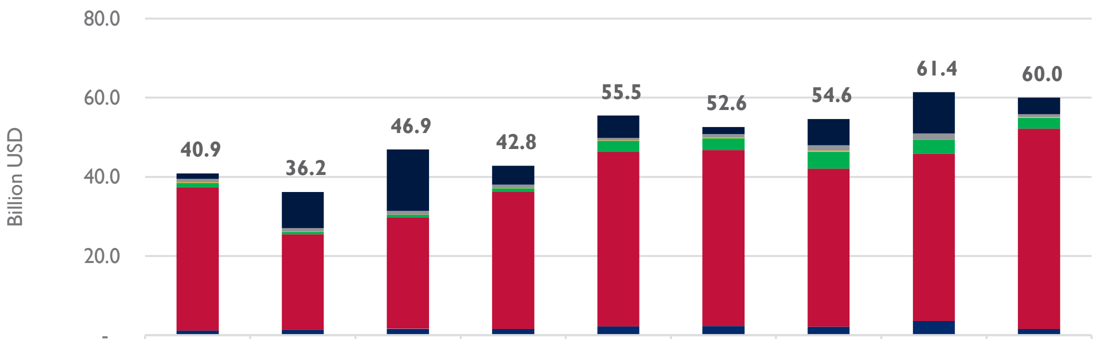
Country	FDI Inflows (USD Billions)	FDI Outflows (USD Billions)	Inflow as % of GDP	Outflow as % of GDP
Bangladesh	1.60	-0.00	0.53%	0.00%
Bhutan	0.01	-	0.29%	0.00%
India	50.55	12.10	1.76%	0.42%

Country	FDI Inflows (USD Billions)	FDI Outflows (USD Billions)	Inflow as % of GDP	Outflow as % of GDP
Myanmar	2.77	-	3.64%	0.00%
Nepal	0.19	-	0.60%	0.00%
Sri Lanka	0.76	0.08	0.90%	0.09%
Thailand	4.15	11.85	0.76%	2.18%
BIMSTEC	**60.01**	**24.03**	**1.53%**	**0.61%**

Source: UNCTAD [37]

In 2019, out of the total FDI inflows to BIMSTEC region, 84% was to India and 7% to Thailand. In the long term, the countries can be observed to have increased the FDI inflows, though when compared year-on-year, there are years when the inflows have also reduced. In fact, there is also no common regional trend within the same year. For example, in 2017, FDI inflows to Thailand increased, whereas FDI inflows to India decreased. In 2019, FDI inflows to India increased, while those to Thailand decreased.

Figure 29: FDI inflows in BIMSTEC



	2011	2012	2013	2014	2015	2016	2017	2018	2019
BIMSTEC	40.9	36.2	46.9	42.8	55.5	52.6	54.6	61.4	60.0
Thailand	1.4	9.1	15.5	4.8	5.6	1.8	6.7	10.4	4.1
Sri Lanka	1.0	0.9	0.9	0.9	0.7	0.9	1.4	1.6	0.8
Nepal	0.1	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.2
Myanmar	1.1	0.5	0.6	0.9	2.8	3.0	4.3	3.6	2.8
India	36.2	24.2	28.2	34.6	44.1	44.5	39.9	42.2	50.6
Bhutan	0.0	0.1	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Bangladesh	1.1	1.3	1.6	1.6	2.2	2.3	2.2	3.6	1.6

Bangladesh Bhutan India Myanmar Nepal Sri Lanka Thailand BIMSTEC

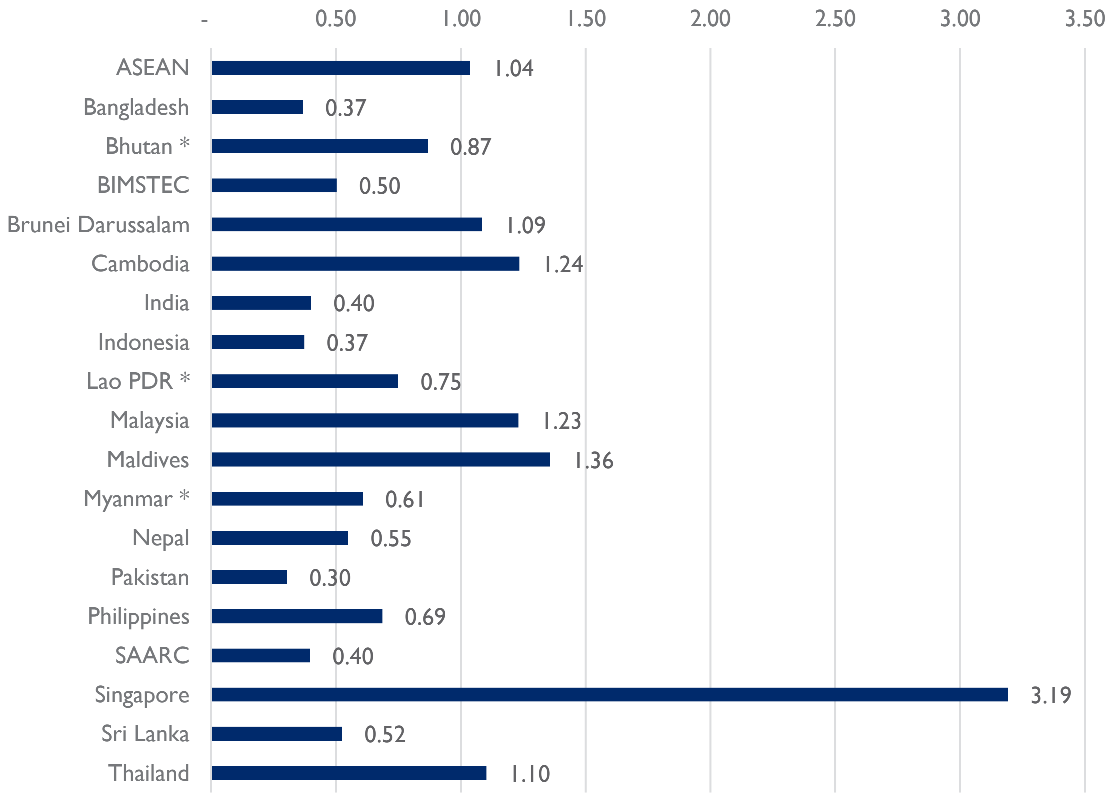
Source: UNCTAD [38]

4.4 Intra-regional trade and investments

Intra-regional trade among BIMSTEC countries are estimated to be only 7% of the global trade.[39] In spite of the low share compared to global trade, BIMSTEC region has still seen a significant boost in the level of trade between its countries as well. The intra-regional trade in BIMSTEC region was 83.90 billion USD in 2017 up from 72 billion USD in 2016 and 37 billion USD in 2014. [40]

The below figure compares the trade dependency ratio of various countries in the South Asian and Southeast Asian countries. This ratio has been arrived at by using the aggregated value of exports, imports as a ratio of GDP. A higher ratio indicates the relative importance of international trade in the economy of a country and also measures the openness of a country to international trade. As shown in the figure, the countries that form the ASEAN region have a higher trade dependency ratio than those that form the BIMSTEC region.

Figure 30: BIMSTEC - Trade Dependency Ratio



** 2018. All other data for 2019.*   *Source: World Bank [41]*

The trade dependency ratio also varies from country to country. Singapore has the highest trade dependency ratio of 3.19 as of 2019. The trade dependency ratio for BIMSTEC region was 0.5 as of 2019.

As most BIMSTEC economies are relatively smaller, there is a limitation to their ability to undertake economic activities that could exploit the substantial economies of scale. However, significant benefits can be derived by the BIMSTEC economies by adjoining and sharing the factors of production and the huge marketplace through preferential trading policies. Investments in the trade bloc would largely depend on governance, transparency, accountability and the predictability of policies, rules and regulations relating to investments, both in the public and private sectors. In order to achieve an increased intra-regional FDI and portfolio investment flow, member countries should further reinforce macroeconomic environments, leading towards liberalising and harmonising their investment regime. Robust native fiscal structures and the deregulation of domestic monetary and capital markets are vital for drawing private investment as well as for intra- regional investment.

A framework agreement on BIMSTEC Free Trade Area was signed in 2004. Till 2018, BIMSTEC's Trade Negotiating Committee (TNC) has held 20 rounds of negotiation to operationalize BIMSTEC Free Trade Area (FTA). However, the process of signing an agreement for BIMSTEC FTA is yet to conclude.

5 Regional Energy Profile

5.1 Resource Potential

The BIMSTEC region is endowed with abundant natural resources comprising of 331 billion tonnes of coal, 718 million tonne of oil, 76 Trillion Cubic Feet (TCF) of natural gas, 11,346 million tonnes of biomass, 386 GW of large hydropower and renewable energy of 1359 GW potential.

Bulk of the hydropower potential is in India, Myanmar, Nepal and Bhutan. India also has the highest coal reserves in the region, and the largest renewable energy (solar and wind) potential. India, Myanmar, Thailand and Bangladesh has substantial gas reserves also. There is also the case of Sri Lanka, where exploration activities are underway for oil and gas fields, and therefore there could be discoveries of proven reserves in the future.

Figure 31: BIMSTEC resource potential

Resources / Country	Coal **(Million Tonnes)**	Oil **(Million Tonnes)**	Gas **(Trillion Cubic Feet)**	Bio-mass# **(MT)**	Hydro **(GW)**	Renewable* **(GW)**
Bangladesh	3,089	8	12	218	-	4
Bhutan	1	-	-	625	41	13
India	372,256	619	49	4,150	145	1,242
Myanmar	544	14	7	3,303	100	61
Nepal	<1	-	-	1,056	83	5
Sri Lanka	-	-	-	156	2	12
Thailand	1,063	77	9	1,838	15	23
BIMSTEC Total	**376,953**	**718**	**76**	**11,346**	**386**	**1,359**

*- Either resource is nil or value less than 0.5; *Solar and Wind; # Forest & Other Wooded Land*

Source: BP Statistical Review, SAARC, Bangladesh Ministry of Petroleum, Investment Board of Nepal, Bhutan Statistical Bureau, Asian Development Bank, Food and Agricultural Organization, Central Electricity Authority, Bangladesh Power Division, Government of Myanmar, NITI Aayog, India Ministry of Power, India Ministry of Statistics and Program Implementation, European Journal of Sustainable Development Research [42]

The diversity in these endowments are as important as the quantum of resources. India has large coal reserves allowing both coal exports, and coal based electricity exports to neighbouring countries. India's large renewable energy potential also offers a chance of energy export to other countries in the region. Similarly, Myanmar's abundance in gas deposits is already being tapped by Thailand. As regional energy cooperation expands, there will be more such opportunities to achieve synergies in resource utilization.

The reserve to production ratios of key resources in the countries are listed below. Coal reserves are expected to last for another 214 years in India (153 years for lignite)[43], and 72 years in Thailand[44]. However, there are concerns on remaining reserves for oil in Thailand, and gas in Bangladesh and Thailand, where these reserve to production ratio is very low. This has an impact on energy transition in the countries. For example, Bangladesh has started import of LNG, which would provide some compensation against the drop in gas production. Thailand already imports gas from Myanmar, while its own gas reserves will be exhausted soon.

Table 9: Reserve to production ratio of key resources

	Resources		
Country	Coal	Oil	Gas
Bangladesh			5.9

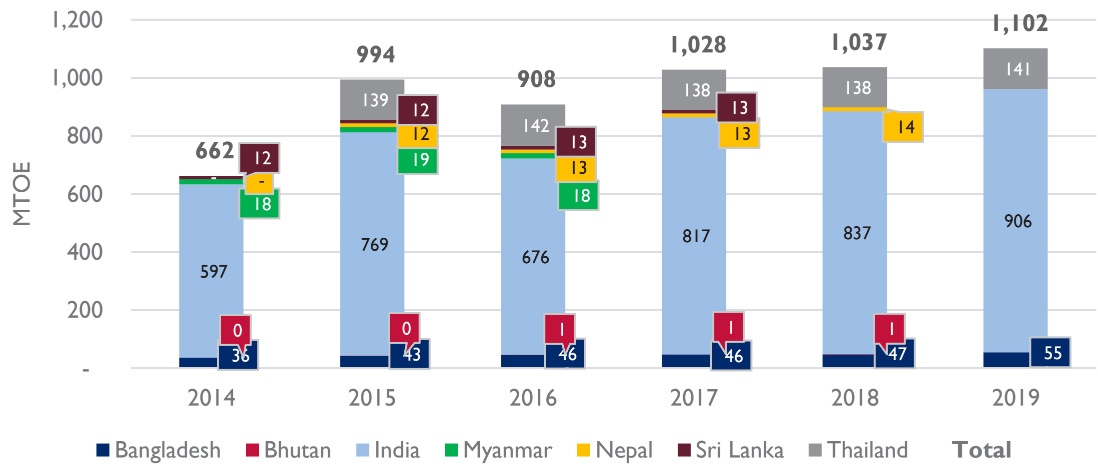
	Resources		
Country	Coal	Oil	Gas
India	214	18	42
Myanmar			65.6
Thailand	72	1.8	5

Source: BP Statistical Review 2019, India Ministry of Statistics and Program Implementation[45]

5.2 Primary Energy Supply

Primary Energy Supply (PES) in the BIMSTEC is primarily dependent on Coal and Oil Products with Hydro and Renewable Energy share also gradually increasing. India has the highest share of total PES amongst all BIMSTEC country members followed by Thailand and Bangladesh. Between 2014 and 2019, the energy supply in the region has grown at an average rate of 10.72%.

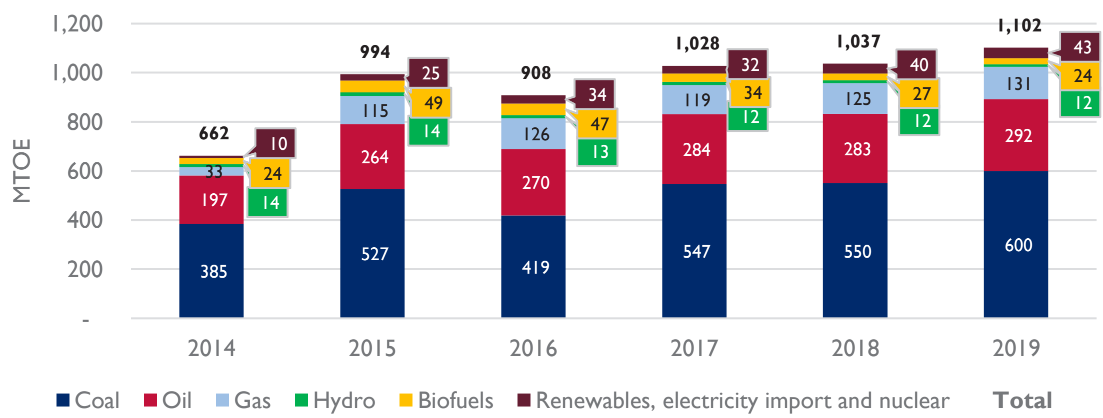
Figure 32: BIMSTEC - Primary energy supply



For some of the countries, as data from government sources is not available for some years, the same have not been included.
Source: Statistical departments of respective governments. Detailed source provided in chapter 5

Coal (54%) and oil (27%) together contributed to 81% of the primary energy supply in the region in 2019. Only biofuels show a downward trend in growth, whereas supply from all other sources have been increasing. If the energy transition, especially in rural areas continue, the use of biofuels and waste for energy requirements may further reduce.

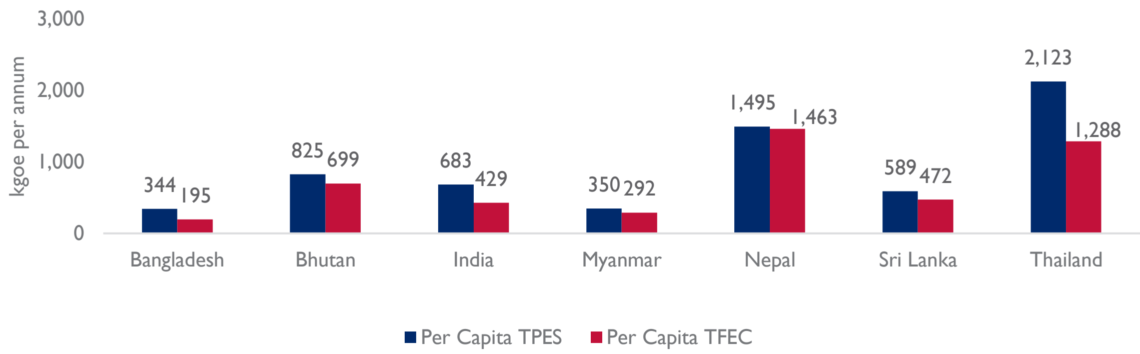
Figure 33: BIMSTEC - Source wise primary energy supply



For some of the countries, as data from government sources is not available for some years, the same have not been included.
Source: Statistical departments of respective governments. Detailed source provided in chapter 5

The per-capita energy supply and consumption details are provided below. The per-capita energy is highest in the case of Thailand and lowest in the case of Bangladesh and Myanmar.

Figure 34: Per capita energy supply and consumption - 2019

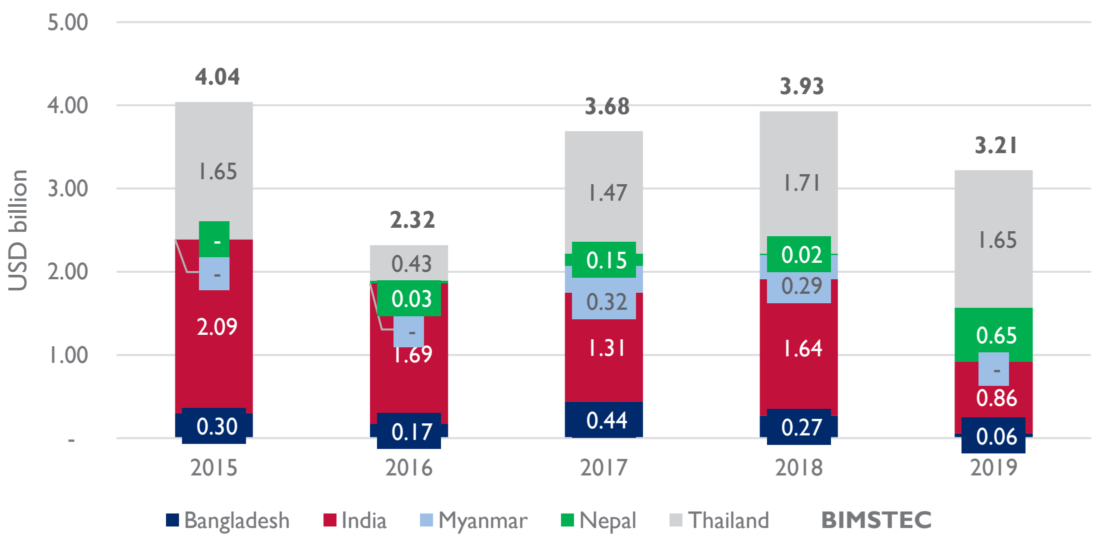


For some of the countries, as data is not available for 2019, latest available data has been used.
Source: Statistical departments of respective governments. Detailed source provided in chapter 5

5.3 Private sector investment

Private sector participation is an important factor in analysing the investment environment in any country. It shows the trust of the private players in the country's growth and certainty with respect to returns. For the energy sector investments in private sector, the following information is available.

Figure 35: BIMSTEC - Energy investments in private sector



Source: World Bank[46]

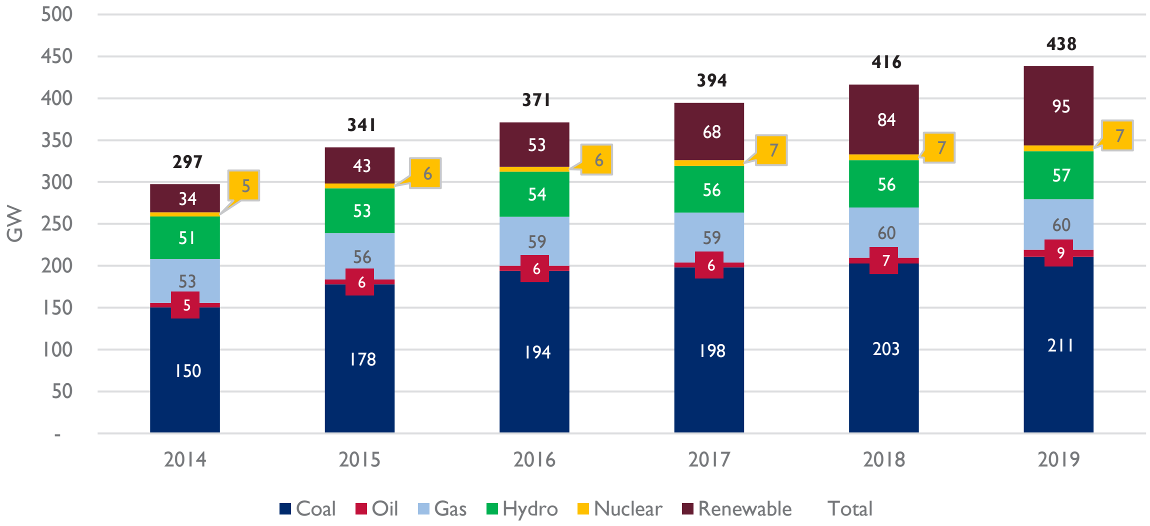
BIMSTEC region attracted private investment in the energy sector to the tune of 2-4 billion USD every year, in the last five years. It totalled approximately 17.1 billion USD between 2015 and 2019, with India and Thailand leading the way. However, these investments form only a small portion of the FDI inflows. The total FDI inflows to BIMSTEC in 2019 was USD 60 billion, as detailed in section 4.3.

The previous illustration on private participation in BIMSTEC shows a fluctuating trend, which could be due to both global and country specific reasons. For example, the drop in investments in 2016 is mainly on account of reduction in investments reported in Thailand.

5.4 Electricity Sector

The installed capacity of electricity in BIMSTEC region increased by 47% between 2014 and 2019, from 297 GW in 2014 to 438 GW in 2019. The CAGR of installed capacity during this period was 8%. The steepest growth rate was for renewables, which increased at a CAGR of 23%. In absolute terms, the highest capacity addition was for coal power plants, where 60.5 GW was added between 2014 and 2019.

Figure 36: BIMSTEC - Growth of electricity capacity

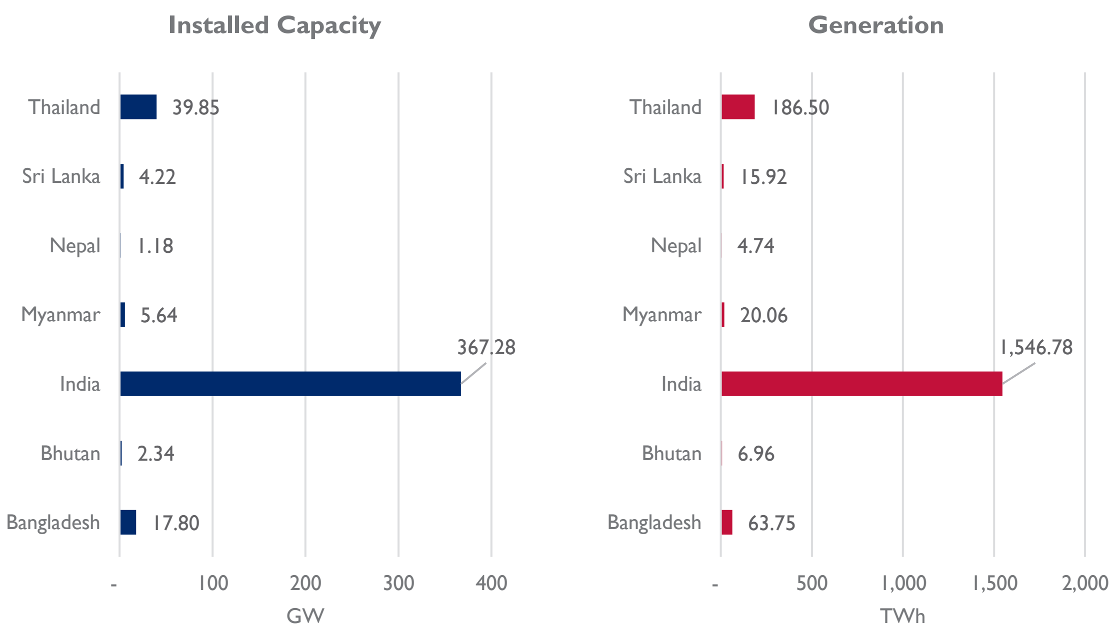


For Myanmar, 2018 values are taken for 2019 also. Import capacities are not considered, to avoid double counting.

Source: Annual reports of respective utilities or ministries

The installed capacity of electricity is highest in the case of India (367 GW), followed by Thailand (40 GW). The share of India and Thailand in total installed capacity in the region is 93%. In terms of generation, India has the largest share of 84% (1547 TWh), followed by Thailand with 10% (187 TWh). Nepal has the lowest installed capacity and lowest generation.

Figure 37: BIMSTEC electricity generation - 2019

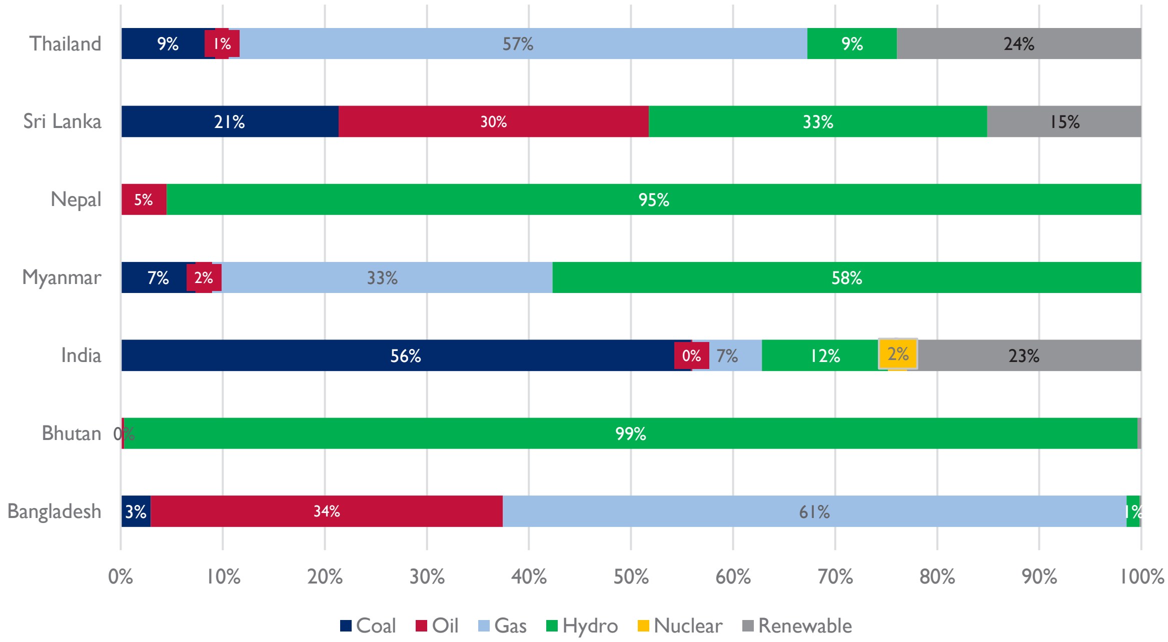


For Myanmar, 2018 values are taken. Import capacities are not considered, to avoid double counting.

Source: Annual reports of respective utilities or ministries

In terms of electricity generation capacity mix, different countries can be seen to have adopted a mix based on their available resources and constraints, leading to a hydro dominated mix for Nepal and Bhutan; coal dominated mix for India, gas dominated mix for Thailand, Bangladesh etc.

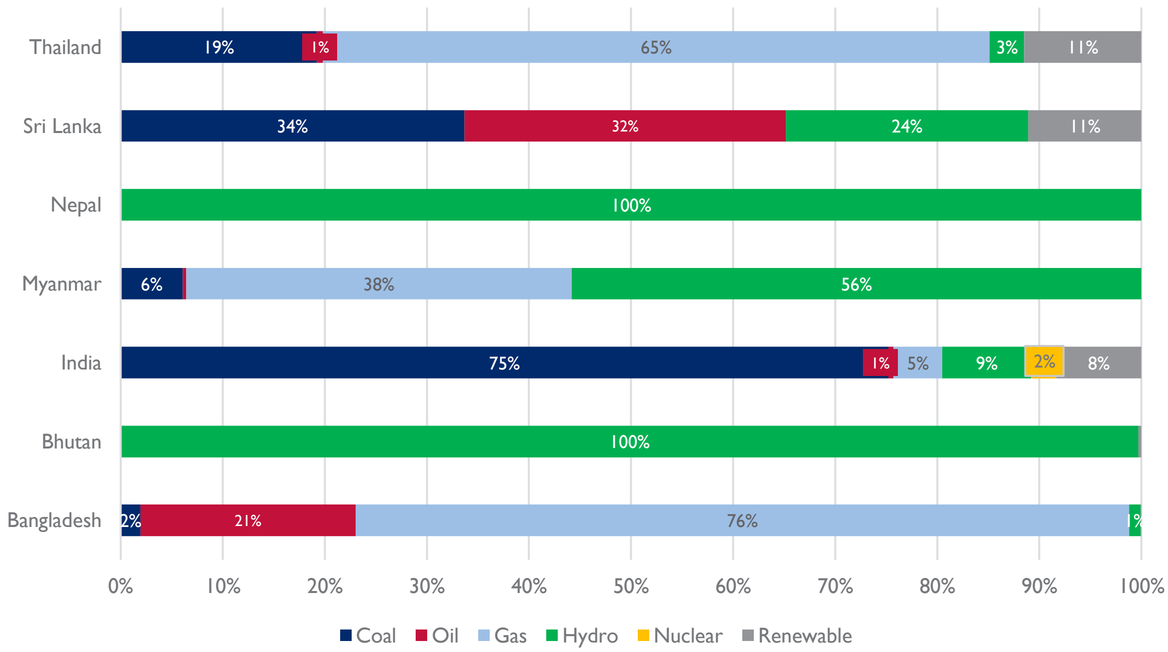
Figure 38: BIMSTEC electricity capacity mix – 2019



For Myanmar, 2018 values are taken. Source: Annual reports of respective utilities or ministries

Trends similar to that of electricity capacity mix can also be observed in electricity generation mix. The resource correlation is more visible here than in capacity mix, with share of predominant resources showing more dominance in the energy numbers than the capacity examples, as can be observed in case of coal in India, hydro in Nepal and Bhutan and gas in Bangladesh and Thailand.

Figure 39: BIMSTEC electricity generation mix - 2019

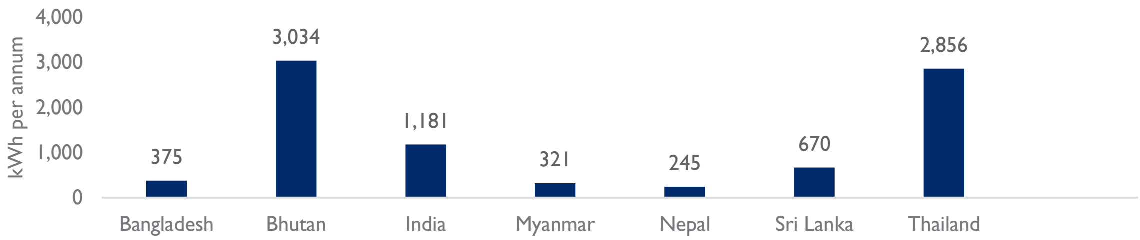


For Myanmar, 2018 values are taken. Source: Annual reports of respective utilities or ministries

There is a wide variation in per capita electricity consumption among BIMSTEC Member States. The per capita consumption of countries such as Thailand and Bhutan are more than twice to that of other countries. Even in case of Thailand and Bhutan, the per capita electricity consumption is still low, if compared to advanced economies such as European Union (6,100 kWh) and USA (12,900 kWh). [47]

BIMSTEC Member states other than Bhutan and Thailand have very low per-capita electricity consumption, and therefore there is substantial potential for improvement in energy supply, thereby improving the economic and social growth.

Figure 40: BIMSTEC Per-capita Electricity Consumption – 2019

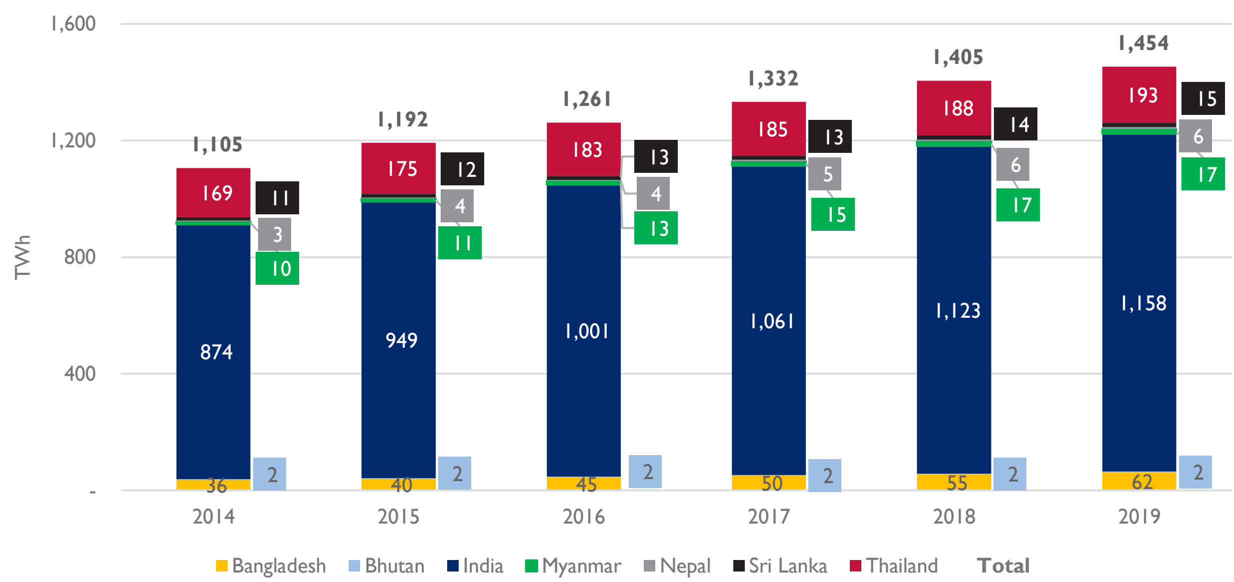


All values pertain to CY/FY 2019 other than Myanmar where 2018 values are used.
Values for Bhutan and Myanmar are calculated from sales and population.

Source: Multiple sources [48]

Bulk of the electricity sales in the region is in India and Thailand. The sales have grown at a CAGR of 5.6% from 2014 to 2019. The growth rate is especially notable in Bangladesh, Myanmar and Nepal, which have grown by an annual rate of more than 10% during the same period.

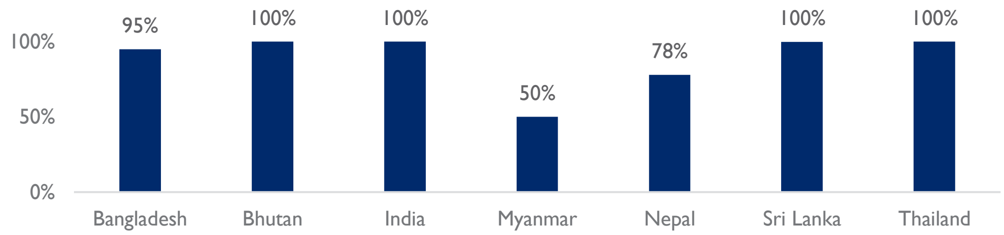
Figure 41: BIMSTEC - Electricity sales



For Sri Lanka and Myanmar, 2018 values are taken for 2019 also. Source: Annual reports of respective utilities or ministries

In terms of Electricity Access, Sri Lanka, India and Thailand has achieved 100% or near to 100% access. Bhutan has also reported 100% access, though the same includes access through off-grid sources.[49] Similarly, Nepal has also reported 78% access.[50] Bangladesh has managed to improve its rural electrification coverage, which stands at 95% as on end of June 2019.[51] Myanmar's electrification ratio stands at 50%.[52]

Figure 42: Electricity Access



Source: Bangladesh Power Development Board, Bhutan Power Corporation, Rural Electrification Corporation, Myanmar office of President, Nepal Electricity Authority, Sri Lanka Ministry of Power, The World Bank[53]

5.5 BIMSTEC framework for regional energy cooperation

In the first BIMSTEC summit held in Bangkok on 31 July 2004, energy was identified as one of the sectors for focussed cooperation. The summit deliberated upon various options and strategies for expanding and strengthening cooperation in energy sector and adopted a Ministerial Declaration in this regard on 04 October 2005. It also approved a Plan of Action to implement the decisions of the Conference.

As part of the Ministerial Declaration, the BIMSTEC Energy Ministers agreed to a vision of electric grid connectivity in the region by developing country-to-country grid inter-connections for ultimately facilitating flow of electricity across the region. The summit also recognized the need for detailed feasibility studies and techno-economic agreements between and among participating countries to allow for the optimal utilization of the natural gas resources of the region.[54]

Thereafter, there have been three key developments relating to regional cooperation in energy sector within BIMSTEC[55]:

1. The Joint Ministerial Statement adopted at the Second BIMSTEC Energy Ministerial Meeting (2nd BEMM) held in Bangkok, Thailand on 05 March 2010 decided to commence a BIMSTEC Grid Interconnection Master Plan Study.
2. On 22 January 2011, the Member States signed the Memorandum of Association (MoA) for the establishment of a BIMSTEC Energy Centre (BEC) in Bengaluru, India.
3. On 31 August 2018, a **Memorandum of Understanding (MoU) for establishment of the BIMSTEC Grid Interconnection** was signed at the Fourth BIMSTEC Summit held in Kathmandu, Nepal.

5.5.1 BIMSTEC Grid Interconnection

The MoU for establishment of BIMSTEC Grid Interconnection[56] provides a broad framework for the BIMSTEC Member States to cooperate towards the implementation of cross border grid interconnections for trade, with a view to promoting rational and optimal power transmission. The MoU also recognizes the need to have a BIMSTEC Grid Interconnection Coordination Committee (BGICC) to actively coordinate for the successful implementation of grid interconnections and trade in electricity.

Table 10: Key contents of MoU for establishment of BIMSTEC Grid Interconnection

Clause	Summary
Article 1: Purpose of the MoU	The purpose of this Memorandum of Understanding (MoU) is to provide a broad framework for the Parties to cooperate towards the **implementation of grid interconnections for the trade in electricity** with a view to promoting rational and optimal power transmission in the BIMSTEC region.
Article 2: Principles and Objectives	The Parties accept that their relationship be based on the following principles: a) Cooperation: The issues related to regional interconnections be handled in a spirit of cooperation and mutual benefit that the Parties have sovereign equal rights and obligations, act in solidarity, and refrain from taking advantage of one another.

Clause	Summary
	Each Party agrees to cooperate and implement the principle set forth in this MOU in accordance with the laws, rules and regulations of the Member States. b) Sustainable Development: The BIMSTEC Trans-Power Exchange and Development Projects be implemented through strengthening of bilateral and intra-regional cooperation within the framework of relevant laws, rules and regulations of the Member States.
Article 3: Institutional Arrangements	The Parties recognize the need to have an appropriate structure referred to as the **BIMSTEC Grid Interconnection Coordination Committee (BGICC)**, to actively coordinate, for successful implementation of grid interconnections and trade in electricity. The BGICC may engage **BIMSTEC Energy Sector Committee of Experts/Officials, Task Force for BIMSTEC Trans-Power Exchange and Development Projects, BIMSTEC Energy Center** and other institutions to provide technical support.
Article 4: Dispute Settlement	The Parties implementing this MOU shall seek amicable resolution through negotiation/consultation if there is any divergence in interpretation or implementation of this MoU. In the event that the divergence continues, it will be referred to BGICC. If BGICC is unable to resolve the differences, that issue shall be referred to the **BIMSTEC Senior Officials' Meeting on Energy** for resolution.

In line with the MoU, the fourth BIMSTEC summit declaration[2] expressed the commitment of Member States in removing barriers to grid interconnections and ensuring early establishment of a BIMSTEC Grid.

> *"Energy*
>
> *15. Recognize the high potentials of energy resources in the region, particularly renewable and clean energy sources, and agree to expedite our efforts to develop a comprehensive plan for energy cooperation by working closely with each other within the region and decide to constitute an intergovernmental group of experts to enhance energy cooperation including in hydro-power and other sources of renewable energy.*
>
> *16. Remain committed to providing uninterrupted and affordable power supply for the economic development of our peoples, including through energy trade; welcome the signing of the Memorandum of Understanding on BIMSTEC Grid Interconnection and instruct the relevant agencies to take concrete measures to **initiate harmonization of technical, planning and operational standards for removing barriers to grid interconnections and also ensure early establishment of a BIMSTEC Grid and call for an early operationalization of the BIMSTEC Energy Centre** in order to strengthen energy cooperation in the region."*

BIMSTEC had envisaged the creation of a BIMSTEC Grid Interconnection Coordination Committee (BGICC) to actively coordinate and represent parties involved in the regional energy trade. In the first meeting of the BIMSTEC Expert Group on Energy which was held in Myanmar on 28-29 March 2019, draft Terms of Reference (TOR) of BGICC was finalized.[3] The commencement of meetings and activities of BGICC in the near future is expected to provide a forum of discussion and coordination on activities related to regional energy cooperation within BIMSTEC.

5.6 Regional cooperation in electricity

BIMSTEC Member States have a long history of bilateral cooperation in electricity sector. There are cross border transmission interconnections and cross border power trade between many of the Member States. In some cases, there is also transmission interconnection and trade with outside the region, such as in the case of Myanmar (with China) and Thailand (Laos, Malaysia).

5.6.1 Electricity interconnections and trade

Within BIMSTEC, power grid interconnections are currently operational between India-Nepal, India-Bangladesh, India-Bhutan and Myanmar-Thailand.

[2] *BIMSTEC, Fourth BIMSTEC Summit Declaration -* https://mofa.gov.np/wp-content/uploads/2018/08/Fourth-BIMSTEC-Summit-Declaration-final.pdf
[3] *BIMSTEC (13 June 2019), The First Meeting of the BIMSTEC Expert Group on Energy -* https://bimstec.org/?event=the-first-meeting-of-the-bimstec-expert-group-on-energy

Table 11: Status of power grid interconnections

Countries	Power grid interconnection	Nature of power trade
India – Nepal	One 400 KV line (currently charged at 220 KV), and multiple lines at 132 KV and lower voltages connected under synchronous mode. This includes: ▪ 400 KV D/c Dhalkebar-Muzzafarpur line (presently it is charged at 220 KV) ▪ 132 KV lines: Kataiya – Duhabi, Raxaul-Parwanipur, Kataiya-Kushaha, Gandak East – Gandak/Surajpura, Tanakpur - Mahendranagar	▪ On an annual net basis, power is imported by Nepal from India. The line can also support export of seasonal surpluses from Nepal to India. ▪ Net export from India to Nepal in April 2019 to March 2020 was 2373 MU.[57]
India – Bangladesh	Primarily connected through an HVDC link. However there is also another AC interconnection at 132 KV. ▪ 400 KV Bheramara – Baharampur HVDC (2x500 MW) ▪ 132 KV Surjyamaninagar - South Comilla AC line	▪ Bangladesh buys power from India under medium and long term PPAs. ▪ Net export from India to Bangladesh in April 2019 to March 2020 was 6988 MU.[58]
India – Bhutan	Multiple lines at 400 KV, 220 KV, 132 KV and lower voltages connected under synchronous mode. This includes: ▪ 400 KV Tala HEP - Siliguri (Two lines) ▪ 400 KV Malbase – Siliguri (LILO of one of the Tala – Siliguri lines) ▪ 400 KV Jigmeling - Alipurduar ▪ 220 KV Chukha HEP – Birpara ▪ 220 KV Malbase - Birpara ▪ 132 KV Geylephu – Salakati ▪ 132 KV Deothang – Rangia	▪ Net export from hydro power plants in Bhutan to India on an annual basis. ▪ However, during dry season when river flows reduce due to low temperature, there is import of power from India. ▪ Net export from Bhutan to India in April 2019 to March 2020 was 6311 MU.[59]
Myanmar – China	▪ 230 KV Shweli I HPP to China ▪ 500 KV Dapein I HPP to China	▪ Export of power from export oriented hydropower plants in Myanmar
Thailand – South East Asia	▪ 500 kV Nam Theun 2 HPP (Lao PDR) - Roi Et 2 (Thailand) ▪ 230 kV Theun Hinboun HPP – Thakhek (Lao PDR) – Nakhon 2 (Thailand) ▪ 230 kV Huoay Ho HPP (Lao PDR) – Ubon 2 (Thailand) ▪ 230kV/500 kV Na Bong (Lao PDR) – Udon 3 (Thailand) ▪ 500 kV Hongsa TPP (Lao PDR) - Nan (Thailand) - Mae Moh 3 (Thailand) ▪ Multiple 115 KV lines with Lao PDR (Laos) and Cambodia ▪ 300 KV Thailand-Malaysia HVDC Interconnection	▪ Import of power from HPPs and a lignite power plant in Laos to Thailand ▪ Power trade with Malaysia and Cambodia

In addition to the above, there is an 11 KV line from India, which supply power to Myanmar's border town of Tamu. However, the quantum of supply is very low, usually limited to a maximum of 3 MW. The amount of power exported between April 2019 to March 2020 was only 8.6 MU.[60] Similarly, Tachileik, a town in Myanmar border is supplied electricity from Chaing Rai in Thailand.[61]

India – Bangladesh

Bangladesh Power Development Board (BPDB) imports power from India through the Indian trading entities PTC India and NTPC Vidyut Vyapar Nigam Ltd. (NVVNL). The supply has commenced from October 2013 after completion of Bheramara (Bangladesh)–Baharampur(India) 400 KV HVDC transmission link between India and Bangladesh. The initial line capacity of 500 MW was later enhanced by adding an additional line, to 1000 MW. There is also a 132 KV transmission line from Tripura in India to Bangladesh, through which nearly 160 MW of power is imported by Bangladesh.

Bhutan – India

Various power plants were developed by Bhutan under Inter-governmental arrangements with India, including 336 MW Chukha HPP, 60 MW Kurichhu HPP, 1020 MW Tala HPP and 750 MW Mandhechu HPP. There is also a 126 MW Dagachhu HPP in Bhutan, which is a PPP with private investment from one of India's private sector generation companies.

The cooperation between India and Bhutan in the Hydropower sector is covered under the 2006 Agreement on Cooperation in Hydropower and the Protocol to the 2006 agreement signed in March, 2009. Under this Protocol, Government of India has agreed to assist Royal Government of Bhutan in developing a minimum of 10,000 MW of hydropower and import the surplus electricity from this to India by the year 2020. Currently, there are two Inter-Governmental (IG) model HPPs - 1200 MW Punatsangchhu-I and 1020 MW Punatsangchhu-II under implementation. The 720 MW Mangdechhu which is also under this protocol has already been commissioned.

In April 2014, an Inter-Governmental Agreement was signed between India and Bhutan for development of four more HEP's of capacity 2120 MW (600 MW Kholongchhu, 180 MW Bunakha, 570 MW Wangchhu and 770 MW Chamkharchhu) under the Joint Venture Model. These projects will have both the JV partners owning 50:50 shareholdings each in the JV- company. Debt-equity ratio would be 70:30, with equity shared equally between JV partners. Further, MEA is providing Druk Green Power Corporation's (Bhutanese) share of equity as grant.[62]

India - Nepal

On February 2016, the 400 KV Dhalkebar (Nepal) - Muzaffarpur (India) was commissioned, though it is charged initially up to 132 KV, and now up to 220 KV due to delay in construction of 400 KV substation. There are also multiple 132 KV cross border lines. The import of power by Nepal from India is under various bilateral treaties / contracts under Government-to-Government mode, and a few commercial PPAs through Indian power traders.

Myanmar - China

Regional energy cooperation in power trade between Myanmar and China is in the nature of establishment of export oriented hydropower projects by China in Myanmar. This includes:

- 600 MW Shweli 1HPP, commissioned in 2009; and
- 240 MW Dapein 1 HPP, commissioned in 2011.

Power from Shweli is evacuated through 230 KV double circuit line, and from Dapein 1 through a 500 KV line, to China's Yunnan province.

There is also a 99 MW Chipwi Nge HPP, developed by China, and commissioned in 2013, which supplies power within Myanmar.

Thailand – South East Asia

The 1075 km Nam Theun 2 HPP in Laos is contracted to supply 995 MW to EGAT's grid in Thailand via the cross-border transmission lines. Similarly, the entire power from 430 MW Theun Hinboun HPP and 150 MW

Huoay Ho HPP is exported to Thailand. There is also a 1875 MW lignite power plant - Hongsa TPP in Laos, which supplies 1473 MW to Thailand.[63]

The Thailand-Malaysia HVDC Interconnection is comprised of two 300 MW converter stations joined by a 110 km long 300 kV DC transmission line. The system provides for exchange of energy and peaking power between the two countries.

The summary of cross border power trade in BIMSTEC is provided below.

Table 12: Cross border power trade in BIMSTEC

Countries	2014	2015	2016	2017	2018	2019	2020*
Bhutan to India	5,555	5,109	5,557	5,864	5,611	4,657	6,311
India to Bangladesh	1,448	3,272	3,654	4,420	4,809	5,690	6,988
India to Myanmar				3	5	7	9
India to Nepal	840	997	1,470	2,021	2,389	2,799	2,373
Myanmar to China	2,532	1,463	1,239	2,381	#	#	#
South East Asia to Thailand	10,193	12,148	18,389	23,321	25,576	22,665	21,779

** India related numbers are for April 2019 – March 2020. Thailand's value for 2020 is prorated based on seven month data. # - Not available*

Source: POSOCO, Government of Myanmar, EPPO[64]

5.6.2 Future plans

Power grid interconnections in BIMSTEC are planned to be strengthened and expanded. A brief profile of the CBET interconnections in the BIMSTEC region that are proposed to be developed is provided below. [65]

1 **India – Bhutan**

- Punatsangchu HEP – Alipurduar 400 KV Double Circuit (D/c): 170 km
- Alipurduar – Siliguri 400 KV D/c line and Kishanganj – Darbhanga 400 KV D/c line

2 **India – Nepal**

- Upgradation of Dhalkebar-Muzzafarpur line to 400 KV (presently charged at 220 KV)
- 400 KV New Butwal-Gorakhpur
- 400 KV evacuation lines for export oriented hydropower plants such as Arun-III and Upper Karnali

3 **India – Bangladesh**

- 765 KV Bornagar (India NER) – Parbotipur (Bangladesh) – Katihar (India ER)

4 **India – Sri Lanka**

- Undersea HVDC cable or overhead transmission line, from Madurai in India to Anuradhapura in Sri Lanka, with a planned capacity of up to 1000 MW

5 **Thailand – Myanmar**

- Thailand and Myanmar had signed a Memorandum of Understanding (MOU) on energy on 4 July 1997 in order to develop a partnership to purchase electricity 1500 MW of electricity from Myanmar. However, the MoU expired in 2010 without any progress on the planned projects.

6 **Bangladesh – Myanmar**

- Cox's Bazar – Myanmar (500 MW).

7 **Thailand - Laos**

- 500 kV Pakse (Lao PDR) – Ubon 3 (Thailand)

- 500 kV Xayaburi HPP (Lao PDR) – Thali – Kon Kaen 4 (Thailand)

8 Myanmar - China

- Depending on the progress of various projects such as Dapein 2 and Shweli 2.

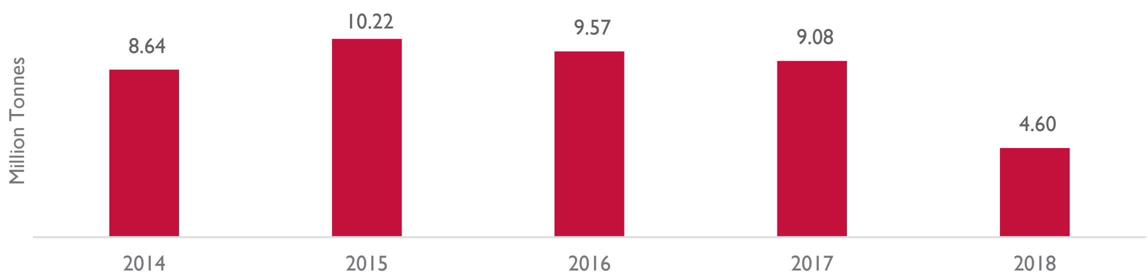
5.7 Regional cooperation in fossil fuel resources

5.7.1 Oil and gas interconnections and trade

In comparison to the power grid interconnections, gas grid interconnections within BIMSTEC are still at a very nascent stage. The only cross border pipelines that are currently operational are the pipelines that supply gas from Myanmar to Thailand and China. These include the following:

4. Pipelines for transfer of gas from Yadana, Yetagun and Zawtika gas fields in Myanmar to Thailand[4].
5. 771 km Myanmar-China gas pipeline, commissioned in 2013, from Madè Island on the west coast of Myanmar to Ruili in the southwestern Chinese province of Yunnan .
6. 793 km Myanmar-China crude oil pipeline, commissioned in 2017, from Ramree Island on the western coast of Myanmar to Ruili in China's Yunnan Province.[66]

Figure 43: Myanmar - Export of gas



Source: Myanmar Statistical Information Service[67]

There is also a petroleum pipeline between Motihari in India and Amlekhgunj in Nepal, which was commissioned in 2019.

5.7.2 Future plans

New cross-border cooperation initiatives are also planned in the oil and gas sectors where initial agreements/MoUs among the countries have been initiated. Some of the key developments in the BIMSTEC region include:

1 India – Bangladesh

The construction of 130 KM India – Bangladesh Friendship Pipeline Project was jointly inaugurated by the Prime Ministers of Bangladesh and India on September 2018. Once completed, the pipeline will transport refined diesel from India to Bangladesh.

2 India – Bangladesh - Myanmar:

India's Oil and Natural Gas Corporation (ONGC) and Bangladesh Petroleum Corporation (BPC) are in talks to build a 6900 km gas pipeline that will link Bangladesh, Myanmar and India's north-eastern states. This pipeline would link Sitwe in Myanmar's Arakan to Mizoram and Tripura in northeast India and Chittagong in Bangladesh. The pipeline would extend to West Bengal on the Indian mainland and Assam and other north-eastern states on the eastern side.

[4] *Petroleum Economist, Gas Exports Up and Running - https://www.petroleum-economist.com/articles/misc/misc/2001/gas-exports-up-and-running*

3 India – Nepal

A Joint Working Group on cooperation in the oil and gas sectors is considering advancing cooperation in areas such as the construction of a LPG pipeline from Motihari to Amlekhgunj and the construction of a natural gas pipeline from Gorakhpur to Sunwal.

5.8 Challenges and opportunities in Regional Energy Cooperation and Cross Border Energy Trade in the BIMSTEC Region

Even though there is a history of regional energy cooperation and CBET within BIMSTEC, the full potential of the same seems to have been not achieved, owing to various barriers and challenges. A few such challenges are described below.

1. Physical connectivity

Within BIMSTEC, the energy trade infrastructure between South Asia and South East Asia remain weak. Between Myanmar and India/Bangladesh, there are no high voltage transmission lines to enable cross border power trade. The power trade infrastructure between Myanmar and Thailand is also yet to be developed, though there are gas pipelines. A more connected grid stretching from Thailand at its eastern most point, to India in the west will enable wider regional energy cooperation and cross border electricity trade efforts within BIMSTEC.

2. Institutional frameworks

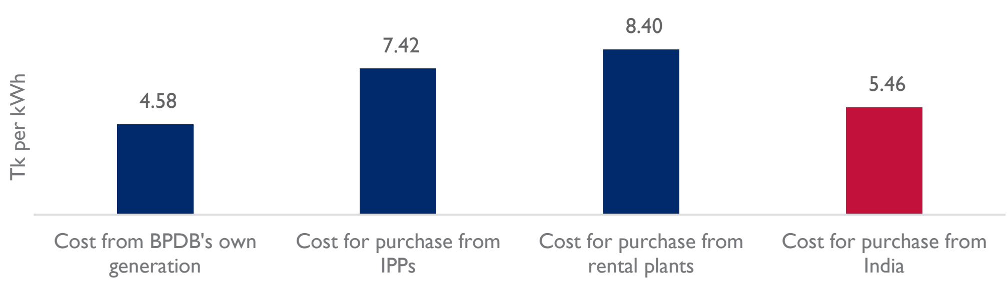
Compared to initiatives such as Greater Mekong Sub region (GMS), and Association of South East Asian Nations (ASEAN), the institutional frameworks for regional energy cooperation have not fully realised their potential in the case of BIMSTEC. For example, ASEAN has a master plan for connectivity, and a plan for ASEAN Power Grid (APG) with identified cross border links to be developed in the future. A similar regional roadmap has not yet been prepared for BIMSTEC. However, the situation is expected to improve and progress with the active intervention of institutional mechanisms such as BIMSTEC Grid Interconnection Coordination Committee (BGICC) in the near future.

However, despite the above challenges, regional energy cooperation and cross border electricity trade (CBET) in BIMSTEC, extending from India to Thailand offers multiple benefits to the BIMSTEC Member States. This includes the following:

1. Access to cheaper and diverse power sources

With CBET, it becomes possible for countries to access cheaper generation sources in neighbouring countries. A case in example is Bangladesh. The cost for import of power from India in FY19 was 26% cheaper than the cost of power purchased from IPPs.

Figure 44: Difference in cost of power purchase from various sources



Source: BPDB[68]

It is also in the interest of energy security and flexibility to have a country's power produced from multiple sources / fuels. Presence of a regional grid allows the countries to access power even from resources that it lacks domestically.

Figure 45: Dominant fuel sources in domestic electricity generation mix of BIMSTEC Member States

Bangladesh	Bhutan	India	Myanmar	Nepal	Sri Lanka	Thailand
Gas	Hydro	Coal	Hydro	Hydro	Hydro	Gas
Oil		Hydro & renewables	Gas		Coal	Coal

Source: IRADe analysis, based on official data on electricity generation by fuel

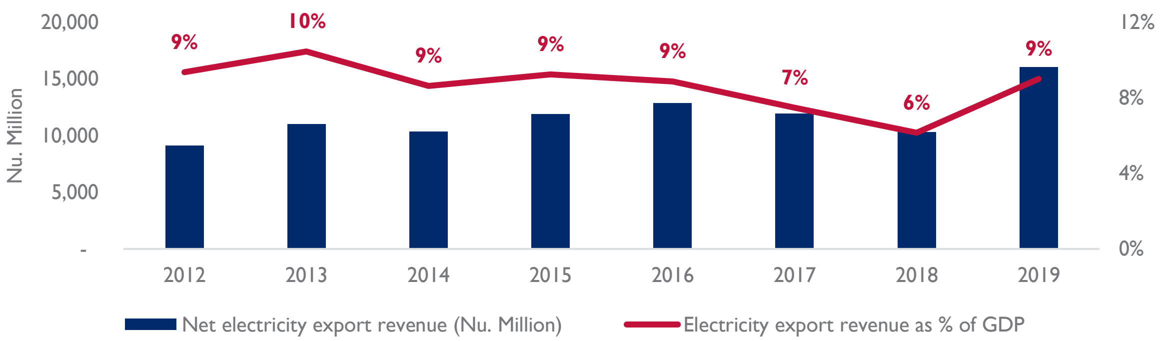
For example, Bangladesh imports power from India's coal power plants, while it lacks its own coal mines. India buys or plans to buy hydropower from large hydro power plants located in Bhutan and Nepal respectively, as it finds difficult to construct new large hydro power plants in its territories due to environmental and social issues. Thailand imports natural gas from the gas fields located in Myanmar, for use in Thailand's power plants.

In future, this could also be extended to supply of cheaper solar power from countries like India to neighbouring countries which have land / geographic limitations that prevent them from installing large solar plants. Another possibility is the use of large hydro reservoirs in hydro rich countries to balance the variability of renewable energy in the region.

2. Foreign exchange revenue and foreign direct investment

Regional energy cooperation allows BIMSTEC Member States with surplus electricity to sell to other Member States that require such energy, in a commercially profitable manner. One of the best illustrations of such a trade is the sale of hydropower from Bhutan to India. Revenue from power exports of Bhutan is estimated to be in the range of 6-10% of its GDP during 2012-2019.

Figure 46: Share of revenue from electricity export in Bhutan's GDP



Source: National Statistics Bureau and Ministry of Economic Affairs, Government of Bhutan [69]

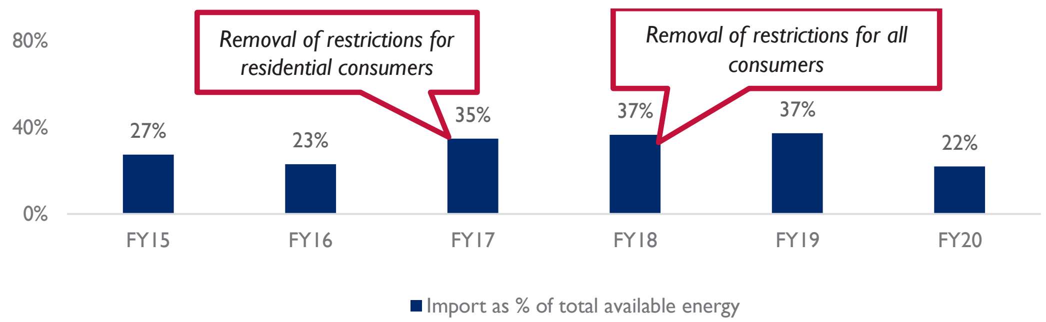
Regional energy cooperation also allows countries to have access to foreign direct investment for developing their generation sources. For example, India is building the 900 MW Arun-III hydropower project in Nepal, which is one of the largest FDI projects in Nepal. Most of the electricity generated from the plant will be exported to India through cross border lines. Such investments in FDI mode also frees up the capital of host countries, which can then be used for alternate purposes.

3. Utilization of surplus generation of one country in another

Countries like Nepal and Bangladesh currently do not have enough generation sources to meet the power demand all-around the year. In comparison, there are countries like India and Bhutan, which has surplus generation sources available. CBET allows trade between surplus to deficit countries, resulting in optimum utilization of generation assets, and availability of electricity to aid the economic growth.

One of the best examples is the case of Nepal wherein increased electricity imports have resulted in withdrawal of electricity load restrictions to all categories of consumers. Till 2017, there were electricity shortages, due to which supply was curtailed for up to four hours every day for all consumers. The commissioning of 400 KV Dhalkebar-Muzaffarpur transmission line on February 2016, though charged at a lower voltage, enabled increase of electricity imports from India. In 2017, the restrictions on residential consumers were removed. During 2018, planned curtailments for all categories of consumers were removed.

Figure 47: Nepal - Electricity import from India

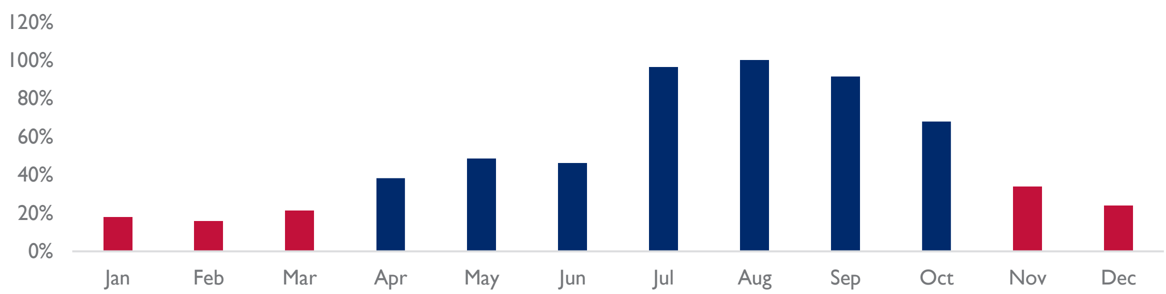


Source: Nepal Electricity Authority[70]

4. Seasonality of generation in hydropower dependent countries

In countries such as Nepal and Bhutan, during winter season the water sources freeze resulting in reduction of generation from hydropower sources. In comparison, in countries such as India, demand is lower in winter season, therefore leaving enough excess generation for trade with hydro dependent countries.

Figure 48: Average PLF of Bhutan's major hydro power plants in 2019



Source: Bhutan Power System Operator[71]

5. Difference in time zones

Due to the difference in time zones, there is a diversity in the exact time of peak demand among the BIMSTEC Member States. This offers the possibility of meeting peak demand with less peak generation capacity coupled with CBET, instead of each country trying to meet peak demand entirely on its own.

Figure 49: Time zones in BIMSTEC

Sri Lanka	India	Nepal	Bangladesh	Bhutan	Myanmar	Thailand
GMT + 5:30	GMT + 5:30	GMT + 5:45	GMT + 6:00	GMT + 6:00	GMT + 6:30	GMT + 7:00

5.9 Regional cooperation in other matters

The BIMSTEC countries can cooperate among each other to identify the emerging renewable energy technologies and policy frameworks relevant in the regional context and leverage domestic learnings from other countries in order to commercialise the renewable energy technologies both for domestic and regional purposes. BIMSTEC countries can learn from each other from various best practices in the area of sustainable hydropower development and various business models associated with it.

The proposed BIMSTEC Energy Center could have played a key role in knowledge sharing, though there has been no substantial progress in its establishment so far. Meanwhile, there have been bilateral initiatives on knowledge sharing within the region. For example, India and Bangladesh signed an agreement on Cooperation in the Peaceful Uses of Nuclear Energy, on 08 April 2017. The agreement envisages cooperation between the countries on various knowledge sharing activities such as:

- Transfer and exchange of knowledge, expertise and technology as appropriate, sharing of resources and experience, training of personnel and capacity building;
- Exchange of operation and maintenance experiences between utilities; and
- Technical training and education.[72]

6 BIMSTEC Country Profiles

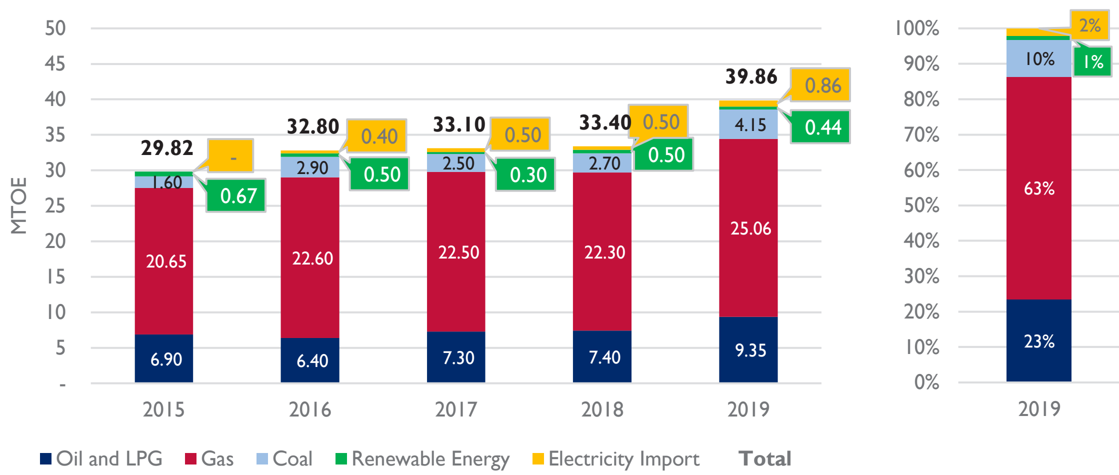
6.1 Bangladesh

Bangladesh is located in the north eastern part of South Asia. The country is bounded by India on the north-west and north-east, with Myanmar (Burma) on the south-east and the Bay of Bengal on the south. The country is spread over a total area of 147,570 square kilometres.[73] The estimated population, as on 2019, is 165.5 million. [74]

6.1.1 Energy consumption and supply trends

Known commercial energy resources in Bangladesh include indigenous natural gas, coal, imported oil, LPG, imported LNG, imported electricity and hydro-electricity. Bangladesh depends mostly on natural gas for meeting its commercial energy requirements. During July 2018 to June 2019, natural gas contributed to 63% of the overall energy mix (25 out of 40 MTOE). The gas is mostly from indigenous production, though there is also a small share of imported LNG.

Figure 50: Bangladesh: Total Primary Energy Supply



** Excluding traditional fuels* *Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources* [75]

It may be noted that, in addition to these commercial sources, traditional biofuels also supply a significant portion of the energy. For example, in 2019, 14.74 MTOE was supplied by these traditional fuels, which if included along with the commercial energy sources, will form 27% of the total energy.

Table 13: Bangladesh - Primary energy in physical terms - 2019

Fuel	Unit	Physical Quantity	MTOE
Oil	K ton	8650	8.65
LPG	K ton	699	0.70
Natural Gas	BCF	964.77	22.37
LNG	BCF	115.89	2.69
Coal (Imported)	K ton	5754	3.64
Coal (Domestic)	K ton	803	0.51
RE (Hydro)	MW	230	0.17
RE (Solar)	MW	368	0.27
Electricity (Import)	MW	1160	0.86

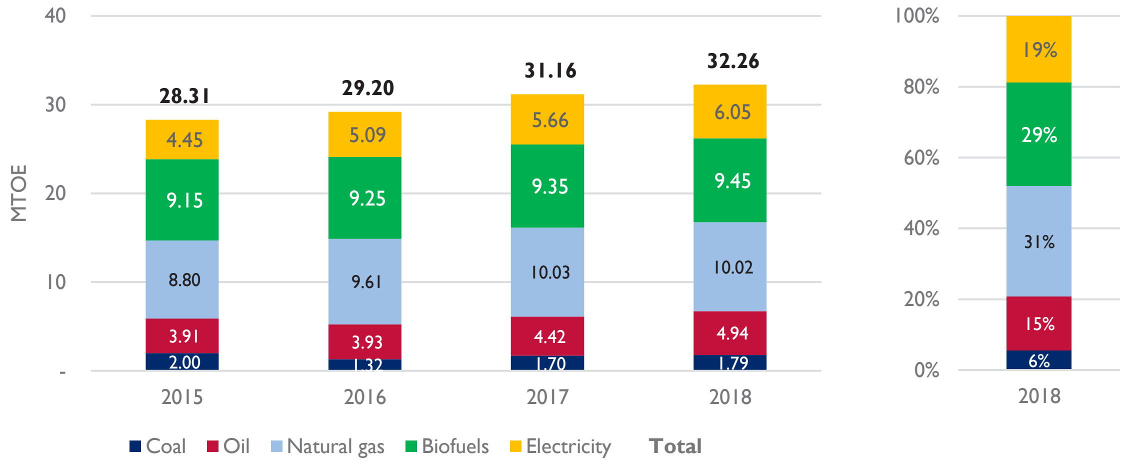
Fuel	Unit	Physical Quantity	MTOE
Total Energy (Excluding traditional fuels)			**39.85**
Traditional biofuels			14.75
Total Primary Energy			**54.60**

Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources [76]

Apart from the domestic production of natural gas, Bangladesh imports coal, LNG and crude oil to meet its energy requirements. To meet the growing demand of electricity, the country is also increasing its bilateral electricity trade with India, and has plans to expand the same with Bhutan and Nepal.

The trends in Total Final Energy Consumption (TFEC) is illustrated below. In the final consumption, the largest share is for natural gas, followed by biofuels and electricity.

Figure 51: Bangladesh - Total Final Energy Consumption



Source: International Energy Agency [77]

Bulk of the energy is consumed by residential sector, followed by industry, and transport sectors.

Figure 52: Bangladesh - TFEC by sector – 2018

Source: International Energy Agency [78]

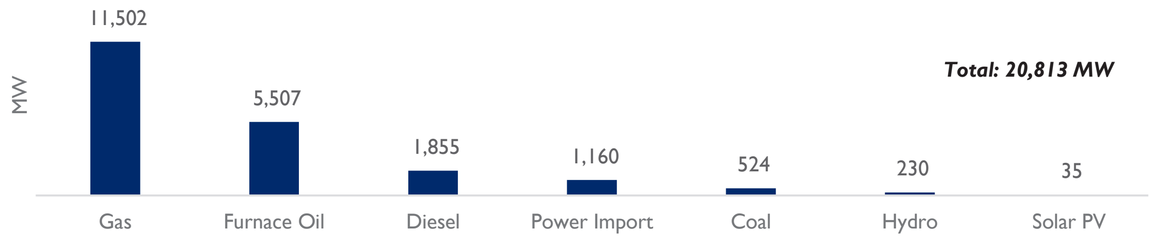
Per capita consumption of energy in Bangladesh is on an average 344 kgoe (Kilogram Oil Equivalent). [79]

6.1.2 Electricity generation

As on September 2020, the total installed capacity of electricity generation in Bangladesh was 20,813 MW inclusive of 1160 MW import from India. The capacity mix is skewed towards gas and furnace oil, which together constitutes 81.7% of the total installed capacity.

Import of power is entirely from India, with almost 1000 MW through Behrampura-Beharampur HVDC link, and rest (160 MW) through a 400 KV link, charged at 132 KV from Tripura in India.

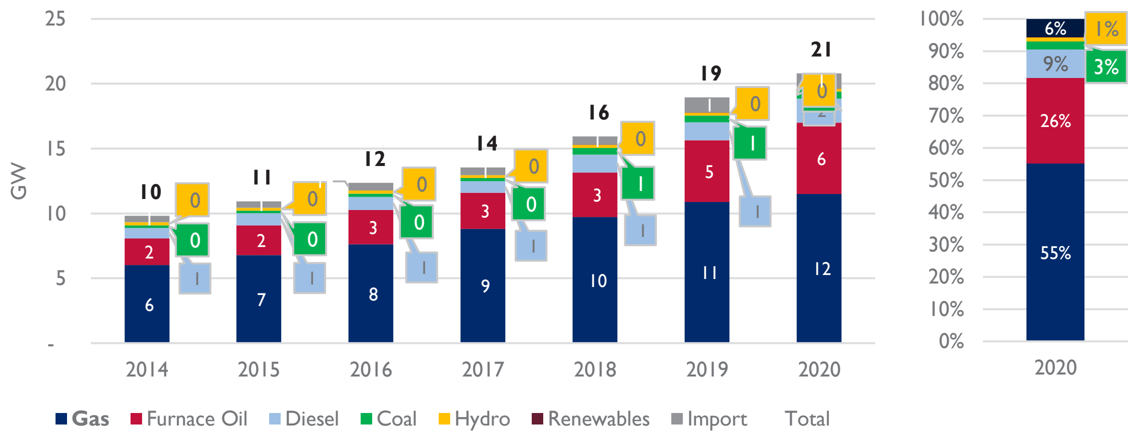
Figure 53: Bangladesh - Electricity installed capacity - 2019



Source: Bangladesh Power Development Board [80]

There has been an impressive achievement in the power sector in Bangladesh in recent years, both in terms of private sector participation and installed capacity addition. The former has grown rapidly over the past few years. The share of private sector, including both large and small independent power producers, has increased from 3% in 2015, to 47% in 2019. The installed capacity has also increased rapidly, and has doubled between 2014 and 2020.

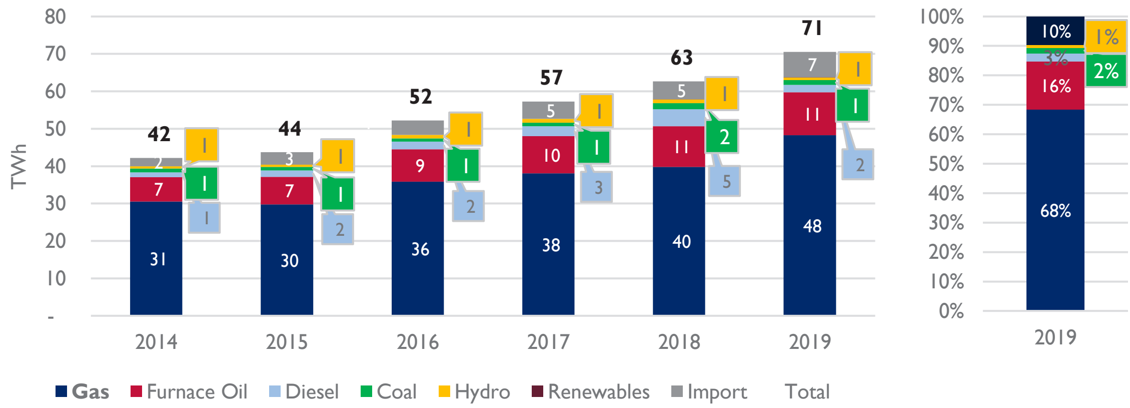
Figure 54: Bangladesh - Electricity installed capacity trend



Source: Bangladesh Power Development Board [81]

In terms of generation mix, bulk of the energy is supplied from gas based power plants. The share of gas has increased in the recent years, along with imported energy.

Figure 55: Bangladesh - Electricity generation mix

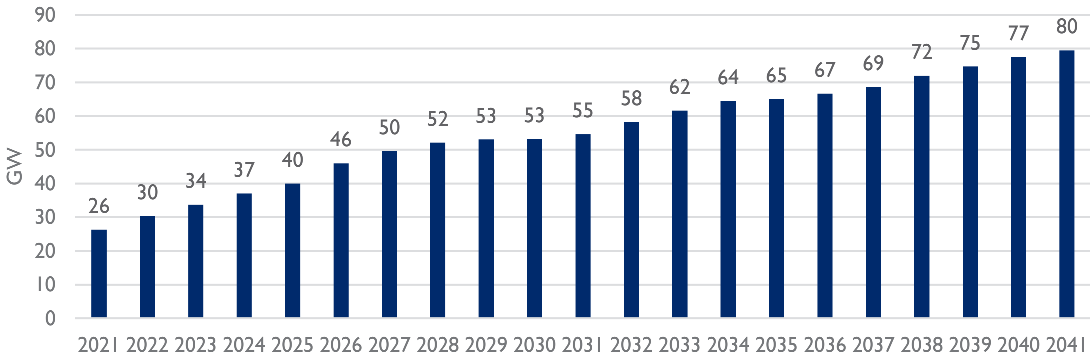


Source: Bangladesh Power Development Board [82]

During FY 2019 (July 2018 – June 2019), the country imported 9.62% of its annual electricity requirement from India. The per-unit generation cost of electricity in 2019 was 5.95 Tk/kWh, which is a decrease from the 6.25 Tk/kWh recorded in 2018. The per-unit fuel cost of public sector plants also decreased from 3.4 Tk/kWh to 1.95 Tk/kWh. [83]

The Power Sector Master Plan (PSMP) targets for generation capacity expansion for 2041 [84] proposes to increase generation capacity to 79,500 MW, including RE capacity of 7,900 MW.

Figure 56: Bangladesh - Generation capacity expansion plans

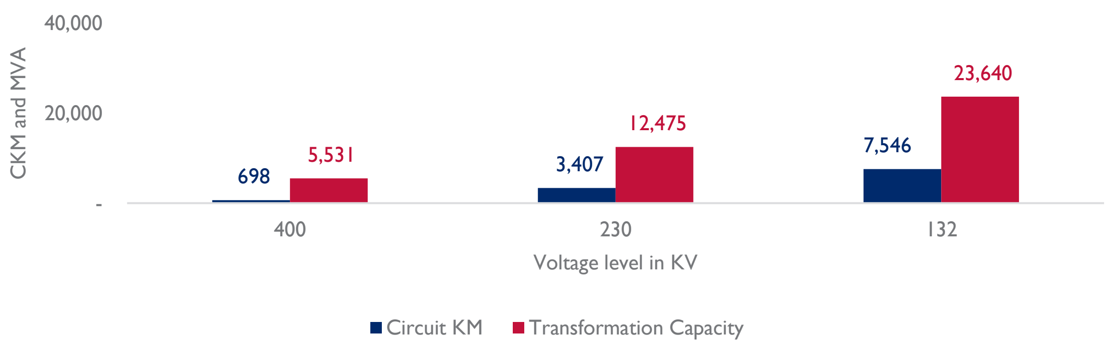


Source: Power Division[85]

6.1.3 Electricity transmission and distribution

The transmission network of the country is built on 400 KV, 230 KV and 132 KV voltage levels. The transmission network includes a 400 KV HVDC interconnection (Behrampur – Behramara), and another 132 KV ac interconnection, with India. The transmission loss recorded in 2019 was 3.15%.

Figure 57: Bangladesh - Electricity transmission network - 2019



Source: Bangladesh Power Development Board [86]

With an objective to meet the growing demand of electricity all across the country, the GOB has plans for upgrading the capacity of existing substations, installing capacitor banks, re-conductoringand second circuit stringing of existing transmission lines. The plan which has a project cost of 110844.36 Lakh BDT, has an estimated duration of project from January, 2020 to June 2023. The scope of work includes the following:

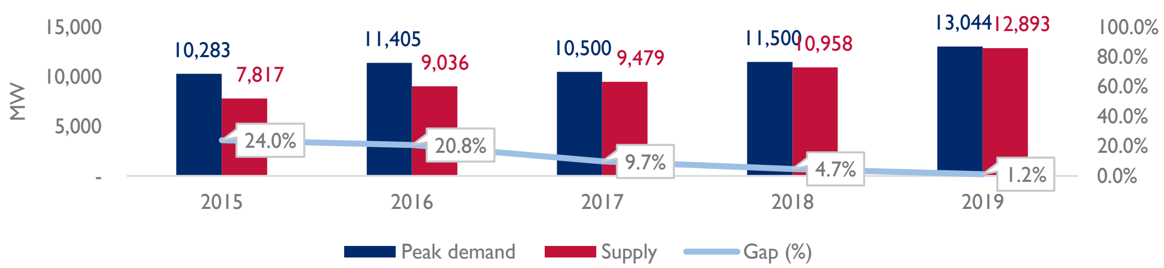
1. Capacity upgradation of existing substations: 18 nos.
2. Capacitor bank at 33 kV.
3. Reconductoring of existing 132 kV transmission line: 199 KM
4. Second circuit stringing of 132 kV transmission lines: 40 KM

5. 132 kV new transmission line: 6 KM. [87]

GoB is also in the process of implementing the 'Dhaka and Western Zone Transmission Grid Expansion Plan' project with an expected delivery by 2025. The project aims to add 7,440 MVA of power transmission capacity and construction of 408 km of transmission lines. The project also aims to reduce total annual power outages to 15 from 60 and reduce transmission loss from 2.76% to 2.5%. It is also expected to result in an annual CO2 emission reduction of 455, 785 tons on an average. The estimated project cost is USD 750 Million.[88]

Peak demand has been increasing at a CAGR of 6.13% between 2015 and 2019, reaching 13,044 MW in 2019. Bangladesh suffers from supply shortages. During FY 2019, 53 Million kWh of electricity could not be served due to various reasons, which was 8.54% of annual electricity sales. However, this is a marked improvement from previous years. The overall demand shortfall has come down from 24% in 2015 to 1.2% in 2019. The country has also managed to improve its rural electrification coverage, which stands at 95% as on end of June 2019. [89]

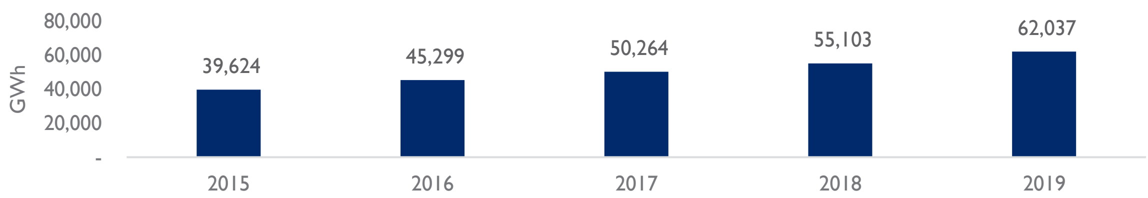
Figure 58: Bangladesh - Demand and supply



Source: Bangladesh Power Development Board [90]

The sales have been growing, recording a CAGR of 11.86% between 2015 and 2019.

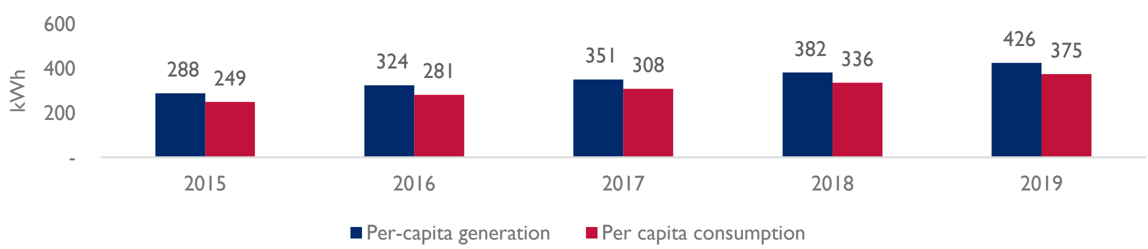
Figure 59: Bangladesh – Electricity sales



Source: Bangladesh Power Development Board [91]

The per-capita electricity generation and consumption has substantially increased in the recent years, reaching 426 kWh and 375 kWh respectively in 2019. The CAGR for per-capita electricity generation and consumption, between 2015 and 2019 were 10.3% and 10.7% respectively.

Figure 60: Bangladesh - Per capita electricity generation and consumption



Source: Bangladesh Power Development Board [92]

6.1.4 Energy resources and potential

Commercial energy in Bangladesh includes natural gas, imported oil, coal, hydro and solar energy. Bangladesh had good deposit of natural gas, most of which have, however, been exhausted. There has not been any discovery of new gas fields in Bangladesh in the recent past. The resource-wise potential for Bangladesh is shown here.

Table 14: Bangladesh - Energy resource potential

Resource	*Natural gas*	*Oil*	Coal
Unit	TCF	Million barrels	Million Tonnes
Total recoverable reserves	**28.69**	**56.9**	**31,00**
Production till June 2019	16.93	NA*	10.75
Remaining reserves	11.76	56.9	30,89

** Current production is condensate, which is not related to the discovered reserves.*

Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources, IAEA [93]

Gas

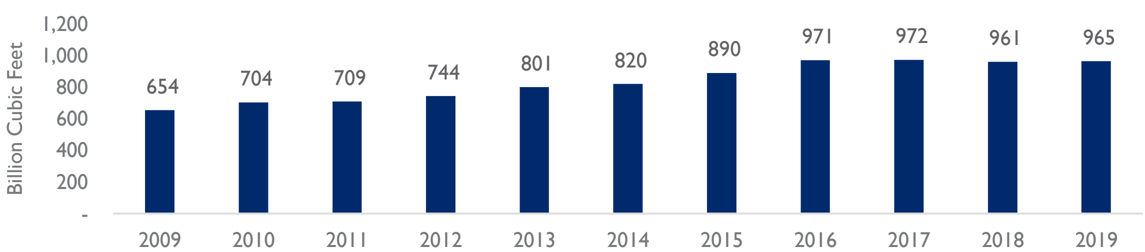
The main energy resource production of Bangladesh is natural gas. Since the first discovery in 1955, to 2019, 25 gas fields in the onshore and 2 in the offshore have been discovered in the country. Out of these, 20 onshore gas fields are in production. One offshore gas field has depleted after 14 years of production while the other offshore field has not been viable for production due to small reserve.

The natural gas reserves in Bangladesh have been depleting, with no new gas discoveries in the recent past. Bangladesh has a limited availability of indigenous hydrocarbon resources and faces challenges in the form of natural gas depletion. It has been estimated that Bangladesh's natural gas reserves will begin to deplete if no new gas reserves are discovered or if technology does not allow a higher rate of extraction from existing gas fields.

Most of the gas that is currently produced is utilized for power production. In 2019, 58% of the gas (564 BCF out of 965 BCF) was utilized for power production, the remaining being used for sectors such as fertilizer, industries, and CNG.

As the gas supply is inadequate, Bangladesh has also started importing LNG. In 2019, 116 billion cubic feet of LNG was imported.

Figure 61: Bangladesh - Natural gas production



Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources [94]

To address the gas crisis, two LNG floating storage and regasification units (FSRU) have been commissioned, which enables procuring LNG from international markets. There are also plans for constructing an onshore LNG import terminal, for which expressions of interest were invited in 2019. One floating LNG terminal has already been installed in Maheshkhali in Cox's Bazar district with a daily capacity of 500 mmcf.

Natural gas has made tremendous contribution towards industrial growth in the country as fuel for heating and captive power generation at very favourable price. In addition, about 7% of the population have directly been benefitted by using piped natural gas for household purposes. Compressed Natural Gas (CNG) is being used as automobile fuel by about 300,000 motor vehicles in the country. Expansion of CNG facilities has been reported to have dramatically improved air quality in large cities such as Dhaka. [95]

Oil

Bangladesh does not produce any substantial crude oil. However, it produces a small amount of condensate, which is only 6% of the total liquid fuel consumption. Bangladesh also produces a small amount of LPG. However, mostly these resources are imported. In 2019, 94% of petroleum requirement and 97% of LPG demand was met from imports.

Table 15: Bangladesh - Import dependence for petroleum and LPG - 2019

Parameter	Petroleum	LPG
Production, Tons	523,123	19,228
Import, Tons	8,158,532	681,036
Total Supply, Tons	8,681,655	700,264
Import as % of supply	94%	97%

Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources [96]

There is only one petroleum refinery in the country. Naptha is exported from Bangladesh, to other countries. In 2019, 36,513 MT of naptha was exported.

As per national energy policy, 60 days stock of petroleum products is required to be maintained for energy security of the country.

Coal

According to the Bangladesh Power System Master Plan 2016 (PSMP-2016) report, the country has reserves of bituminous coal, known as Godwin coal, spread across five coal fields situated between the River Jamuna and the River Padma in the north western part of Bangladesh. The measured and probable coal reserves total 3.3 billion tonnes, while 884 million tonnes of reserves have been identified. Coal in Bangladesh is generally characterised as having a low ash and sulphur content, which is favourable to the environment. By 2030, the share of coal in the overall generation mix will increase from the current levels of 4 per cent to approximately 50 per cent. Almost 43 per cent of the coal generation capacity will be based on imported coal. The country will thus have to explore import options as domestic resources will be inadequate to meet its energy requirements by 2030.

In Bangladesh, the reserve of coal (Bituminous Coal) is about 31,00 million tonnes. Though coal is also produced, 88% of the coal demand was met through imports.

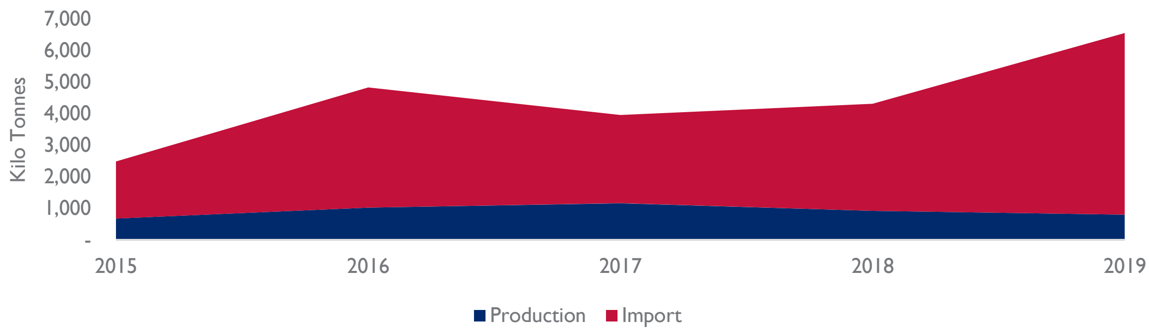
Table 16: Bangladesh - Import dependence for coal - 2019

Parameter	Coal
Production, Tons	803000
Import, Tons	5,754000
Total Supply, Tons	6,557000
Import as % of supply	88%

Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources [97]

The trend in coal productions is illustrated below.

Figure 62: Bangladesh - Coal production and imports

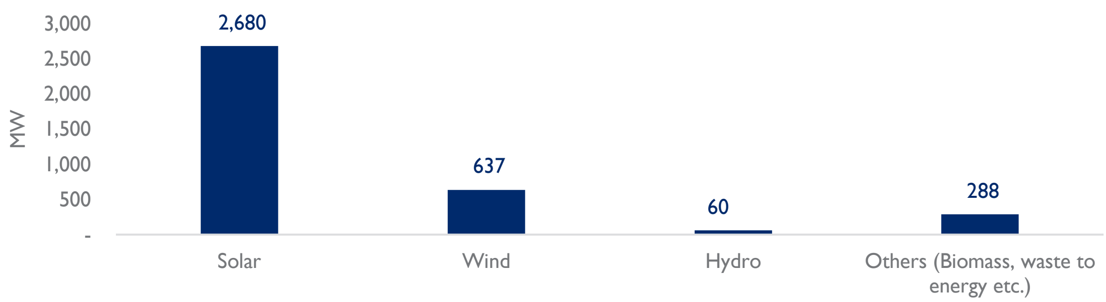


Source: Hydrocarbon Unit, Ministry of Power, Energy and Mineral Resources [98]

Renewable energy

While the share of renewable energy in Bangladesh's electricity sector has not been significant so far, it may be noted that there is substantial estimates of such resource potential in the country. As per the Power System Master Plan of 2016, the country has renewable energy potential of 3.67 GW.

Figure 63: Bangladesh - RE potential



Source: Power Division[99]

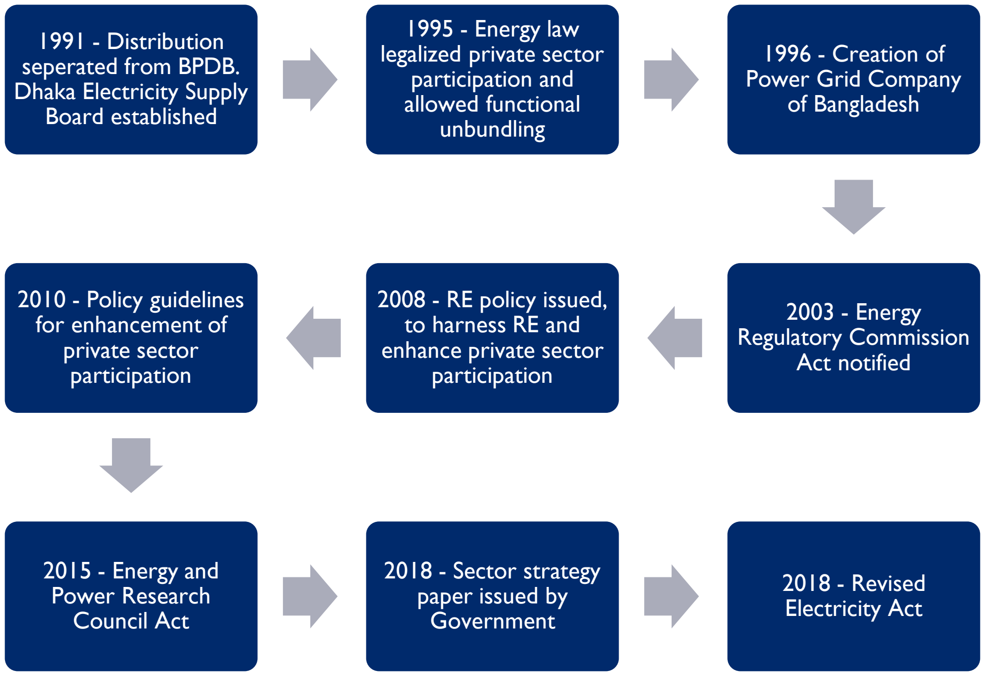
The assessed hydropower potential in Bangladesh that can be economically exploited is limited. The Karnafuli Hydropower Station, with a capacity of 230 MW, is the only major hydropower plant in the country. It is operated by the Bangladesh Power Development Board (BPDB) and there are plans to increase its capacity to 330 MW. Due to the country's flat terrain and potentially large social and environmental impacts, the scope of hydropower generation is limited to small-scale hydro (mostly in the hilly regions of the northeast and southeast parts). PSMP-2016 recognises the regional hydro potential.

6.1.5 Energy transition and reforms

Reforms and restructuring

Bangladesh has undergone significant market reform measures in the past, especially in terms of unbundling of vertically integrated utilities and establishment of independent regulatory commission. To improve the electrification rate across the country, particularly the rural areas, the Government constituted the Bangladesh Rural Electrification Board (REB) in 1978. The decision to open up the sector for private sector participation was taken in 1985 when the GoB liberalised the sector by excluding it from the reserved category. However, private sector participation was only legalised in 1995 under a new energy policy, which also allowed for the functional separation—generation, transmission and distribution—of the integrated utility.

Figure 64: Bangladesh - Sector reforms



In 1996, the GoB took the initiative of splitting the transmission segment and formed the Power Grid Company of Bangladesh (PGCB). PGCB has taken over the transmission assets from BPDP fully and is responsible for the construction of all new transmission assets. In 1998, the Power Division was established under the Ministry of Power, Energy and Mineral Resources (MPEMR); it has been entrusted with the responsibility of the overall management of the power sector in Bangladesh. Subsequently, the Bangladesh Energy Regulatory Commission (BERC) was established on March 13, 2003, through a legislative Act of the Government to regulate the gas, electricity and petroleum products of the country. In April 2004, the Regulatory Commission was established. There have been notable changes in the electricity sector pattern as a result of this restructuring.

Currently, the focus is on reform of the Bangladesh Power Development Board, by moving to strategic business unit (SBU) model for BPDB's generation and distribution functions.

Some of the other reforms are discussed in Government's Sector Strategy Paper of March 2018:[100]

- Adopt a comprehensive National Energy Policy;
- Develop legal framework for the National Load Dispatch Centre (NLDC);
- Develop laws and rules for the improvement of power quality;
- Develop regulations on periodical maintenance of power plants;
- Develop rules and systems for Demand Side Management; and
- Develop an enabling framework for private sector investment.

Masterplans

The major energy sector outlook and plans of the country are outlined in the Power Sector Master Plan (PSMP). The PSMP targets for 2041 currently include:[101]

- Increasing per-capita electricity consumption to 2100 kWh;
- Generation capacity of 79,500 MW, including RE capacity of 7,900 MW; and
- Electricity import of up to 12,000 MW.

The 2030 targets under Nationally Determined Contribution includes the following:

- 100% of new coal based power plants to use super-critical technology;
- 400 MW of wind generating capacity;
- 1000 MW of utility-scale solar power plant;
- 10% energy consumption reduction in the industry sector compared to the business as usual; and
- 25% reduction of overall energy consumption of the commercial sector compared to the business as usual.

Climate Policy

As per its NDC, Bangladesh is projected to achieve a reduction of 15% in emissions leading up to 2030 in comparison to BAU scenario in a conditional contribution scenario. This is to be achieved by a range of targets in power, transport, and the industry (energy-related) sector.

In the power sector, Bangladesh aims to achieve 400 MW of wind generation and 1000 MW of utility-scale solar power plants by 2030. A range of measures are to be implemented. In the transport sector, it aims to achieve a shift in passenger traffic from road to rail of up to around 20% and a 15% improvement in the efficiency of vehicles due to more efficient running.

Lastly, it aims to achieve a 10% energy consumption reduction in the industry sector compared to the BAU. The energy efficiency and conservation master plan up to 2030 has initiatives such as Energy Efficiency (EE) labelling programme, EE building programme, and Energy Efficiency & Conservation (EE&C) finance programme which are key drivers for EE programs in Bangladesh.[102]

Smart grids

A smart grid pilot project is being undertaken by Dhaka Power Distribution Company (DPDC) with funding support from Agence Française de Développement (AFD). The smart grid technology will be deployed in the field and in five substations, with the following features:

- Distribution management system (DMS) in the control room;
- Substation modernization and automation (SAS);
- Feeder automation by deploying intelligent field devices;
- Distribution transformer monitor; and
- Redundant telecommunication infrastructure to assure reliable smart grid operation.

Electric vehicles

In the electric vehicle space, there is already a large number of electric three wheelers, mainly in rural areas, running on cheaper electric technology. However, supporting ecosystem for modern deployment of electric vehicles are yet to commence.

Energy efficiency

For energy efficiency and DSM, the Government has published an 'Energy Efficiency and Conservation Master Plan up to 2030' in 2015, which discusses strategies such as building codes, appliance labelling, industry energy efficiency improvement programs, subsidies and low-interest loans. The Energy Efficiency and Conservation Master Plan 2015 provides the roadmap for the several energy efficiency programmes and initiatives that are proposed to be taken up. These include:

- Energy Efficiency (EE) labelling programme: EE rating for home appliances, manufacturing of EE products.

- EE building programme: Compliance with the new version of the Bangladesh National Building Code; developing Green Building Guidelines.
- Energy Efficiency & Conservation (EE&C) finance programme: Subsidy and low interest rates for EE&C investment.

Efficient energy end-use has emerged as a viable option to sustain economic growth, even as a gas shortage continues in Bangladesh. The textiles and the steel re-rolling sectors hold the greatest opportunity for savings. There have been several initiatives, supported by multilateral donor agencies, targeted at specific segments such as the LED tube light project in a ready-made garments (RMG) factory under the Energy Services Company (ESCO) model; the promotion of improved rice parboiling systems (IRPS) for rice mills and so on. The initiatives for the residential segment include the compact fluorescent lamp (CFL) distribution programme of BPDB, solar powered security lighting in urban buildings and the replacement of diesel/electric pumps by solar irrigation pumps.

6.1.6 Institutional framework

The institutional framework of the Bangladesh energy sector is headed by Ministry of Power, Energy and Mineral Resources (MoPEMR), which is responsible for the overall planning, development and management of the different types of commercial energy resources and the overall power supply value chain. It also formulates power sector policies.

BPDB is responsible for the generation and distribution of electricity, mainly in the urban areas. The Planning & Development (P&D) division within BPDB is in charge of the overall power system planning and procurement for the country. The division is also in charge of procurement planning, covering the quantum of power purchase, catering to base and peak load demands, grid support and so on.

The generation sector is open to private sector participation and Bangladesh has several independent power producers (IPPs). The country has one transmission utility, namely, the Power Grid Company of Bangladesh Ltd (PGCB), which is responsible for the transmission network, its operation & maintenance (O&M) and development. The country has five distribution companies (discoms)—BPDB, the Dhaka Power Distribution Company (DPDC), the Dhaka Electricity Supply Company (DESCO), the West Zone Power Distribution Company Ltd (WZPDCL) and the Rural Electrification Board (REB)—which own and operate the country's distribution network and supply electricity to the end users.

The power sector of Bangladesh is primarily governed by the Electricity Act 1910 and the Bangladesh Electricity Regulatory Commission Act 2003. The Bangladesh Energy Regulatory Commission (BERC) was created under the BERC Act 2003. It is an independent commission with a mandate to regulate the energy sector (gas, electricity and petroleum products) in Bangladesh, including the fixing of electricity tariffs, pricing of gas and petroleum products, and drafting of regulations, codes and standards.

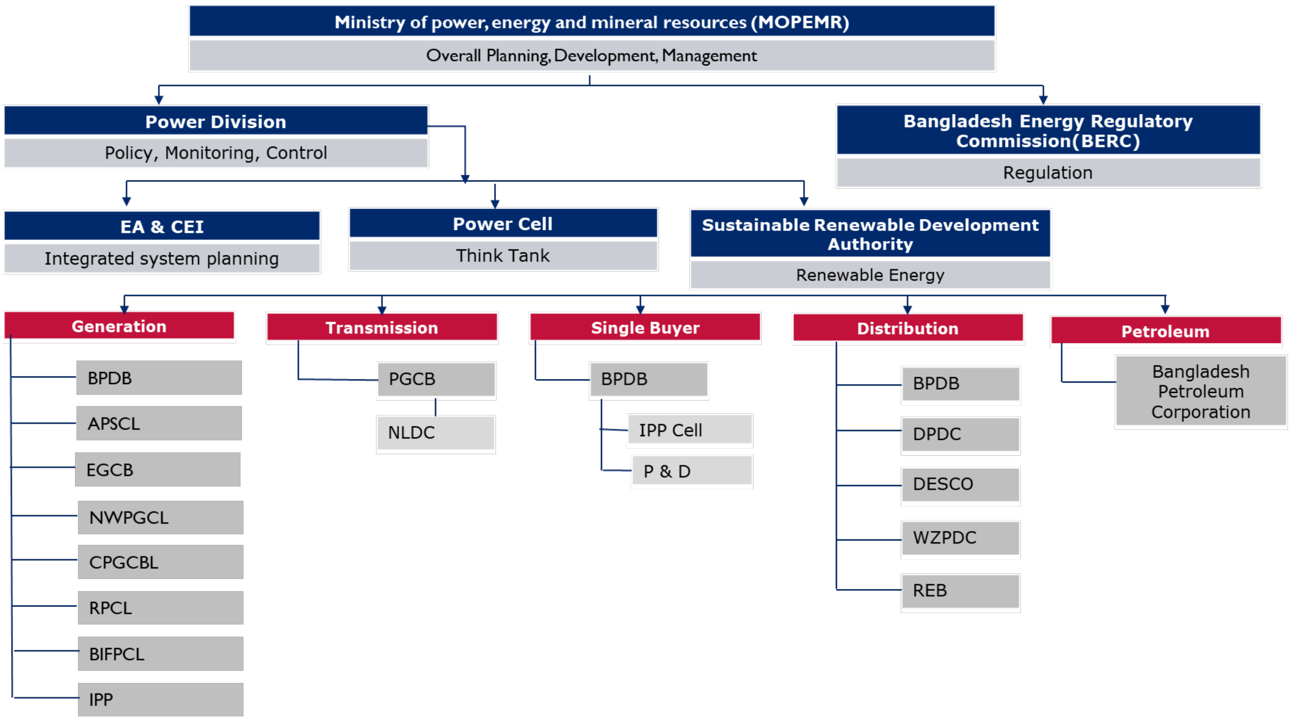
The Bangladesh power sector operates under a single buyer model. BPDB acts as the single buyer of the electricity generated in Bangladesh and it sells bulk electricity to all the distribution utilities. There is no separate power trading entity and this role is being performed by BPDB. To put research and development of power and energy sector into a fast lane, the government of Bangladesh has enacted the Bangladesh Energy & Electricity Research Council Act, 2015 and formed the Bangladesh Energy and Power Research Council (EPRC). The main purposes of the council to coordinate practical and implementable research works in power and energy sector through finding and motivation, identifying the potential areas for energy diversification, conducting research works to implement long term plan, inventing new technologies and to incorporate local and international experts into the research activities of EPRC.

For promoting renewable energy, the government of Bangladesh has enacted the Sustainable& Renewable Energy Development Authority (SREDA) Act, 2012 and has formed SREDA .

The Government issued policy guidelines in 2008 to promote private sector participation in the Bangladesh power sector. These guidelines aim at encouraging competition and enhancing public-private-partnership in the power sector. One of its objectives is that the transmission and distribution lines of PGCB and distribution licensees should provide access to their system on a non-discriminatory basis for the availing of power produced by the commercial power plants, existing as well as new.

All key decisions related to regional energy cooperation are taken at the level of Ministry of Power, Energy and Mineral Resources (MoPEMR). In case of cross border electricity trade, the role of Power Division, Bangladesh Power Development Board (single buyer) and Power Grid Company of Bangladesh (transmission utility) will be crucial. All these entities are under the ultimate control of MoPEMR. In case of cross border petroleum pipelines, operational aspects are expected to be managed by the Bangladesh Petroleum Corporation, which already operates the domestic oil pipelines.

Figure 65: Bangladesh - Institutional framework



Source: Ministry of Power, Energy and Mineral Resources[103]

6.2 Bhutan

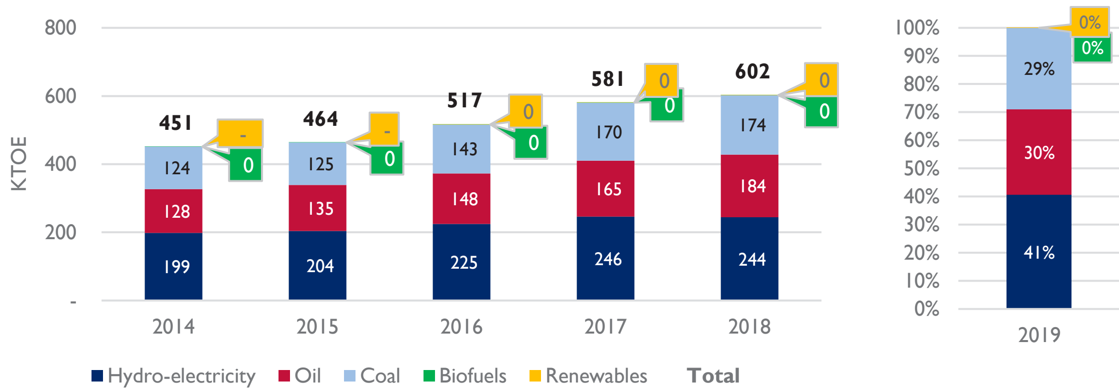
Bhutan is a small and landlocked country, situated between China and India. It has an area of 38,394 square kilometers. It has east-west dimension (longest) stretching around 300 kilometers and 170 kilometers at its maximum north-south dimension. Bhutan is located in the eastern Himalayas and is mostly mountainous and heavily forested.

Bhutan shares 470 kilometers long border with Tibet (China's Xizang Autonomous Region) in the north and northwest, 605 kilometers with the Indian state of Sikkim in the west, West Bengal in the southwest, Assam in the south and southeast, and Arunachal Pradesh in the east. About 70 percent of the country is covered with forests; 7 percent with year-round snow and glaciers; nearly 3 percent is cultivated or agriculture areas; and 4 percent as meadows and pastures, while rest of the land is either barren, rocky or scrubland. The administrative system in the country consists of Central Government and Local Government.[104]

6.2.1 Energy consumption and supply trends

Bhutan's primary energy supply from commercial sources is dominated by electricity, produced from hydropower plants (41%, 2018), followed by oil (30%, 2018) and coal (29%, 2018). The energy supply has increased at a CAGR of 7.5% between 2014 and 2018. It may be noted that in addition to commercial sources, there is a substantial share of energy supplied and met from traditional biofuels and bio waste, which is not captured in the list of commercial energy sources. A study report of Department of Renewable Energy estimated the share of traditional biofuels in the energy supply mix as 235 KTOE, 36% in 2014. [105]

Figure 66: Bhutan - Total Primary Energy Supply from commercial sources



Source: National Statistics Bureau [106]

The primary energy in physical terms is summarized below.

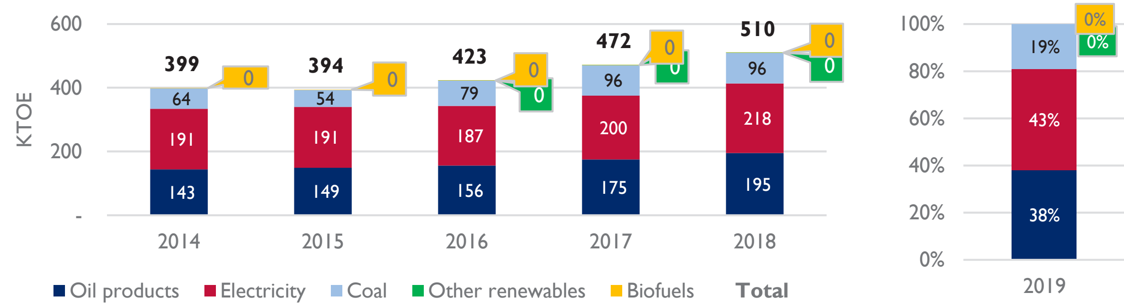
Table 17: Bhutan - Primary energy in physical terms - 2018

Fuel	Unit	Physical Quantity	KTOE
Hydro-electricity	GWh	6594	567
Oil	MT	0	0
Coal	MT	186,824	126
Biofuels	MT	327	0
Total Production			**693**
Imports			286
Exports			376
Total Primary Energy Supply			**602**

Source: National Statistics Bureau [107]

The energy consumption mix is also dominated by hydro power based electricity and petroleum products, including LPG. The share of petroleum products (diesel, petrol, kerosene, LPG etc.) has shown an increase in the recent years. The share of non-hydro renewables has been almost negligible in the past years.

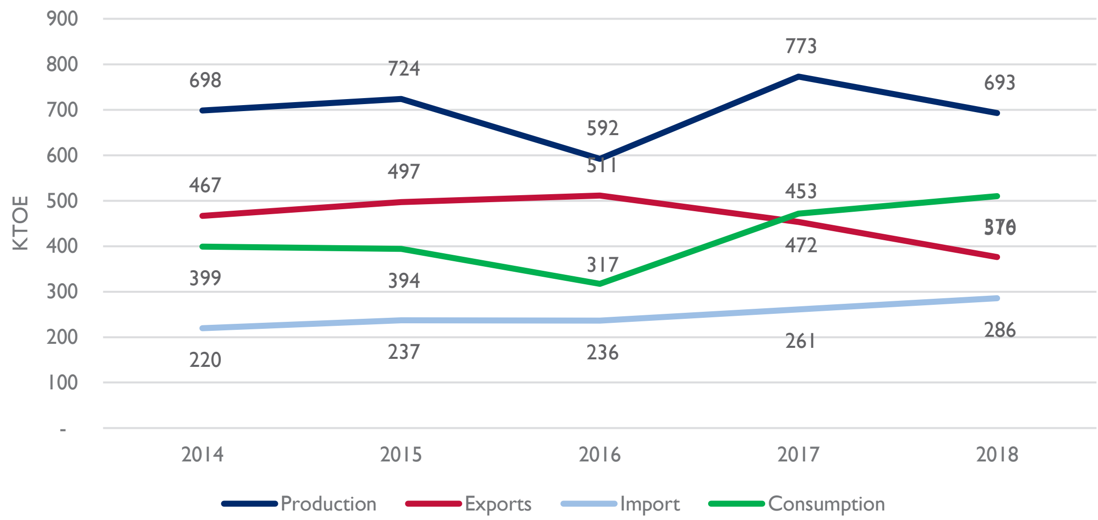
Figure 67: Bhutan – Energy consumption from commercial sources



Source: National Statistics Bureau [108]

The energy export of country is mostly in the form of electricity and coal. Energy import consists of petroleum products and LPG, which are fully imported into the country.

Figure 68: Bhutan - Energy export and import



Source: National Statistics Bureau [109]

The energy balance for Bhutan for 2018 is provided below.

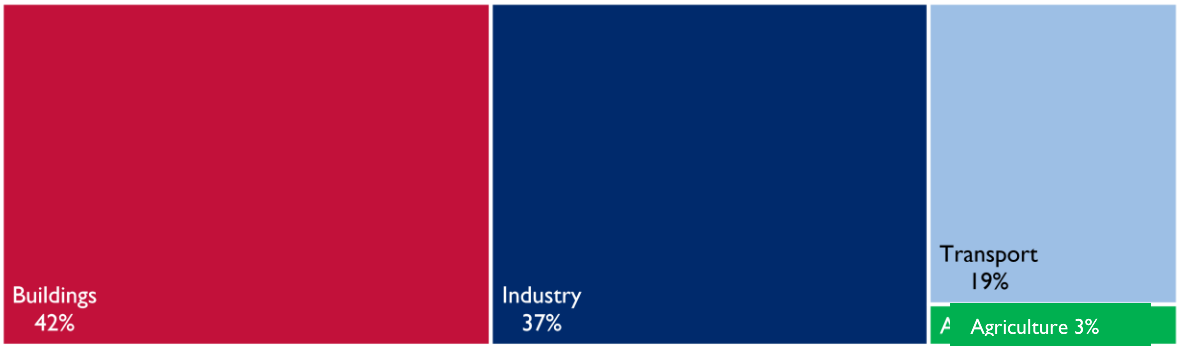
Table 18: Bhutan - Energy balance

Parameters	MTOE
Production	0.69
Import	0.29
Export	-0.38
Total Primary Energy Supply (TPES)	0.60
Transformation and losses	0.092
Total Final Energy Consumption (TFEC)	**0.51**

Source: National Statistics Bureau [110]

Bulk of the energy is consumed by buildings and industries, followed by transport sectors.

Figure 69: Bhutan - TFEC by sector – 2014



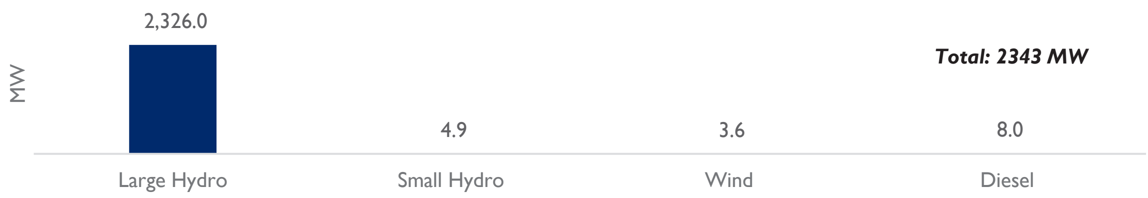
Source: Department of Renewable Energy [111]

Considering the TFEC of 510 KTOE, and population of 0.73 million, the per-capita energy consumption for 2018 comes to 699 kgoe.

6.2.2 Electricity generation

Bhutan's electricity generation mix is almost entirely hydropower based, with most of them constructed for export of power to India. The total installed capacity for electricity generation is 2342.56 MW as on end of 2019, out of which 2326 MW is from large hydro power plants. There are several smaller hydro power plants (4.92 MW), one wind power plant (3.6 MW) and a few diesel power plants (8.9 MW).

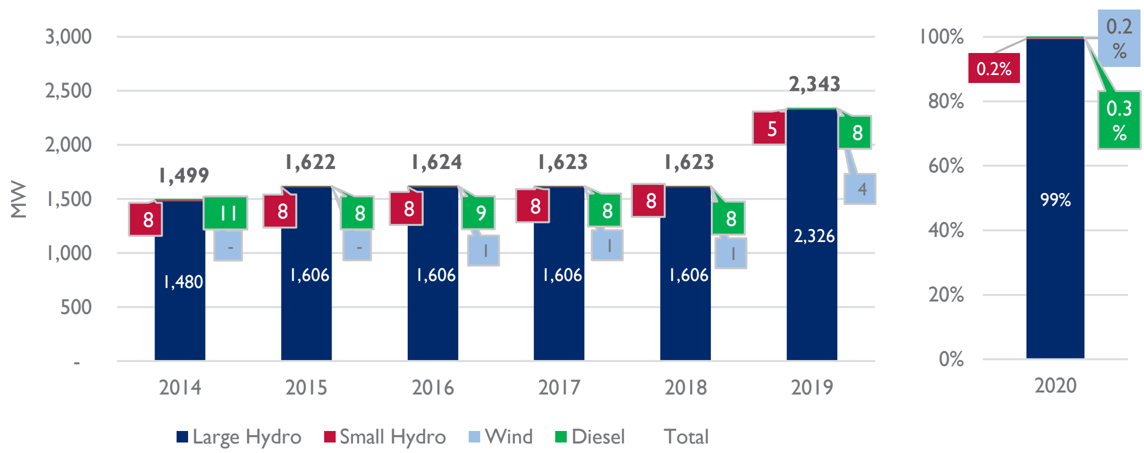
Figure 70: Bhutan - Electricity Installed Capacity – 2019



Source: Bhutan Electricity Authority [112]

The key power plants are 1040 MW Tala HPP, 720 MW Mangdechhu HPP, 336 MW Chukka and 60 MW Kuricchu HPPs. The commissioning of 720 MW Mangdechhu HPP resulted in the installed capacity increasing by 44% in 2019.

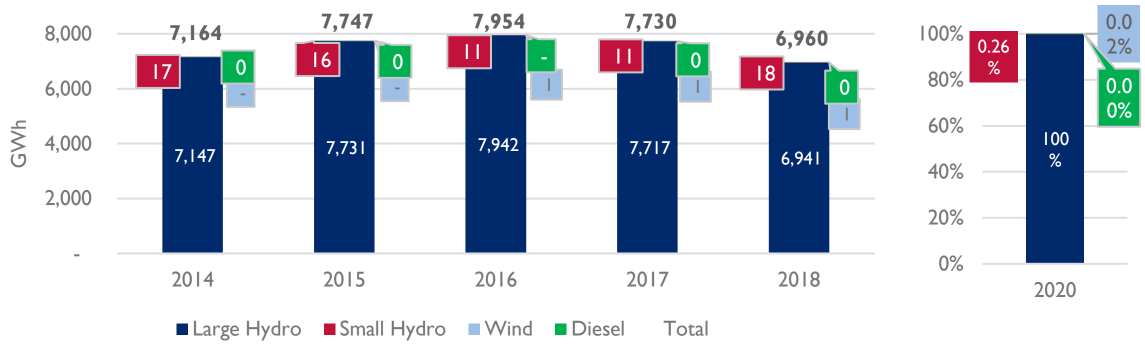
Figure 71: Bhutan - Installed capacity trends



Source: Bhutan Electricity Authority [113]

The electricity generation mix is almost entirely based on hydropower (99.7% in 2018).

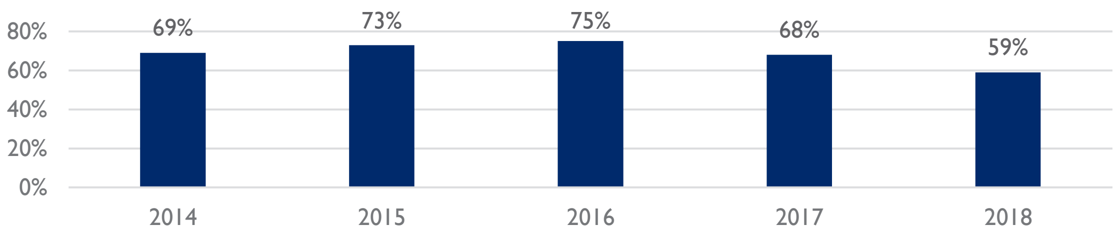
Figure 72: Bhutan - Electricity generation mix



Source: National Statistics Bureau [114]

The country has adequate generation resources to meet its demand. In comparison to the large installed capacity, domestic peak load was only 387.66 MW in 2019. However, there is still a small quantum of import of power from India, on a seasonal basis. Annual net-export of energy vary from 59-75% of the production.

Figure 73: Exports as % of total generation



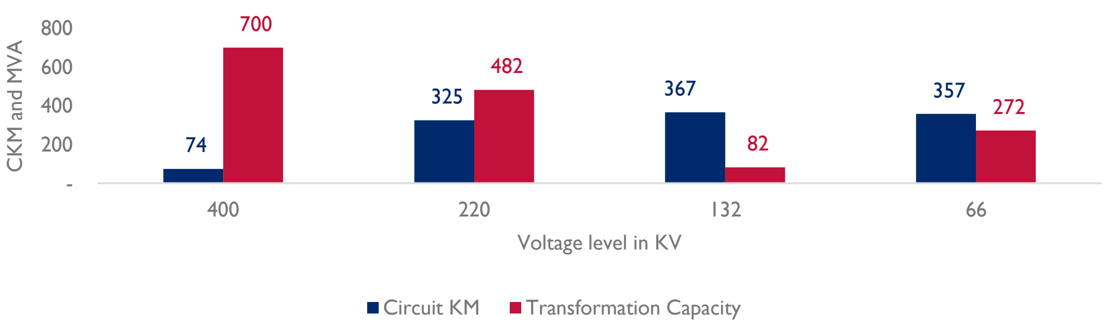
Source: National Statistics Bureau [115]

In 2018, the average cost of electricity purchased by Bhutan Power Corporation (BPC) from Druk Green Power Corporation (DGPC) was 1.59 Nu/kWh. [116]

6.2.3 Electricity transmission and distribution

The transmission network of the country is built at 400 KV, 220 KV, 132 KV and 66 KV levels. The 220kV and 400kV transmission system networks are in the western part, and it was largely developed as Associated Transmission Systems for Chukha and Tala HPPs. Major quantum of electricity generated from these power plants are exported to India after meeting domestic demand. In the eastern part of Bhutan, Kurichhu (60MW) HPP and its 132kV evacuation system caters to the local consumer and industrial load and the surplus power is transmitted to India through 132kV lines. There are interconnections with India, at 400 KV, 220 KV and 132 KV. Major 400 KV interconnections are from Tala and Malbase in Bhutan to Siliguri in India, and from Jigmeling in Bhutan to Alipurduar in India.

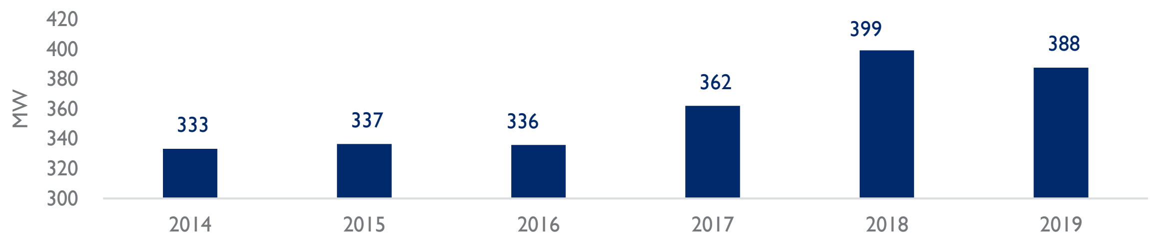
Figure 74: Bhutan - Electricity transmission network - 2018



Source: Department of Hydropower and Power Systems [117]

The peak demand for electricity has been increasing from 2014 to 2018, though the same moderated slightly in 2019.

Figure 75: Bhutan - Peak demand



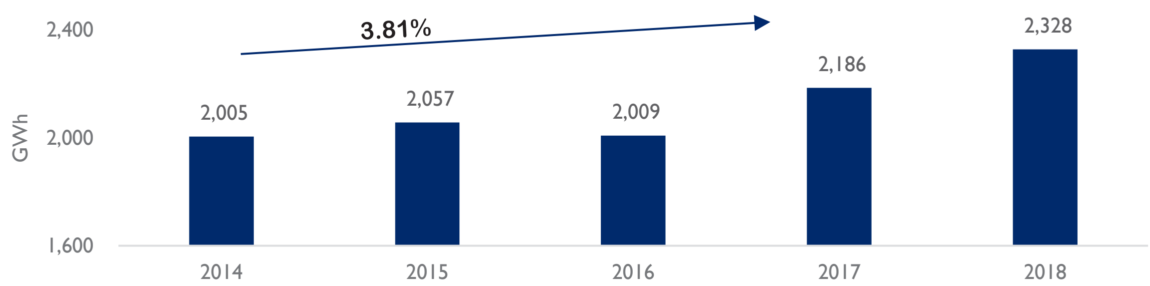
Source: National Statistics Bureau [118]

Government of Bhutan has planned for its transmission grid expansion leading up to 2040 and beyond as part of its National Transmission Grid Master Plan 2018. It is focused on facilitating the development of its rich hydro resources. The plan identified various additional transmission evacuation lines till 2035, such as:

- Two numbers of 400kV D/C transmission line from Punatsangchu HEP-I to Lhamoizingkha (Bhutan border);
- 400kV D/C Twin Moose PHEP-II –Lhamoizingkha (Bhutan border);
- 400kV, 1xD/C Quad Moose line, Yangbari – Rangia/Rowta (Bhutan portion); and
- 400kV, 1xD/C Quad Moose line, Jigmeling to Alipurduar.

Bhutan has reported 100% electricity access, though this includes supply of electricity from off-grid systems. Activities are under-way for improved on-grid electrification. The sales has grown at a CAGR of 3.81% between 2014 and 2018.

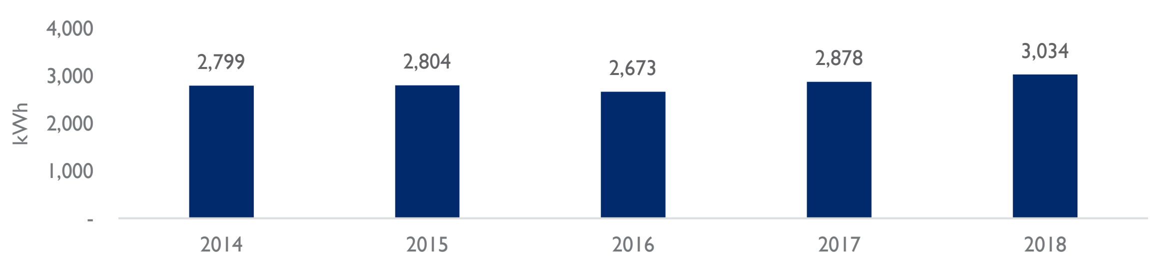
Figure 76: Bhutan - Electricity sales



Source: National Statistics Bureau [119]

The per-capita electricity consumption in the country was 3034 kWh in 2018, which is one of the highest in the region.

Figure 77: Bhutan - Per Capita electricity consumption



Source: National Statistics Bureau [120]

6.2.4 Energy resources and potential

Among the conventional fossil fuels, Bhutan has reserves of only coal. There are no reserves of gas and oil.

Figure 78: Bhutan - Energy resource potential

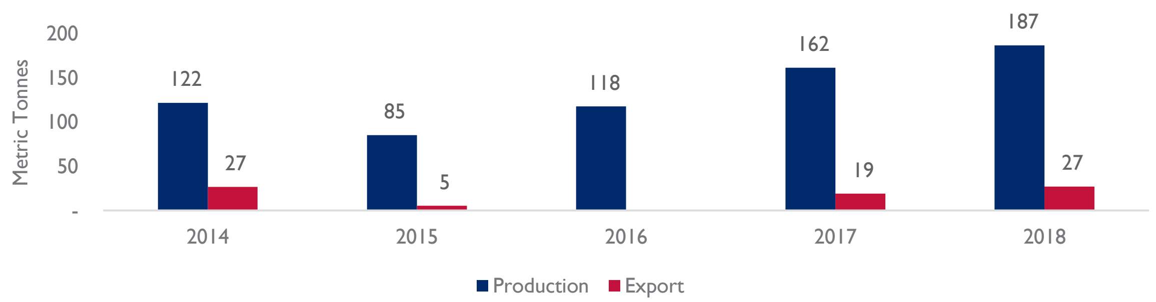
Resource	*Natural gas*	*Oil*	Coal
Unit	TCF	Million barrels	Million Tonnes
Total recoverable reserves	-	-	1 (during 2010)
Remaining reserve	-	-	Negligible

Source: National Statistics Bureau [121]

Coal

The country produces coal, which is partially used within the country, and partially exported. The coal is used mainly by the cement industries. The small reserves have mostly been fully utilized, and the remaining available reserves are not quantifiable, as per Bhutan National Statistics Bureau. [122]

Figure 79: Bhutan - Export of coal

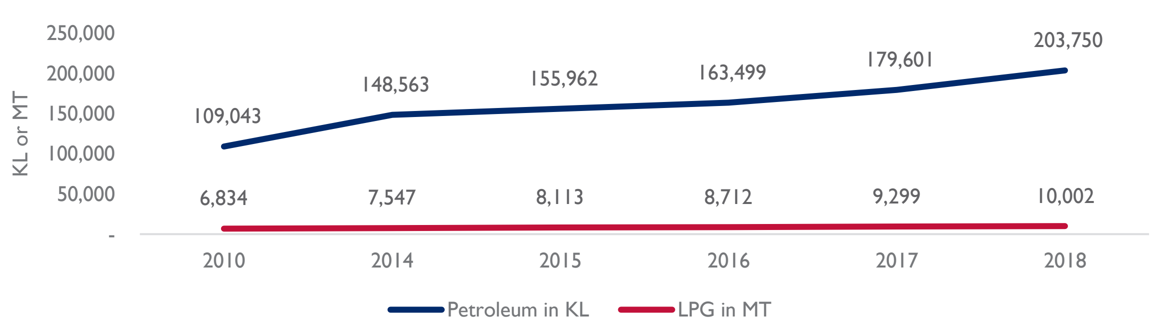


Source: National Statistics Bureau [123]

Oil

The entire petroleum and LPG requirements of the country are met through imports. Both LPG and petroleum imports have increased over the past years. In 2018, 203,750 KL of petroleum and 10,002 MT of LPG was imported.

Figure 80: Bhutan - Import of energy resources



Source: National Statistics Bureau [124]

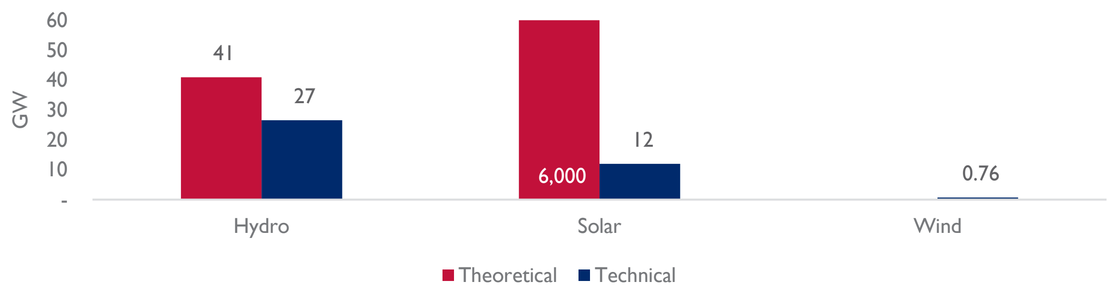
Renewable energy

The theoretical potential of hydropower in Bhutan is estimated at more than 41 GW, whereas the restricted technical potential is estimated at 26.6 GW. The Lhuntse, Mongar and Wangdue dzongkhags (districts) are considered to have excellent hydropower power potential.

Despite its mountainous terrain, the country enjoys good solar resources in several regions. Solar radiation can vary from 1600 to 2700 $kWh/m^2/yr$. A study of Department of Renewable Energy has estimated the theoretical solar potential at 6 terawatts (TW) and restricted technical potential at 12 GW.

Bhutan's overall wind regime is heavily influenced by the seasonal monsoon, which means that wind speeds are high from November to April and low in the remaining months. This coincides with the periods when hydro resources are short, and offers an opportunity for diversifying the supply of power by leveraging the seasonal complementarity between wind and hydro resources. A study by Department of Renewable Energy has estimated that Bhutan can easily deploy close to 760 MW of wind energy, with the northern dzongkhag (district) of Wangdue accounting for close to 19% of this potential, followed by the southern dzongkhags of Chukka (12%).

Figure 81: Bhutan - Renewable energy potential



Source: IRENA[125]

6.2.5 Energy transition and reforms

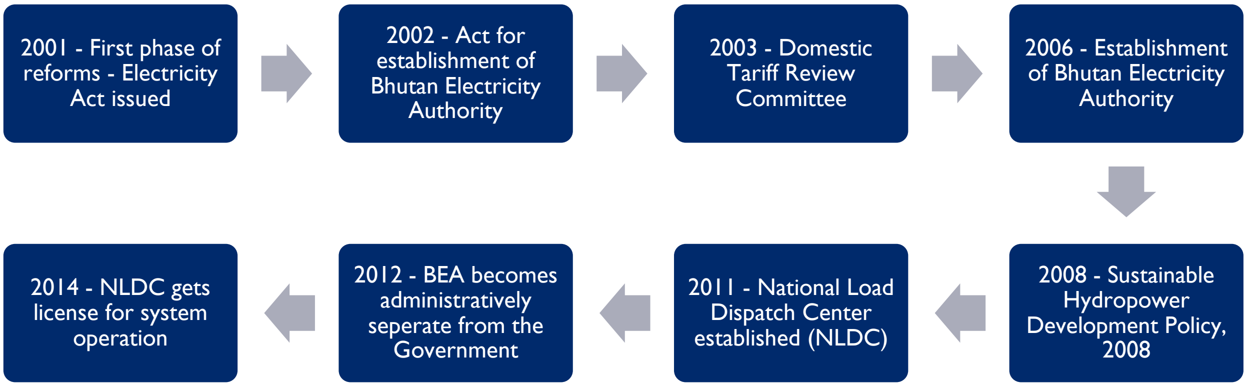
Reforms

Bhutan has undertaken reform measures in its power sector including the establishment of a power sector regulator – the Bhutan Electricity Authority (BEA) in 2006. In 2002, Bhutan's energy sector went through a major restructuring process to separate its management and ownership from the Government. Following these reforms, the policy-making body on energy has been the Ministry of Economic Affairs, which includes three departments relevant to the sector—the Department of Hydropower and Power Systems (DHPS); the Department of Renewable Energy and the Department of Hydromet Services (established on 1 December 2011).

BEA sets the tariff and regulates the sector. The system operator has been segregated - The Bhutan Power System Operator now works as a separate unit within the Bhutan Power Corporation Limited, and has a separate Managing Director.

A Bhutan Power System Coordination Committee (BPSCC) has also been established, with representation from the ministry, electricity utilities, power plants, system operator and regulator, for efficient coordination, operation and supply of electricity.

Figure 82: Bhutan - Sector reforms



Masterplans

Bhutan's National Transmission Grid Masterplan of 2018 lays down the plan for expansion of power system. The plan looks at the hydropower projects and transmission line scenario by 2025, 2030, 2035 and 2040. For example, the 2035 scenario anticipates generation of 13,538 MW, out of which 12,329 MW will be exported.[126]

The Government has also notified a National Energy Efficiency & Conservation Policy in 2017, which entrusted the Department of Renewable Energy (DRE) to come up with roadmap for Energy Efficiency. A draft roadmap published by DRE in 2018 has set a target of cumulative saving of 1.5 MTOE over a period of 15 years.

Electric vehicles

UNDP is implementing the Bhutan Sustainable Low-emission Urban Transport Systems project, which aims to increase the number of electric taxis in the country to 399 by end of 2021. There are also reports about plans to install 23 quick EV charging stations by 2021, to promote the use of electric vehicles.

Climate Policy

Bhutan's NDC commitments to UNFCCC include:

- Offset up to 22.4 million tons of additional CO2e per year by 2025 in the region through the export of electricity from our clean hydropower projects;
- Promotion of low carbon transport system;
- Promote clean renewable energy generation; and
- Energy demand side management by promoting energy efficiency in appliances, buildings and industrial processes and technologies. [127]

Energy efficiency

Through its Energy Efficiency & Conservation Action Plan, Bhutan aims to achieve significant energy savings in its buildings and appliances, industry, and transport sector. Initiatives include utilization of Renewable Energy Development Trust Fund (REDTF) for EE&C measures, established under the Alternative Renewable Energy Policy (AREP) 2013, priority sector lending for eligible projects which increase energy efficiency in production processes or in technologies, and Gross National Happiness Commission and Ministry of Finance to explore access to international funds in the form of climate finance for supporting EE&C measures. The Department of Renewable Energy (DRE) under the Ministry of Economic Affairs (MoEA) shall be the "Nodal Agency" (NA) for implementation of the energy efficiency policy in Bhutan.

Under the Action Plan, the Bhutan Electricity Authority (BEA) is empowered to design tariff instruments to incentivize EE&C, demand response, and demand side management which shall be further strengthened by amendments in the Domestic Electricity Tariff Policy.[128]

6.2.6 Institutional framework

All key decisions related to regional energy cooperation are taken at the level of Ministry of Economic Affairs, with most of the electricity related aspects handled by the Ministry's Department of Hydropower and Power System (DHPS). The operational aspects, such as electricity transmission lines are handled by the Bhutan Power Corporation (BPC) while system operation is undertaken by Bhutan Power System Operator (BPSO).

DHPS reports to the Ministry of Economic Affairs. It is the government body leading and coordinating the activities of the various organisations involved in the planning and development of the country's large hydropower resources (over 25 MW). It is also responsible for formulating national policies and guidelines related to hydropower development; implementing institutional reforms for efficient planning and the management of the sector; providing an enabling environment for the participation of the public and private sectors in the development of hydropower resources; and ensuring that hydropower exports generate the maximum revenue for the nation. DHPS consists of three divisions: Planning and Coordination, Hydropower Development and Transmission and Power Systems.

BPC is responsible for distributing electricity throughout the country and providing transmission access for generating stations for domestic supply as well as export. It has the mandate to ensure that a reliable and adequate electricity supply is available to all consumers within Bhutan. BPC is a Public Utility Company for delivery of electricity supply services in the power sector in Bhutan, under the Ownership of Druk Holding and Investment Limited (DHI), the commercial arm of the Royal Government of Bhutan to hold and manage the existing and future investments of the Royal Government of Bhutan.

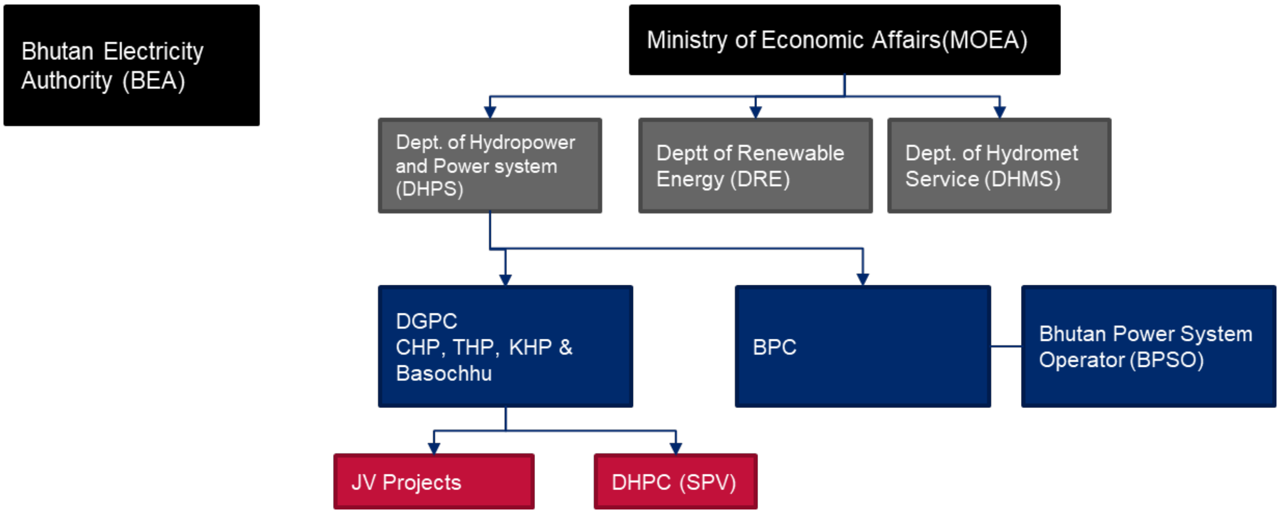
Druk Green Power Corporation (DGPC) is a wholly-owned corporate entity of the Government. It is an autonomous body that operates and maintains the large hydropower assets of the nation and is also responsible for promoting and developing new hydropower stations in the country.

The Electricity Act 2001 defines the legal framework of the power sector in the country, which ensures the healthy growth of the sector through a clear provision for all key stakeholders. The Act defines the role of the key stakeholders involved in the business of power generation, transmission and distribution. Under the Act, BEA is empowered to take on the role of an electricity regulator in the country. It is responsible for developing regulations, standards, codes and procedures for performance standards, technical and safety requirements for construction, O&M for generation and transmission and distribution facilities.

Bhutan's Hydro Development Policy 2008 focusses on the development of hydropower in the country though public and private partnership. Matters related to the off-take of electricity are dealt with by the Bhutan Hydro Sustainable Hydro Power Development Policy 2008.

In Bhutan, tariff determination for power projects is governed by the Tariff Determination Regulation 2007 (updated in 2013), which determines the tariff for all power transactions except the import/export of power to other countries.

Figure 83: Bhutan - Institutional framework



** BPC is under the Ownership of Druk Holding and Investment Limited (DHI), the commercial arm of the Royal Government of Bhutan.*

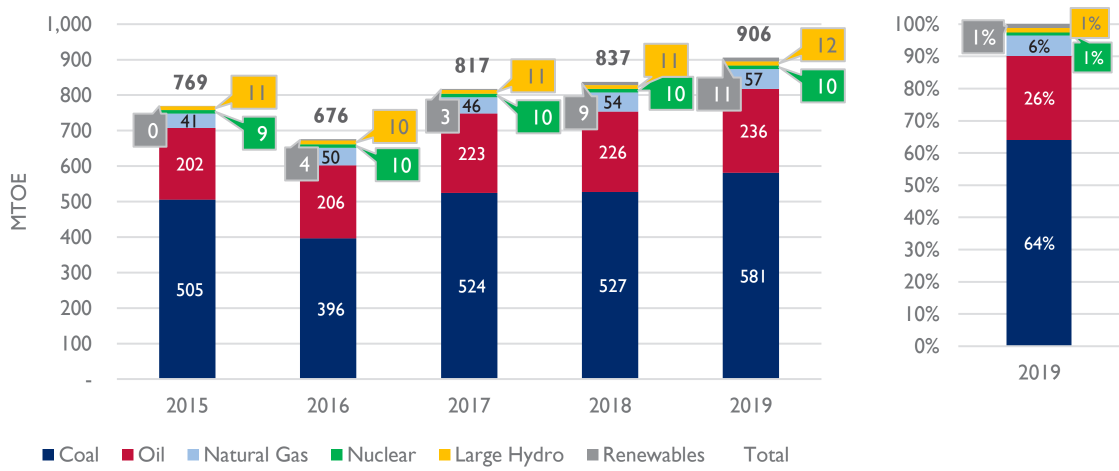
6.3 India

India is the seventh largest country by area and the second most populous country in the world with over 1.3 billion people. India shares land and sea border with all the BIMSTEC member states, other than Thailand. It is the largest country among BIMSTEC in terms of land area and population.

6.3.1 Energy consumption and supply trends

India's primary energy supply has been and continues to be dominated by coal (including lignite), which forms 64% of the overall primary energy supply in 2019 (581 out of 906 MTOE). After coal, the key resources are petroleum and natural gas.

Figure 84: India – Total Primary Energy Supply (Commercial sources)



** The small quantum of net electricity import is considered within renewables   Source: Ministry of Statistics and Program Implementation* [129]

Table 19: India - Primary energy in physical terms - 2019

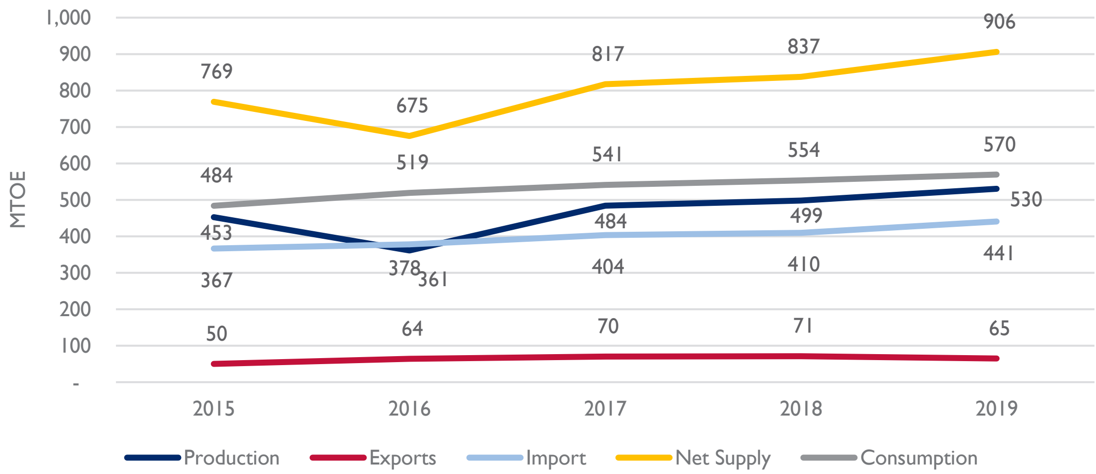
Fuel	Unit	Physical Quantity	MTOE
Coal and lignite	K ton	1000,970	581
Oil	K ton	234,613	236
Natural Gas	MMSCM	61,613	57

Fuel	Unit	Physical Quantity	MTOE
Nuclear	TJ	412,600*	10
Large hydro	GWh	135,013*	12
Renewables	GWh	125,546*	11
Total Primary Energy Supply			**906**

** Derived from IEA conversion factors   Source: Ministry of Statistics and Program Implementation [130]*

India is heavily import dependent for its energy requirement, with imports forming 49% of the overall available energy supply in 2019.

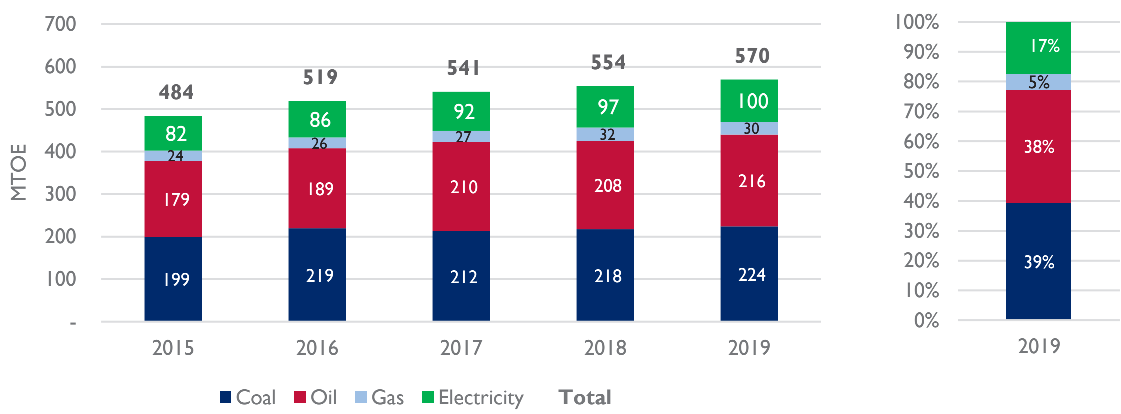
Figure 85: India - Energy export and import



Source: Ministry of Statistics and Program Implementation [131]

The final energy consumption is also dominated by coal (39%), closely followed by oil and oil products.

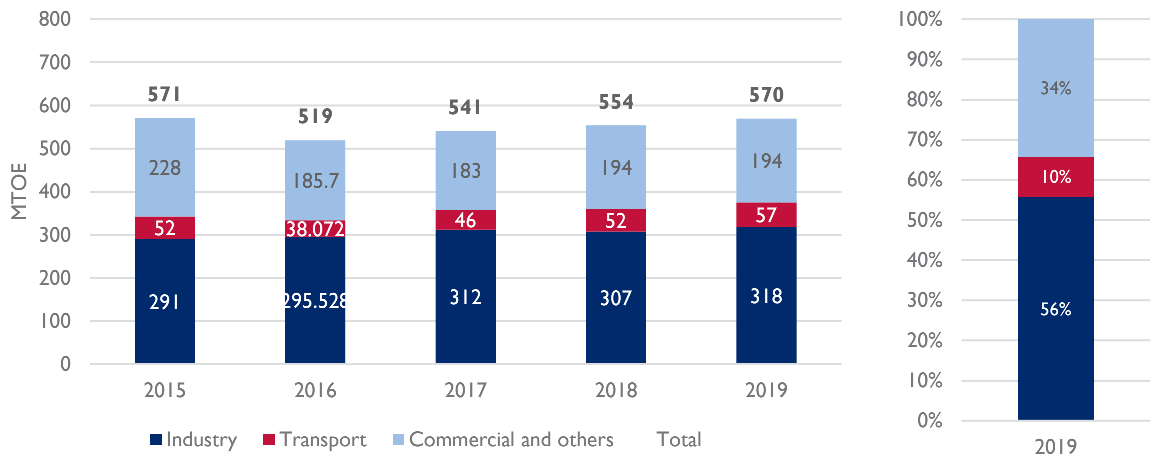
Figure 86: India - Total Final Energy Consumption



Source: Ministry of Statistics and Program Implementation [132]

Industry sector (318 out of 570 MTOE) and commercial sector (194 out of 570 MTOE) are the largest energy consuming sectors. Together, they contribute to 90% of energy consumption. However, share of transport sector has also been increasing in the past years, rising from 7% in 2014, to 10% in 2019.

Figure 87: India - Sector wise energy consumption



Source: Ministry of Statistics and Program Implementation [133]

India's energy balance for 2019 is provided below.

Table 20: India - Energy balance

Parameters	MTOE
Production	530
Import	444
Export	-65
Stock changes	-3
Total Primary Energy Supply (TPES)	**906**
Transformation	322
Own uses and losses	15
Total Final Energy Consumption (TFEC)	**570**

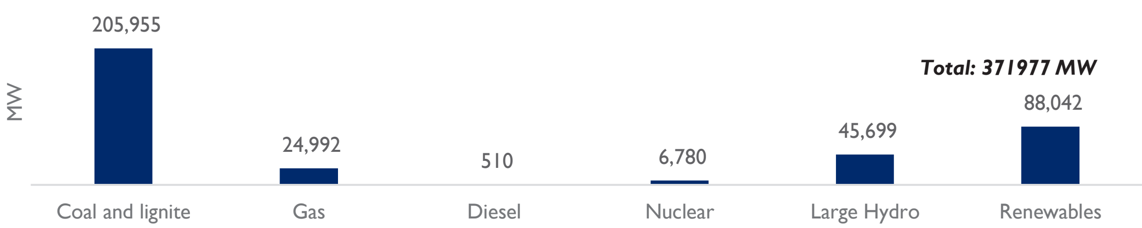
Source: Ministry of Statistics and Program Implementation [134]

During 2019, the annual per capita TPES was 682.8 kgoe and per capita TFEC was 429.2 kgoe.

6.3.2 Electricity generation

The installed capacity of electricity is dominated by coal and lignite, followed by renewables. 47% of the installed capacity is under private sector, while the remaining is directly or indirectly owned by central and state governments.

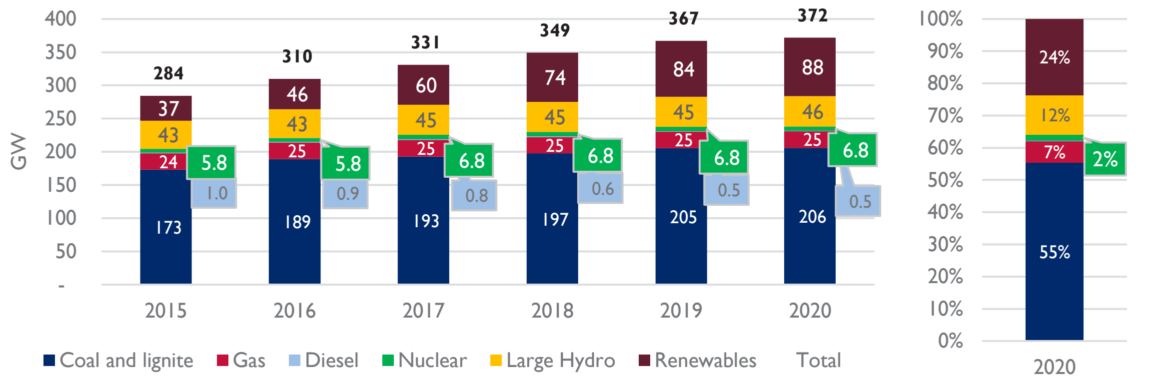
Figure 88: India - Electricity installed capacity - 2020



As on July 2020. Source: Central Electricity Authority [135]

The installed capacity had grown at a CAGR of 5.5% between 2015 and 2020. At the same time, the growth in the renewable energy capacity was 18.7%. Renewable energy sources had the highest increase in both MW and % terms during this period.

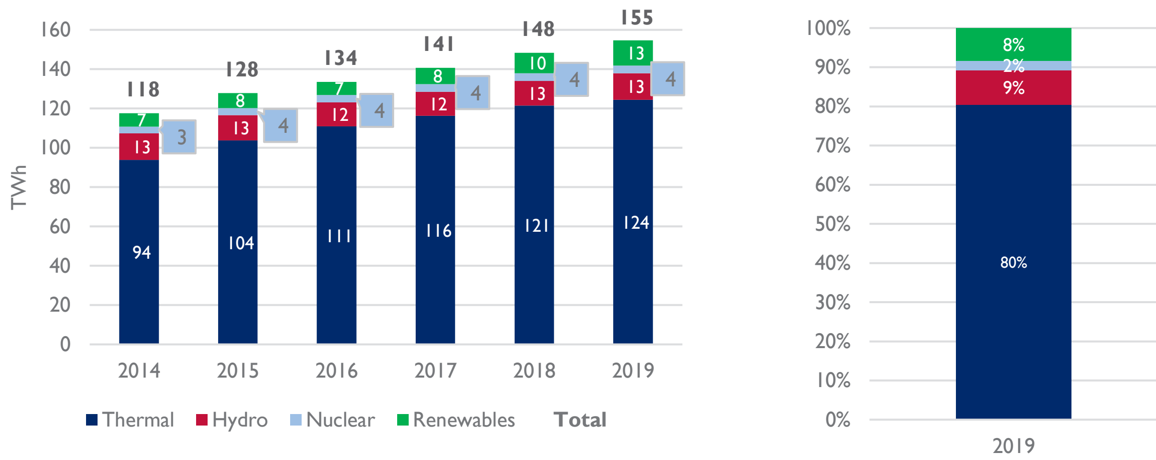
Figure 89: India - Trend of installed capacity



2020 data is as on July 2020. Source: Central Electricity Authority [136]

Similar to the installed capacity, thermal sources contribute the most in terms of electric generation also, generating 80.5% of the overall electricity generation in 2019. Thermal is followed by generation from hydro sources, renewable energy and nuclear energy respectively.

Figure 90: India - Electricity generation mix



Source: Ministry of Statistics and Program Implementation [137]

In terms of electricity import and export, India now exports more electricity than it imports. On an annual net basis, the import is from Bhutan, whereas export is to Bangladesh and Nepal.

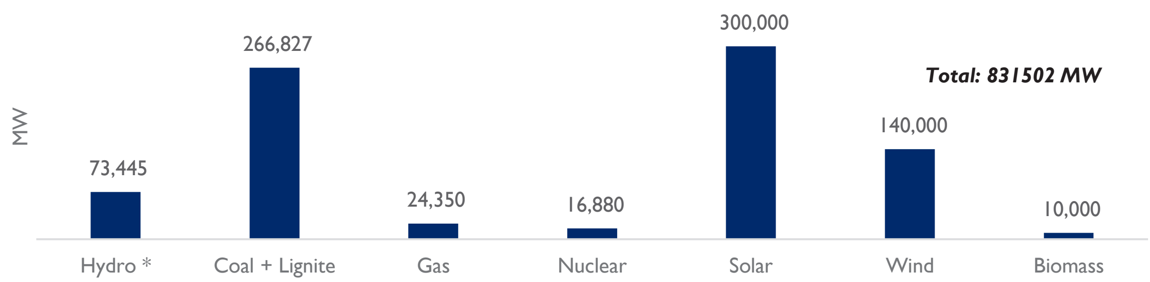
Figure 91: India - Electricity import and export

Source: Ministry of Statistics and Program Implementation [138]

The average price for non-renewable generation in FY 2019 was estimated by the Central Electricity Regulatory Commission as 3.6 Rs./kWh.[139] For renewable projects, the tariff is mostly determined through competitive bidding, and has in the recent past seen tariffs of 2.36 Rs/kWh (solar) and 2.43 Rs./kWh (wind).

India's generation expansion plan is described in its National Electricity Plan (NEP) of 2018 and the CEA study on 'Optimal Generation Capacity Mix for 2030'. As per NEP, total installed capacity will be 619 GW by 2027, out of which 44.4% (275 GW) will be renewable. More forward looking forecast is available in the CEA study on optimal generation max, which forecasts that renewable energy sources (solar + wind) installed capacity will become 440 GW by the end of year 2029-30 which is more than 50% of total installed capacity of 831 GW.

Figure 92: India - Generation capacity for 2030

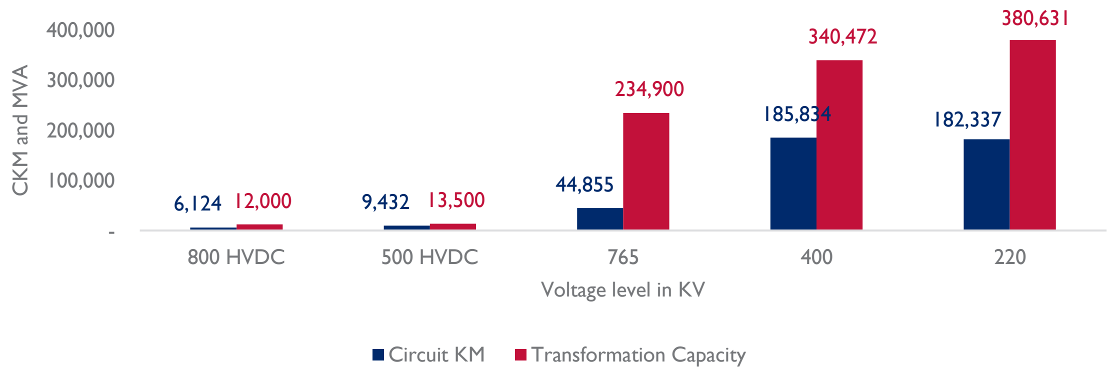


Source: CEA [140]

6.3.3 Electricity transmission and distribution

The transmission network consists of 765KV, 400KV and 220KV AC network, and HVDC network at 800 and 500 KV levels. HVDC lines are used both for domestic network and for cross border interconnection with Bangladesh. Interconnection with Nepal and Bhutan are AC interconnections. As on July 2020, there were 6124 circuit km (ckm) of 800 KV HVDC lines, 9432 ckm of 500 KV HVDC lines, 44855 of 765 KV lines, 185702 ckm of 500 KV lines and 181297 ckm of 220 KV lines. The total line length at 220 KV and above is 428,582 ckm, with a total transformation capacity of 981503 MVA.

Figure 93: India - Electricity transmission network - 2020



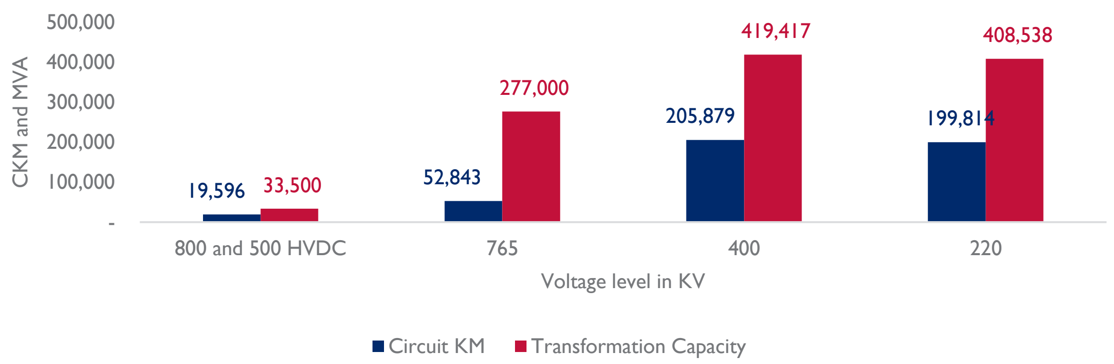
As on August 2020 Source: Central Electricity Authority [141]

The transmission grid has five regions, which are all synchronously interconnected, and operates as a single grid. The total interregional transmission capacity as on August 2020 was 102050 MW.

Additionally, a total of 74,609 CKM of transmission line and 3.69,686 MVA substation capacity are currently under construction along with 1,783 CKM and 21,000 MVA of total transmission line and substation capacity respectively is currently under bidding stage. Government of India, through its grid expansion projects, plans to integrate its renewable energy capacity and further improve access to electricity for its population. [142]

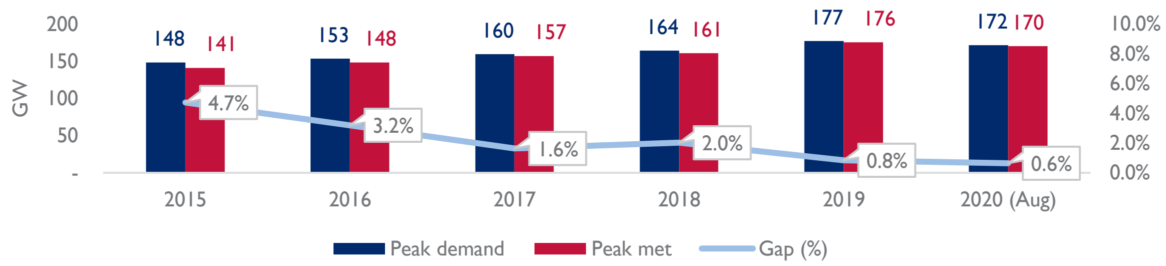
The National Electricity Plan further provides the transmission system for 2022 as below, comprising of 478,132 ckm of transmission lines at 230 KV and above, 1104955 MVA of transmission capacity of AC substations, and 33500 MW of HVDC bipole capacity.

Figure 94: India - Transmission expansion as per NEP, for 2022



In the recent years, the country has managed to eliminate the power demand deficit to a substantially low value of 0.6%, compared to 4.7% as existed in 2015.

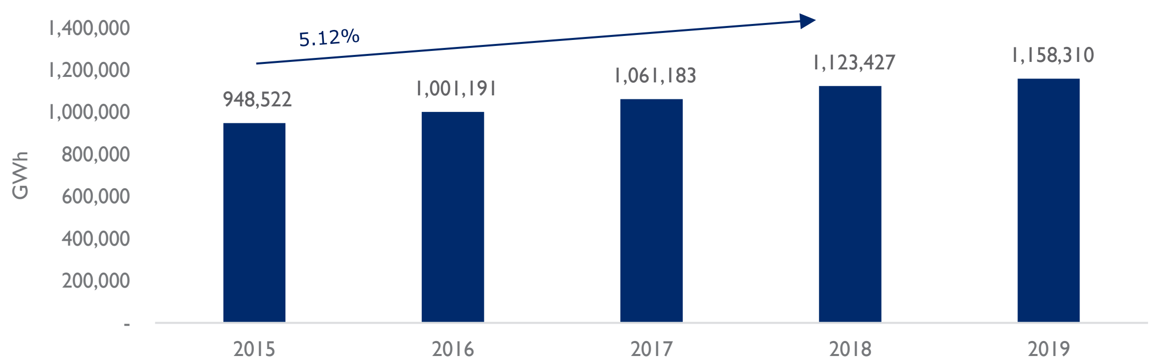
Figure 95: India - Demand supply gap



Source: Ministry of Power[143]

The sales have been increasing at a CAGR of 5.12% between 2015 and 2019.

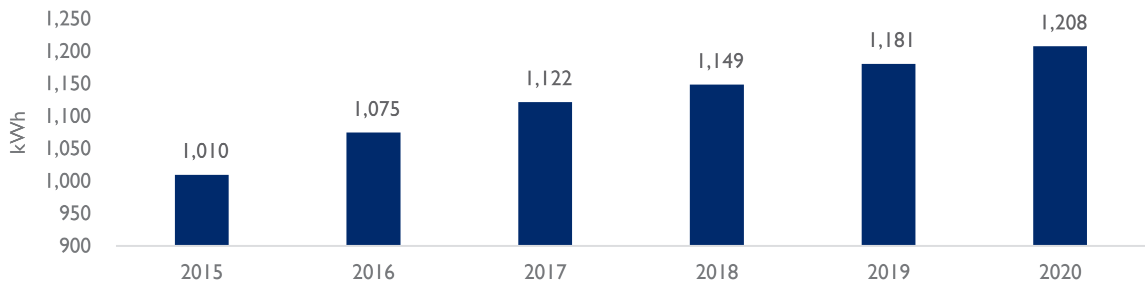
Figure 96: India - Electricity sales



Source: Ministry of Statistics and Program Implementation [144]

The per-capita electricity consumption has increased from 1010 kWh in 2015, to 1208 kWh in July 2020. This corresponds to a CAGR of 3.65% during the same period.

Figure 97: India - Per capita electricity consumption



 # Calculated as (Gross Generation.+ Net Import) / Mid-year population *Source: Central Electricity Authority* [145]

6.3.4 Energy resources and potential

India has a substantial reserve of coal reserves, and also has oil and gas reserves.

Table 21: India - Resource potential from fossil fuels

Resource	Natural gas	Oil	Coal	Lignite
Unit	Billion Cubic Meter	Million Tonnes	Billion Tonnes	Billion Tonnes
Reserves as on March 2019	1380.63	618.95	326	45.76
Reserve to production ratio (years)	42	18	214	153

Source: Ministry of Statistics and Program Implementation [146]

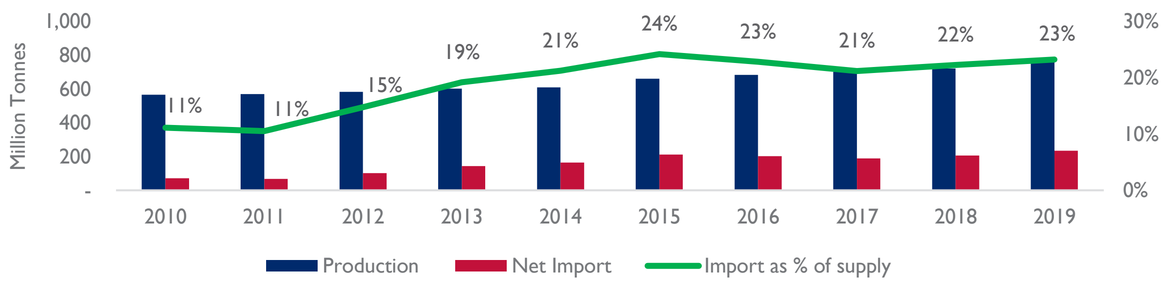
India is heavily dependent on fossil fuel imports. About 23% of coal supply, 87% of crude oil supply, and 47% of natural gas supply, in terms of physical quantity, were met through imports in 2019.

Coal

Coal deposits are mainly confined to eastern and south central parts of the country. The states of Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Telangana and Maharashtra account for 98.09% of the total coal reserves in the country. The State of Jharkhand had the maximum share (25.88%) in the overall reserves of coal in the country as on 31st March 2019, followed by the State of Odisha (24.76%).

Coal import is driven due to a combination of quality and grade related factors, as the domestic coal is mostly of lower calorific value and higher ash content in comparison to coal imported from countries such as Indonesia and South Africa. Commercial factors may also play a role in enabling such imports.

Figure 98: India - Production and import of coal



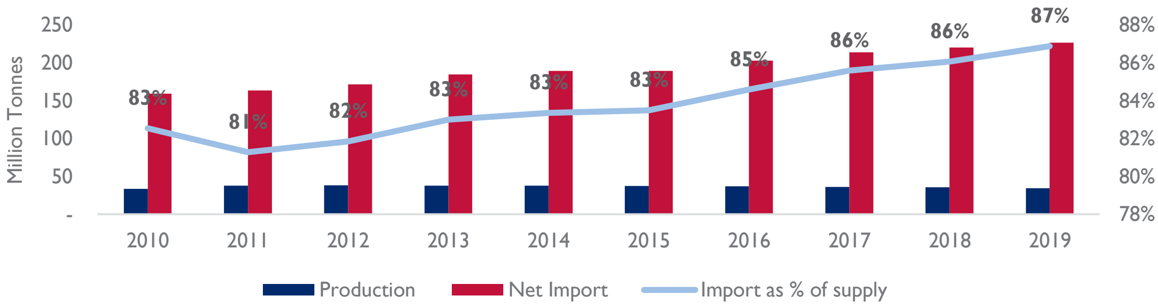
Source: Ministry of Statistics and Program Implementation [147]

Oil

The estimated reserves of crude oil in India as on 31.03.2019 stood at 618.95 million tonnes (MT) against 594.69 million tonnes on 31.03.2018. Geographical distribution of crude oil indicates that the maximum reserves are in the western offshore (38%) followed by Assam (25.6%).

Due to the very low levels of production, import dependence is high in the case of crude oil. Most of the oil is imported from Middle East.

Figure 99: India - Production and import of crude oil



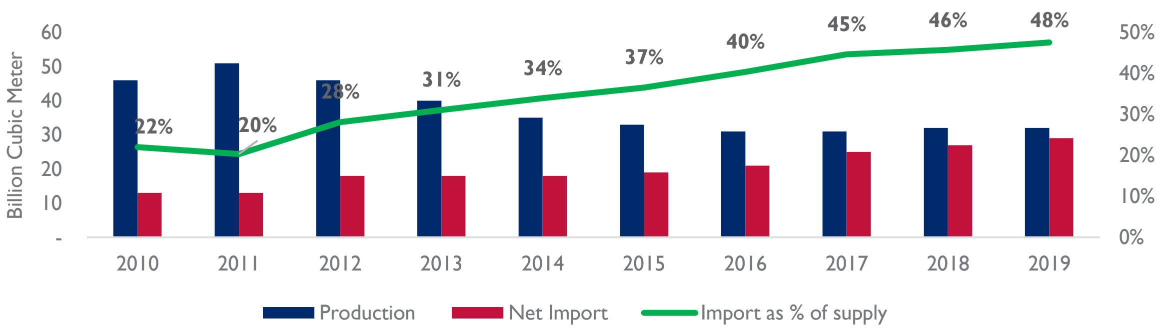
Source: Ministry of Statistics and Program Implementation [148]

Natural Gas

The estimated reserves of Natural Gas in India as on 31.03.2019 stood at 1380.63 Billion Cubic Meters (BCM) as against 1339.57 BCM as on 31.03.2018. Geographical distribution of natural gas indicates that maximum reserves of natural gas are in the eastern offshore (41%) followed by western offshore (23.4%).

For natural gas also, the import dependence has been steadily increasing, from 20% in 2011 to 48% in 2019. A drop in production of gas within the country is one of the key factors behind this trend, while there could also be some effect due to increase in demand for gas. Import of gas is mostly through LNG procured under long term contracts.

Figure 100: India - Production and import of natural gas

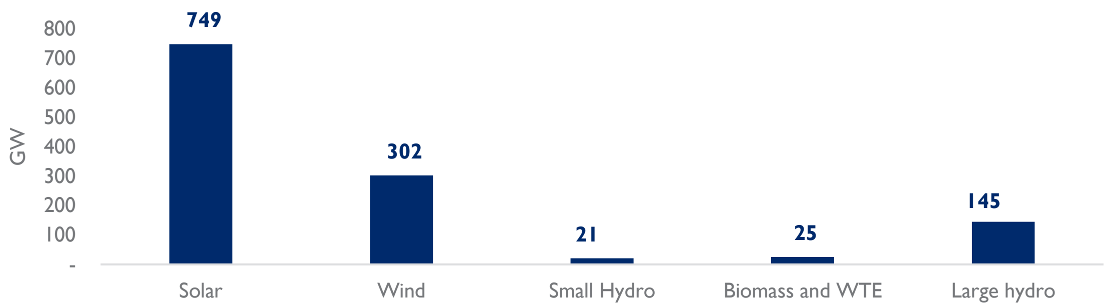


Source: Ministry of Statistics and Program Implementation [149]

Renewable Energy

There is high potential for generation of renewable energy from various sources- wind, solar, biomass, small hydro and cogeneration bagasse. The total potential for renewable power generation in the country as on 31.03.2019 is estimated at 1242 GW. This includes solar power potential of 748990 MW, wind power potential of 302251 MW at 100m hub height, SHP (small-hydro power) potential of 21134 MW, Biomass power of 17,536 MW, 5000 MW from bagasse-based cogeneration in sugar mills, 2554 MW from waste to energy and large hydropower potential of 145,000 MW.

Figure 101: India - RE potential



Source: Ministry of Statistics and Program Implementation [150]

6.3.5 Energy transition and reforms

Reforms

India has gone through multiple rounds of energy sector reform. This includes unbundling, establishment of independent regulatory commission, removal of price controls, delicensing of generation, introduction of power trading, establishment of power exchanges etc. The market is of Multi Buyer and Multi Seller structure. Competition is present in generation, transmission, distribution and trading. Large consumers, subject to restrictions, are free to procure power directly through bilateral contracts, or from power exchanges, by wheeling of power using the distribution utility's own lines.

The Indian power sector has come a long way since the laying down of the basic framework in 1910 right up to the Electricity Act of 2003, which brought about necessary changes. Over the decades, the sector has moved from being mostly a vertically integrated structure with the State Electricity Boards (SEBs) owning the generation, transmission and distribution businesses to a more unbundled corporate structure.

When India gained independence from British colonial rule in 1947, private companies or local authorities supplied more than four-fifth of the total generation capacity in the country, which amounted to slightly less than 1,400 MW. Subsequently, the Electricity Supply Act 1948 was enacted by the GoI, leading to the establishment of State Electricity Boards, which took over the licensees operating in the private sector. Thus, by virtue of enacting the Electricity Supply Act, the Government limited the provisions of the Electricity Act 1910 that allowed public and private companies to participate in the generation business.

The period between 1948 and 1991 witnessed remarkable development in the electricity sector, particularly the generation segment, in the country. During this time, the generation capacity grew by over 50 times, at a breakneck speed of 9.2 per cent. The availability of electricity not only supported the rapid economic expansion in the infrastructure sector, but also improved the electrification rate in the country.

While in this phase of power sector reforms, the Government focussed at adding more power generation capacity in the country, it largely neglected the distribution sector. Structural inefficiencies that had crept into the sector on account of continued political interference and subsidised electricity without adequate compensation, led to financial difficulties for the SEBs. The inefficiencies in the distribution sector also began to manifest themselves in the form of poor quality of power, both in terms of availability and fluctuations, brownouts and blackouts, which not only rankled but also caused inestimable financial losses to all users. Considering the state of the sector, by the end of the 1980s there was broad consensus that the power sector was in dire straits, and that major reform was needed to change its functioning.

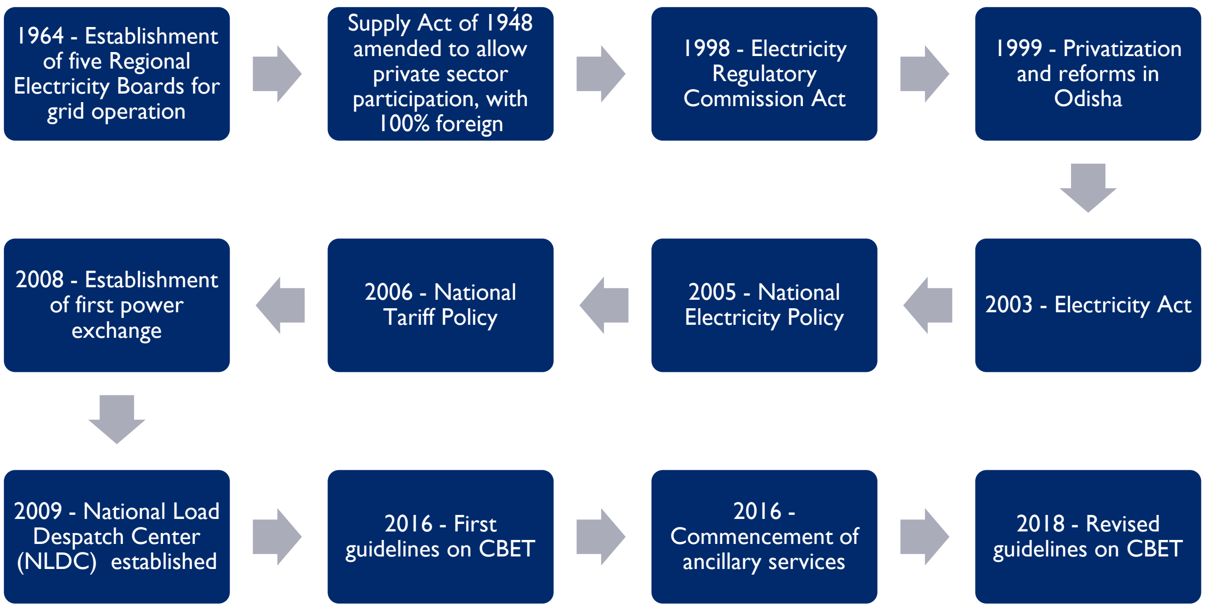
The year 1991, therefore, became a watershed of sorts in the history of the Indian power sector. The Ministry of Power published a notification permitting private entities to establish, operate and maintain generating power plants of virtually any size and to enter into long-term power purchase agreements with SEBs.

The period following 1991 has witnessed multiple reforms across the value chain. The first in the succession was the passage of the Orissa Electricity Reform Act, which was considered as a landmark measure, as it marked a departure from the common framework with regard to the functioning of the sector. Though what transpired in Odisha, post the power sector reforms, is far from the textbook outcome, it succeeded in the decentralisation of responsibilities from one bundled entity with an attendant improvement in the performance of the sector.

By the late 1990s, several other states had initiated reforms along the same lines as Odisha but the establishment of a Regulatory Commission in 1998 paved the way for independent functioning of the sector with virtually no role for the Government. This measure was followed by another landmark one in the form of the Electricity Act 2003 in which all other rules and laws related to power sector were subsumed.

The current level of reforms and market development are focused on creating a market for ancillary services, increasing the adoption of renewable energy, and improving the commercial viability of distribution utilities.

Figure 102: India - Sector reforms



Climate policy

India has specified its long term plans as part of its NDC document:[151]

- Reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level; and
- Achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030.

However, most recently, the Government has adopted a more ambitious target of 450 GW of renewable energy by 2030.

The detailed electricity generation and transmission plans are laid out in India's National Electricity Plan. A longer time perspective planning for transmission is also undertaken.

Energy efficiency

India has a very comprehensive ecosystem for energy efficiency, under the overall guidance and control of the Bureau of Energy Efficiency (BEE). BEE runs energy efficiency standards, appliance labelling, and energy certification programs. The Energy Conservation Building Codes (ECBC) are also imposed at Central and State level for various sectors. In many states, the electricity distribution utilities have their own demand side management (DSM) programs. India has undertaken a successful and large scale adoption of energy efficient lighting, by switching over to LED bulbs.

Smart Grids

Smart grid adoption in the country is being implemented by various electricity utilities including the central transmission utility – Power Grid Corporation of India Limited (PGCIL). India's National Smart Grid Mission (NSGM), operating under the aegis of Ministry of Power, is charged with the planning and monitoring of implementation of policies and programmes related to smart grid activities in India. The NSGM goals relating to SmartGrid rollout are to be implemented in two phases (Phase-I till 2020 and Phase-II from 2020-2025). It envisages creating state project management units (PMUs), preparation of utility level roadmap for SmartGrid, rollout of Advanced Metering Infrastructure (AMI), Network mapping and consumer indexing, Distribution Automation, Microgrid and renewable integration, and preparing utility infrastructure to facilitate deployment of electric vehicles. The NSGM measurement, reporting, and verification (MRV) framework is an important tool to monitor progress of these various initiatives. [152]

It is further envisaged that the Smart Grid Knowledge Centre (SGKC) under the Power Grid Corporation of India Limited will be the resource for providing technical support to NSGM. NSGM commenced with an initial budget outlay of 990 crores.

Electric Vehicles

Electric Vehicle adoption is still in in the initial stages, though a scale-up is expected in the medium term. The Government has recently launched Phase II of its Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles (FAME) program. The program in its current phase aims to generate demand by way of supporting 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars (including Strong Hybrid) and 10 lakh e-2 Wheelers.[153]

6.3.6 Institutional framework

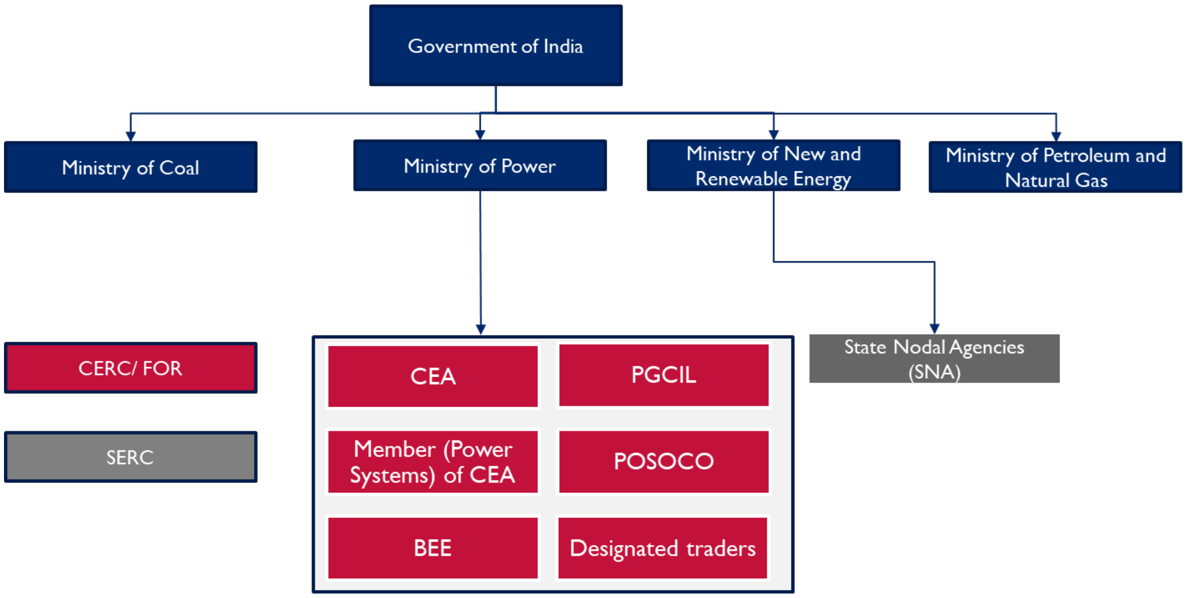
In case of electricity, all key policy decisions are taken by the Ministry of Power in consultation with the Ministry of External Affairs. However, approval for import and export are granted by the Member (Power Systems) of Central Electricity Authority (CEA), which is the Designated Authority for CBET under India's guidelines for import/export of power. CBET also comes under the regulatory jurisdiction of the Central Electricity Regulatory Commission (CERC). [154]

The Indian power sector has a federal structure where both the centre and the state have the authority to make rules in their respective jurisdictions. The Ministry of Power (MoP) is the apex body for decision-making in the Indian power sector. At the central level, CEA and BEE are responsible for formulating policy and act as planning advisors to the MoP. The Central Electricity Regulatory Commission (CERC) and the State Electricity Regulatory Commissions (SERCs) are regulators at the central and state levels. The central level has both, power generation and power transmission, but it does not have any distribution player under it. The states have separate transmission, generation and distribution entities. Private players also have their presence in the transmission, generation and distribution sectors.

Power sector policies are developed by the MoP at the central level and by the state energy ministries at the state level. These policies become the governing blocs for the sector. Based on these policies, various rules and regulations are issued by the respective authorities, including the CEA, CERC, SERCs and so on.

India has the most evolved policy and legal framework for power generation, transmission and distribution among the South Asian countries. The Electricity Act 2003 provides the legal foundation of the power sector in the country. The Act was introduced to promote competition in the Indian power sector. It triggered a process of transformation in the sector, changing it from a vertically integrated power market to an unbundled one.

Figure 103: India - institutional structure



Source: Ministry of Power, Ministry of Petroleum and Natural Gas[155]

On cross border interconnections, India's Powergrid Corporation of India Limited (PGCIL) which is the Central Transmission Utility (CTU) will also play a key operational role, in terms of approval of open access (along with POSOCO/NLDC), and if required in case of new lines, approval of connectivity. The day to day scheduling will be through the system operator – Power System Operation Corporation (POSOCO).

For oil and gas sectors, the policy decisions are taken by the Ministry of Petroleum and Natural Gas (MoPNG). The oil and gas pipelines are operated by various state owned and private entities.

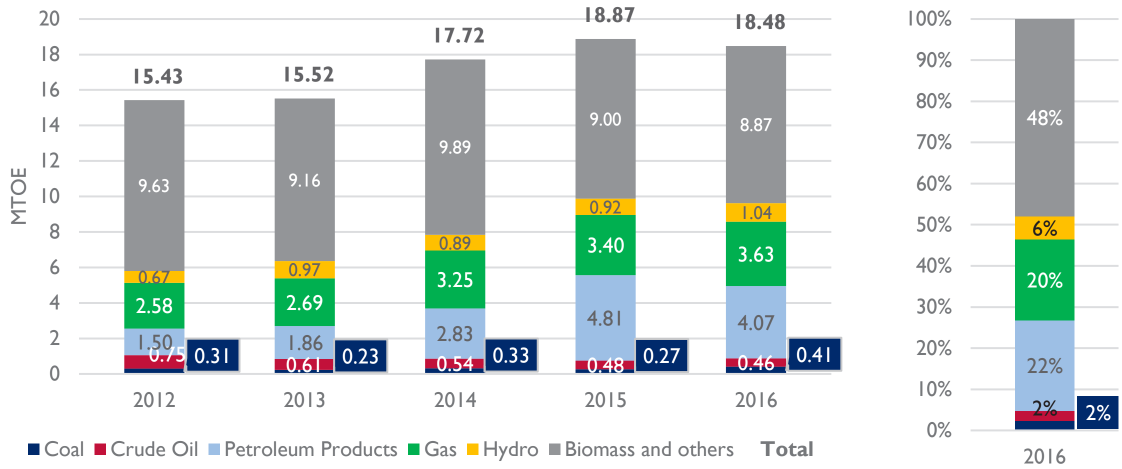
6.4 Myanmar

The Union of Myanmar, earlier known as Burma in situated in South East Asia, with India and Bangladesh in the west, China in the north, Thailand and Laos in the east. The country covers a surface of 676,552.7 km^2, divided into 7 States, 7 Regions and 1 Union Territory. About one-third of Myanmar's total perimeter of 5,876 km forms an uninterrupted coastline of 1,930 km along the Bay of Bengal and the Andaman Sea.

6.4.1 Energy consumption and supply trends

Myanmar's primary energy mix is dominated by biomass, followed by petroleum and gas. The use of biomass is mainly by the residential sector, as fuelwood and charcoal. Among the commercial energy sources, petroleum tops the list, followed by natural gas. Compared to other sources, the share of petroleum has grown in the past years.

Figure 104: Myanmar – Total Primary Energy Supply mix



Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [156]

The primary energy supply in physical terms is provided below.

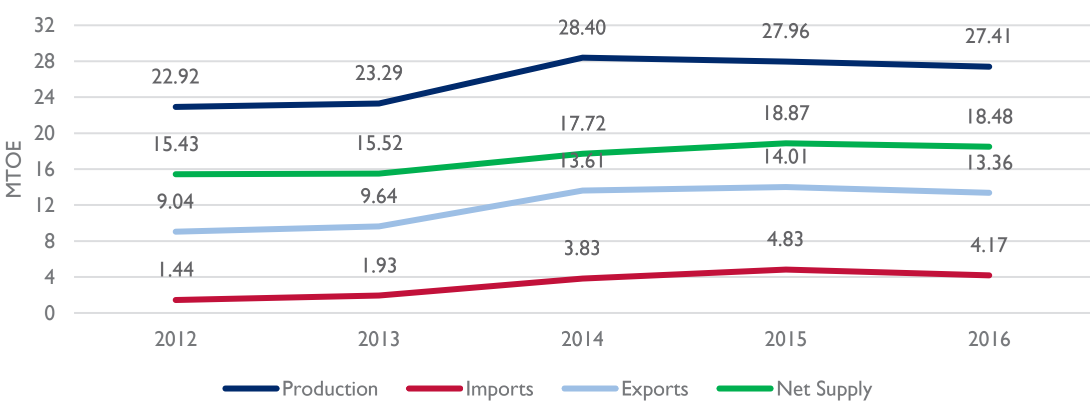
Table 22: Myanmar - TPES in physical and MTOE terms

Source	Physical Unit	Physical Amount	MTOE
Coal	Million Metric Tonnes	1.04	0.41
Crude oil and petroleum products	Million Metric Tonnes	2.77	4.53
Gas	Million Cubic Meter	4,247	3.63
Hydro	GWh	12,131	1.04
Biomass and others	TJ	371,231	8.87
Total			**18.48**

Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [157]

The country is a net exporter of energy. In 2016, net export of energy was 13.4 MTOE, which is equivalent to 49% of domestic energy production (27.4 MTOE). As on 2016, 95% of the imported energy was from petroleum products (4 MTOE out of 4.2 MTOE). 96% of the exported energy was from natural gas (12.8 MTOE out of 13.4 MTOE).

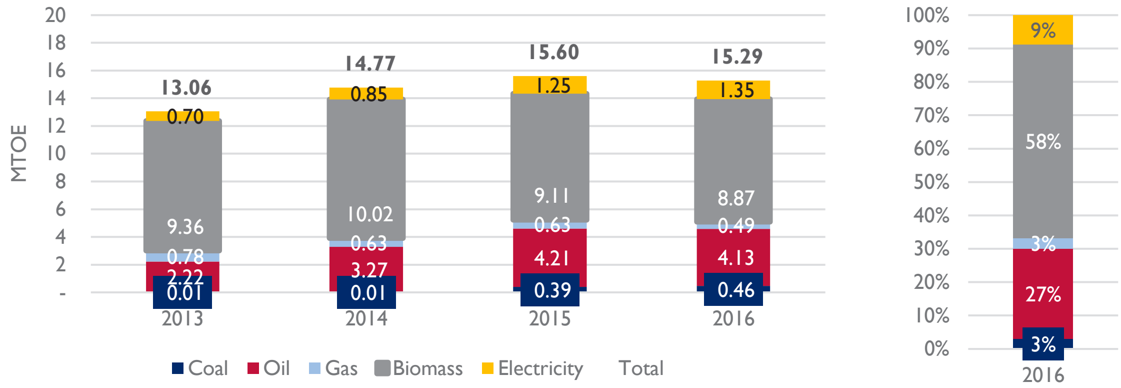
Figure 105: Myanmar - Import and export of energy



Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [158]

In the TFEC, share of electricity was only 9% in 2016. Coal share in the TFEC was the lowest among sources in 2016 (3%). Although the largest, the share of biomass in the TFEC decreased from 75% in 2000 to 58% in 2016. Natural gas share was 3% in 2016, slightly higher than coal.

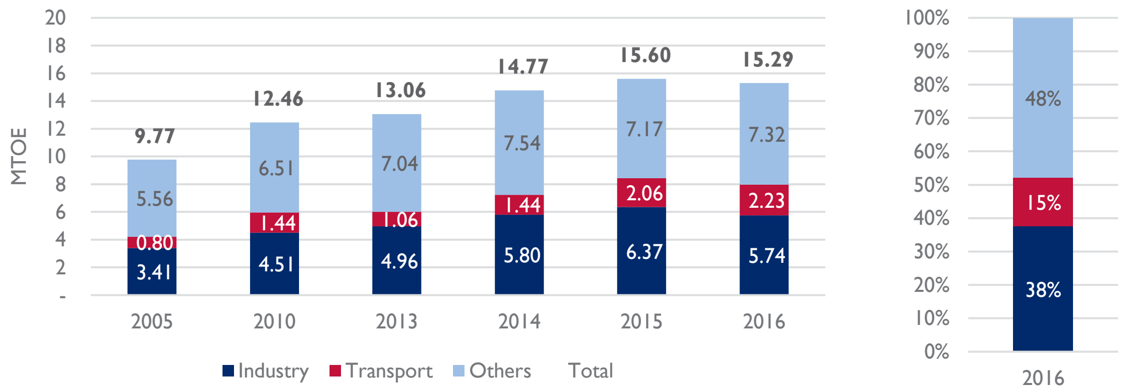
Table 23: Myanmar - Total Final Energy Consumption



Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [159]

In 2016, out of final energy consumption of 15.3 MTOE, 7.3 MTOE was related to commercial, services and related sectors (48%) followed by 5.7 MTOE for industry (38%) and 2.2 MTOE (14%) by transport sectors.

Figure 106: Myanmar – Total Final Energy Consumption by sector



Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [160]

The energy balance of Myanmar for 2016 is provided below.

Table 24: Myanmar - Energy balance

Parameters	MTOE
Production	27.4
Import	4.2
Export	-13.4
Stock changes	0.3
Total Primary Energy Supply (TPES)	18.5
Transformation	2.2
Own uses and losses	1.0
Total Final Energy Consumption (TFEC)	**15.3**

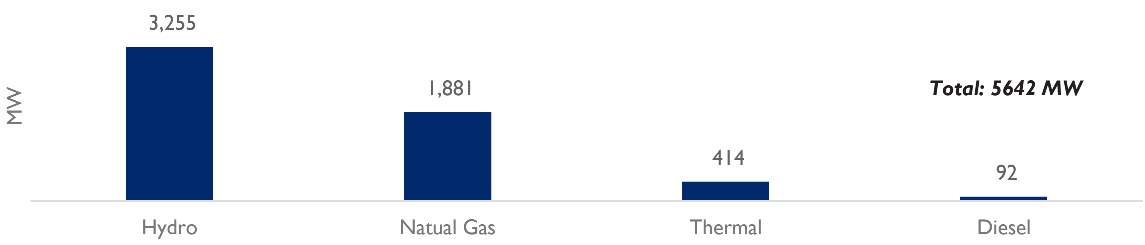
Source: Ministry of Electricity and Energy; and Economic Research Institute for ASEAN and East Asia [161]

The per-capita energy consumption for 2016 was 350 kgoe, in 2016. [162]

6.4.2 Electricity generation

Myanmar's installed capacity of electricity generation was 5642 MW as on end of March 2018. Most of the generation is based on hydro (3255 MW, 58%), followed by natural gas (1881 MW, 39%). Most of the hydropower generation resources are owned by the Government. However, there are a few joint ventures, and two of the power plants supply power exclusively to China (600 MW Shweli 1 and 240 MW Dapein).

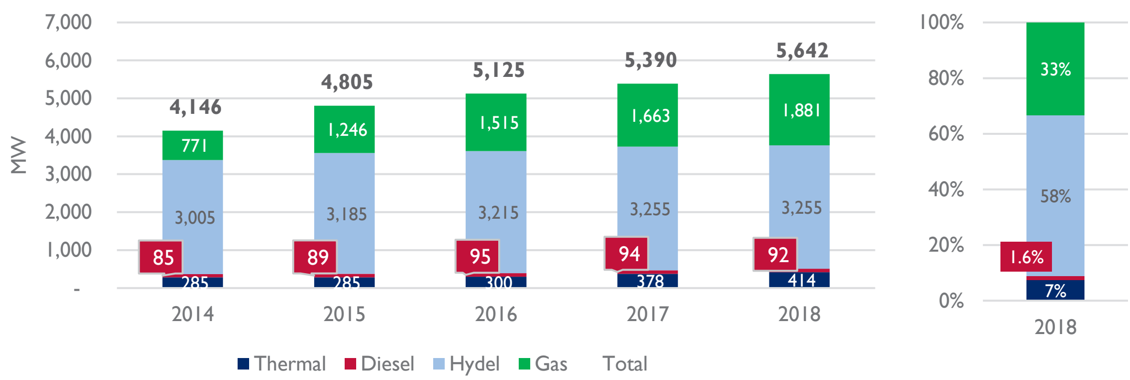
Figure 107: Myanmar - Electricity installed capacity - 2018



Source: Central Statistical Organization [163]

The electricity generation capacity in the country has increased in the recent years, from 4146 MW in 2014 to 5642 MW in2018, at a CAGR of 8.01%.

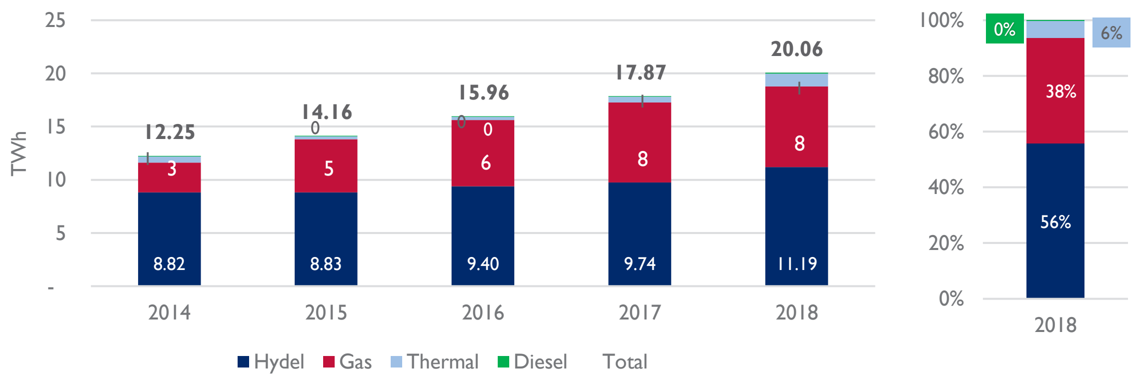
Figure 108: Myanmar - Electricity installed capacity trends



Source: Central Statistical Organization [164]

As on 2018, 56% of the annual electricity production was from hydro (11.2 TWh out of 20.1 TWh), and 38% from natural gas (7.6 TWh out of 20.1 TWh).

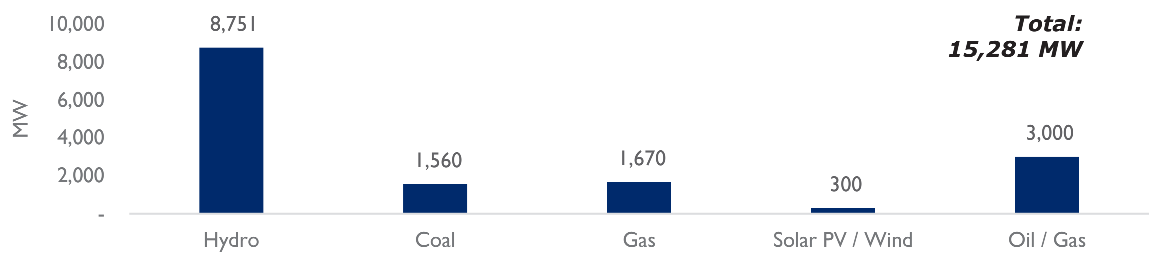
Figure 109: Myanmar - Electricity generation mix



Source: Central Statistical Organization [165]

The Myanmar Energy Master Plan envisages generation capacity expansion to 13.8 – 16.7 GW based on various scenarios.

Figure 110: Myanmar - Generation capacity plan for 2030 (Case I)



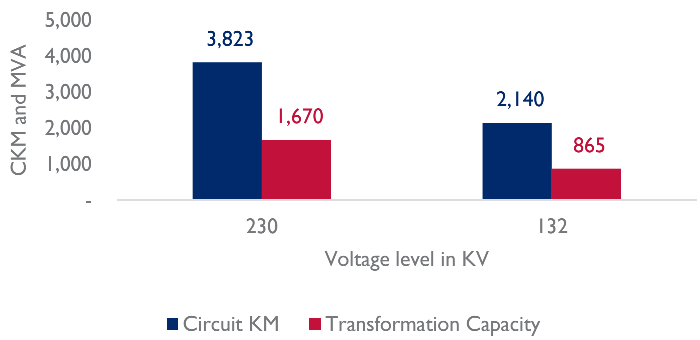
Source: Government of Myanmar [166]

6.4.3 Electricity transmission and distribution

Myanmar faces a large challenge in terms of improving access to electricity, and expansion of the national grid. The electrification ratio as on 2019 stands only at 50%, though the Government is focusing its efforts in this area.[167] Many of the areas are not connected to the national grid. There are also reports of electricity shortages of up to 400 MW in April 2019, with possibility of further increase in such shortages.[168]

Historically, the transmission network in the country has been at 132 KV and 66 KV levels. However, currently, the focus is on 220 KV and 132 KV network expansion. . Most of these lines lead from the northern part of the country, where most hydropower plants are, to the southern load centers, particularly the Yangon area. A 454-km long 500-kV transmission line is under implementation from north to south through bilateral assistance.

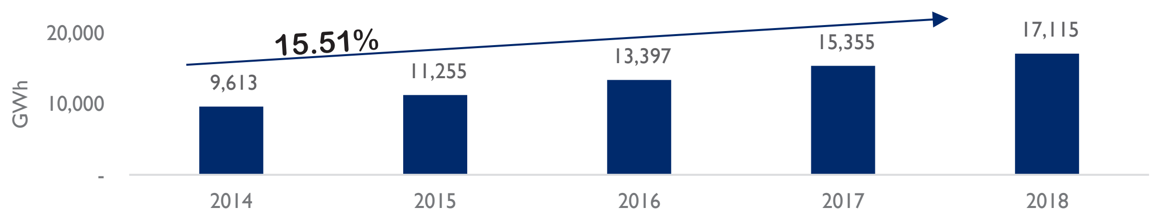
Figure 111: Myanmar - EHT Electricity Transmission Network



Source: Ministry of Electricity and Energy [169]

Electricity sales have recorded a considerable CAGR of 15.51% between 2014 (9613 MU) and 2018 (17,115 MU). Some of the increased sales is attributable to the improved pace of electrification, which was only 34% in 2016, and currently stands at 50%. The country aims to achieve 100% electrification by 2030.[170]

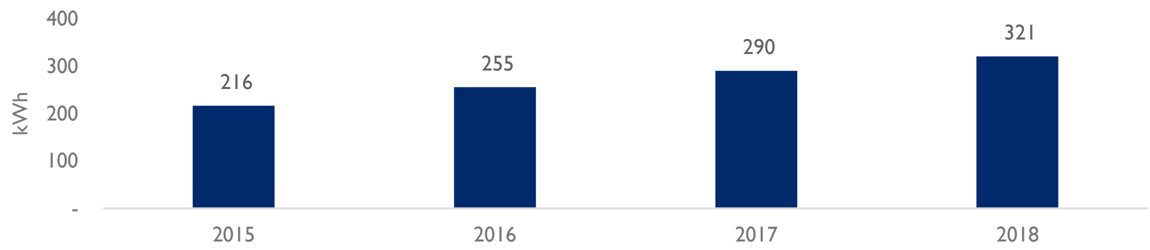
Figure 112: Myanmar - Electricity sales



Source: Central Statistical Organization [171]

The per-capita electricity consumption, calculated on the basis of reported net electricity production and population, has increased from 216 kWh in 2015 to 321 kWh in 2018.

Figure 113: Myanmar - Per capita electricity consumption



Source: Central Statistical Organization [172]

6.4.4 Energy resources and potential

In Myanmar, there are crude oil, natural gas and coal reserves, which are utilized.

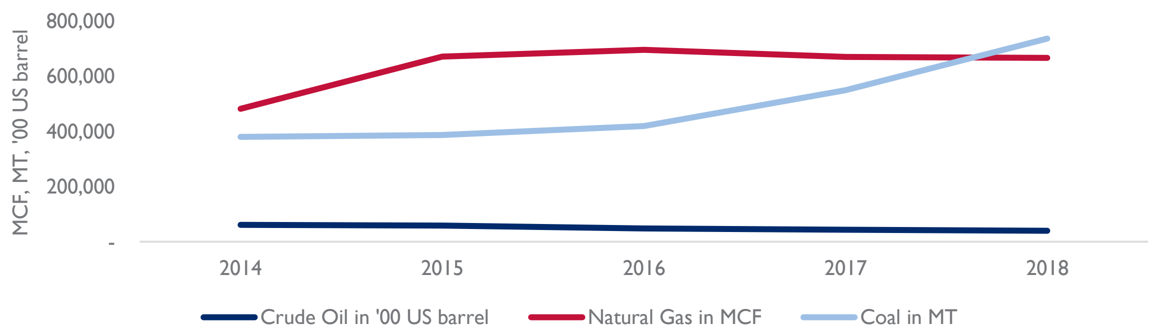
Table 25: Myanmar - Energy resource potential

Resource	Natural gas	Oil	Coal
Unit	TCF	Million barrels	Million Tonnes
Total reserves	**6.60**	**105.78**	**543.75**

Source: Ministry of Electricity and Energy [173]

The production trend of these resources are illustrated below.

Figure 114: Myanmar - Production of energy resources



Source: Central Statistical Organization [174]

Oil

The crude oil production has shown a declining trend in the past years, reducing from 6.8 million US barrels in 2011 to 4 million US barrels in 2018. In comparison, the production from other sources have increased / stabilized. Coal production has substantially increased, while natural gas growth has stabilized.

Myanmar was one of the earlier countries to have a national oil and gas industry in the Southeast Asia region. The monthly oil production was 1 million barrels in 1984. However, no new oil reservoirs were discovered later, and the production per well reduced due to the natural depletion of reservoirs. [175]

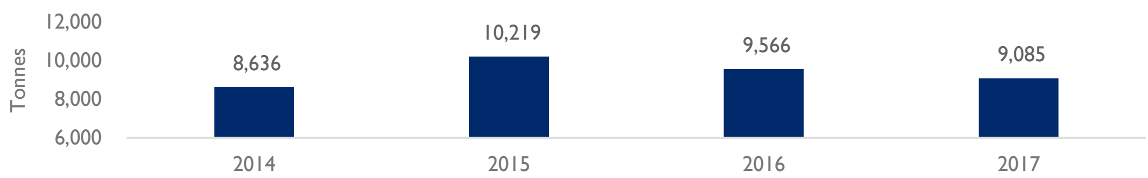
Gas

Myanmar possesses large reserves of natural gas, both onshore and offshore. More than 70% of Myanmar's domestically produced natural gas is exported to Thailand and more recently to China. In 2016, 78% of the gas production was exported.

The discovery of large offshore gas deposits in the early 1990s led the government to export the gas partly due to low domestic usage at the time. Myanmar's production of offshore gas started in 1998 from the Yadana gas field, followed by the Yetagun gas field in 2000, the Shwe gas field in 2013, and the Zawtika field in mid-2014.[176]

The gas produced in offshore fields in Myanmar – Thailand border are transported to Thailand through pipelines. The imported gas is mainly used by Thailand for power generation. Natural gas represents one of the major export items of Myanmar and is a major earning source of export revenues.

Figure 115: Myanmar - Export of natural gas



Source: Central Statistical Organization [177]

The export of gas to China is from the Shwe gas field, which started in 2013 for 4.5 trillion cubic feet of gas over 30 years via an 870-kilometer (km) 40-inch gas pipeline financed and operated by the PRC. Export to Thailand started from the Yadana field in 1998.

Myanmar Oil and Gas Enterprise (MOGE) constructs and operates domestic oil and gas pipelines and the overall network is 4,100 km. MOGE has been laying the pipes throughout Myanmar to expand its national pipeline network and gas is distributed via an onshore pipeline system (6–24 inch diameter) and offshore from Yadana to Yangon via a 410-km, 24-inch pipeline. [178]

Coal

Myanmar has identified 34 major coal deposits. The largest coal reserves are located in the Sagaing division and Shan state—northwest and central east of Myanmar.

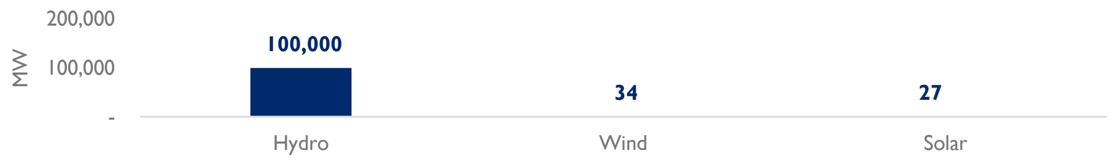
About half of the coal produced is used for power generation at the 120-MW coal-fired power plant in Tigyit, and a similar amount is used by cement and steel companies. Only a small proportion is used for cooking and heating in households. With the increasing demand for coal in the industry sector and thermal power plants, its production is expected to increase.

Renewable Energy

As per estimates, there is more than 100,000 MW of installed capacity potential for large hydropower plants. Myanmar has identified 92 large hydropower potential projects with a total installed capacity of 46,000 MW. With the four main large rivers flowing across the country, namely, Ayeyarwady, Thanlwin, Chindwin, and Sittaung, there are around 200 large dams for hydroelectric power in the country.

For wind and solar, the estimated potential is wind energy (33,829MW), and solar energy (26,962MW).

Figure 116: Myanmar RE potential



Source: European Journal of RE sources[179]

6.4.5 Energy transition and reforms

Reforms

The electricity sector has been partly unbundled. Private involvement is present in the electricity generation sector. The power market works on single buyer model with all electricity aggregated by the Electric Power Generation Enterprise (EPGE), which is owned by the Government.

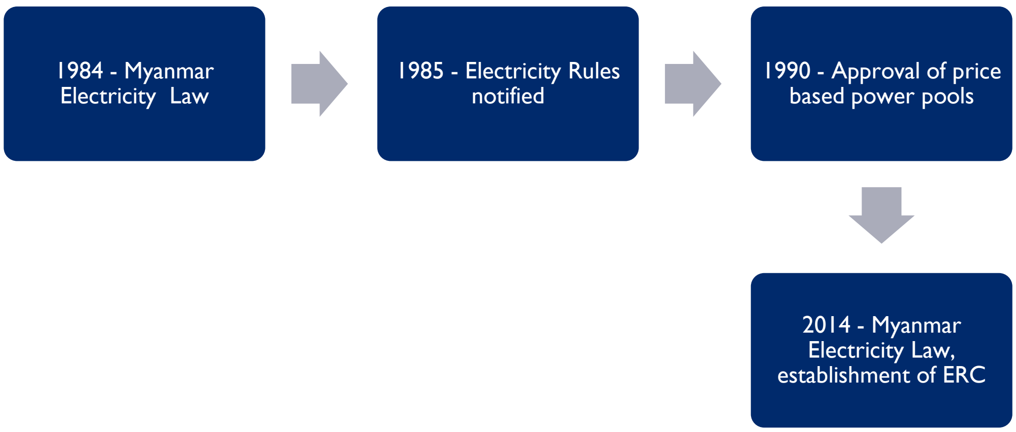
The electricity sector in Myanmar was historically governed by the Electricity Law (1984), which was amended in 1990 until it was replaced by the new Electricity Law 2014. The old electricity law was enacted during Myanmar's socialist period and lacked the legal framework to include private sector participation in power projects and independent power producers. It empowered the Government to grant rights to specified organisations, including foreigners, to participate in the sector. In addition, the old law placed importance on the electricity inspector by making the Electrical Inspection Department responsible for settling disputes between the producers and consumers of electricity.

The new Myanmar Electricity Law was enacted by the Myanmar Parliament on October 27, 2014, replacing the law of 1984. The new law has been enacted with an aim to introduce a legal framework that would reflect current international standards and encourage foreign and domestic investments in Myanmar's power projects. One of the main features of the new law is to establish the Electricity Regulatory Commission (ERC) to supervise the monopolistic electric power entities. This law provides a limited grant of regulatory responsibilities to the ERC.

The law gives the Ministry of Electric Power (MOEP), region and state governments and leading bodies of Self-Administrated Zones (SAZ) and Self-Administrated Divisions (SAD) the power to grant permits to allow persons to engage in electricity-related works, including the generation, transmission and distribution of power.

The most significant reform measure in the recent past has been the increased focus on improving electrification. The government has launched a National Electrification Plan to achieve universal access to electricity by 2030.

Figure 117: Myanmar - Sector reforms



Master Plans

Myanmar's National Electrification Plan calls for $5.8 billion in investments to extend the distribution grid and electrify off-grid areas, so that universal access to electricity can be achieved by 2030. Myanmar's National Energy Master Plan of 2015 reviewed the energy sector outlook on various scenarios, and recommended use of electricity instead of fuel wood for cooking, rely on domestic gas for power generation instead of LNG and to expand domestic coal based power generation capacity.

Myanmar's Power Sector Master Plan 2013–2030 envisages mix of energy sources to provide a stable and reliable energy supply through 2030, in which coal-fired power generation as a share of the total energy mix will increase from 2% in 2015 to 20% in 2030. The plan estimated that Myanmar's energy sector will need $30 billion to $40 billion over the next 15–20 years.

Climate Policy

Myanmar's Nationally Determined Contribution under UNFCCC stated climate mitigation actions such as developing 9.4 GW of hydropower, contributing to 38% of electricity generation, by 2030; and to realise a 20% electricity saving potential by 2030 of the total forecast electricity consumption.[180]

Electric vehicles

Myanmar's Ministry of Industry has promoted the idea of developing EV manufacturing capacity within the country, and has signed agreements, including one agreement for production of electric buses. The Government's Automotive Policy also speaks about promoting the use of EV, and providing incentives to EV manufacturers.[181] The policy mentions the following:

- Special taxation and privileges for manufacture and import of EVs;
- Special offers and privileges for international investors for manufacture of EVs; and
- Provide necessary infrastructure and support for EVs.

Energy efficiency

National Energy Efficiency and Conservation Policy of Myanmar aims to achieve 5% total energy consumption savings by 2020 and 8% by 2030 using 2005 as a baseline. This includes initiatives information sharing and capacity building for energy efficiency, energy efficiency building codes (EEBC), large scale adoption of solar water heating systems, energy management programs, minimum energy performance standards (MEPS), appliance labelling schemes, and promotion of LPG based cooking etc.[182]

6.4.6 Institutional framework

Myanmar's energy sector is controlled by the Ministry of Energy and Electricity (MOEE). All major decisions related to regional energy cooperation are undertaken by MOEE. Various departments such as Department of Electric Power and Planning (DEPP), Oil and Gas Planning Department (OGPD) and state owned entities such as Electricity Supply Enterprise (ESE) and Myanmar Oil and Gas Enterprise (MOGE) function under the control of MOEE. Electricity transmission is undertaken by the Department of Power Transmission and System Control (DPSC) which is also under MOEE.

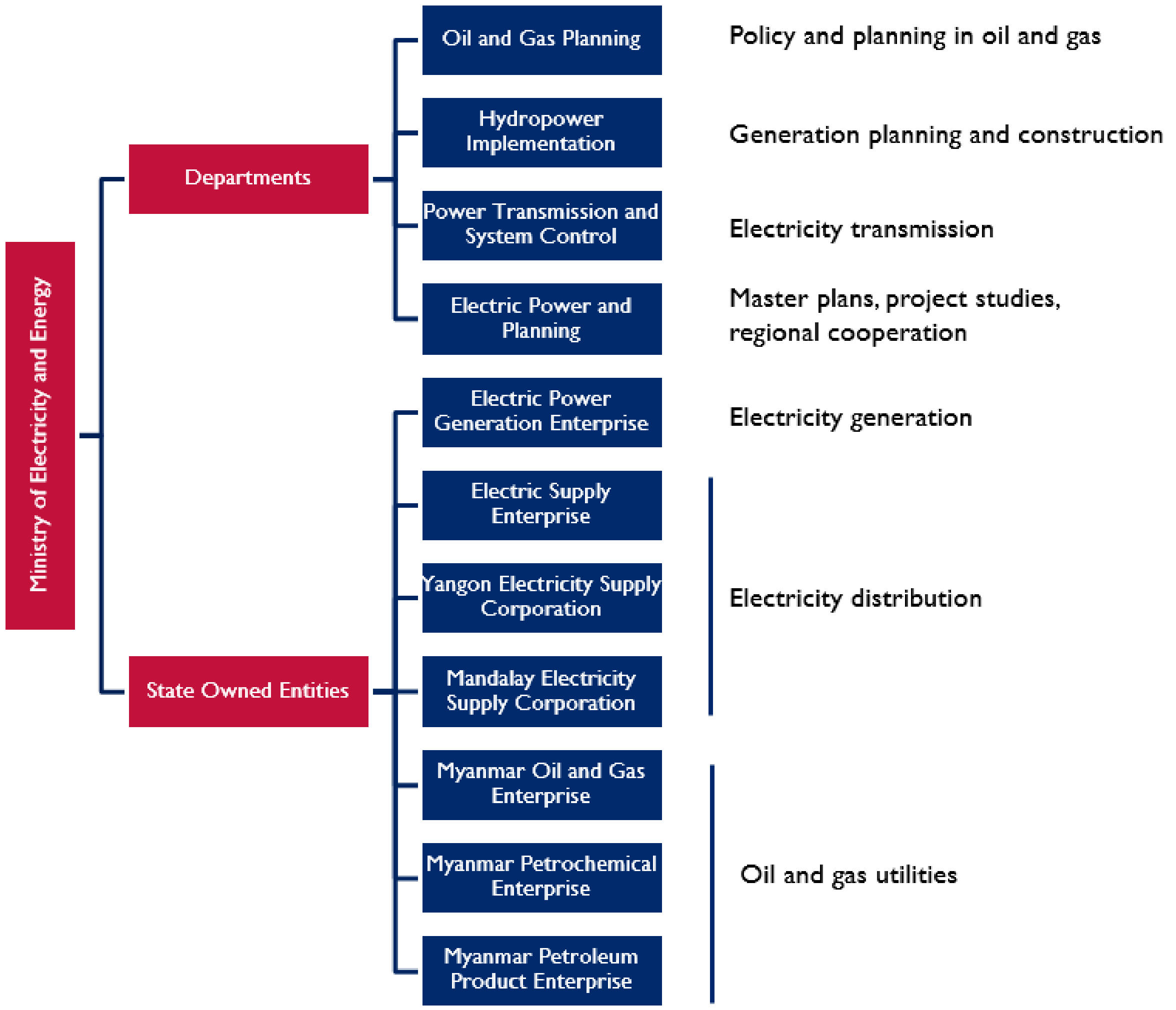
The Myanmar Electricity Law of 2014 governs the power sector of Myanmar. It institutionalises the ERC and awards it some regulatory duties. The law authorises the MOEP, region and state governments, and leading bodies of SAZs and SADs the power to grant permits to entities to engage in electricity-related works such as generation, transmission and distribution.

The power sector of Myanmar is governed by the following policies:

- Effective utilisation of the power generated from available resources such as thermal, hydro, solar, wind and other alternative resources by the expansion of the national power grid.

- Conduct the socio-impact analysis for generation and transmission projects to minimise undesirable impact.
- Restructure the power sector to encourage the participation of local and foreign investments and the formation of competitive power utilities.
- Boost the growth and development of power generation, transmission and distribution throughout the country and the employment of PPP in each sector.
- Conduct electricity generation, transmission and distribution in accordance with progressive technologies, and develop private participation in regional distribution activities.

Figure 118: Myanmar - Institutional framework



Source: Ministry of Electricity and Energy [183]

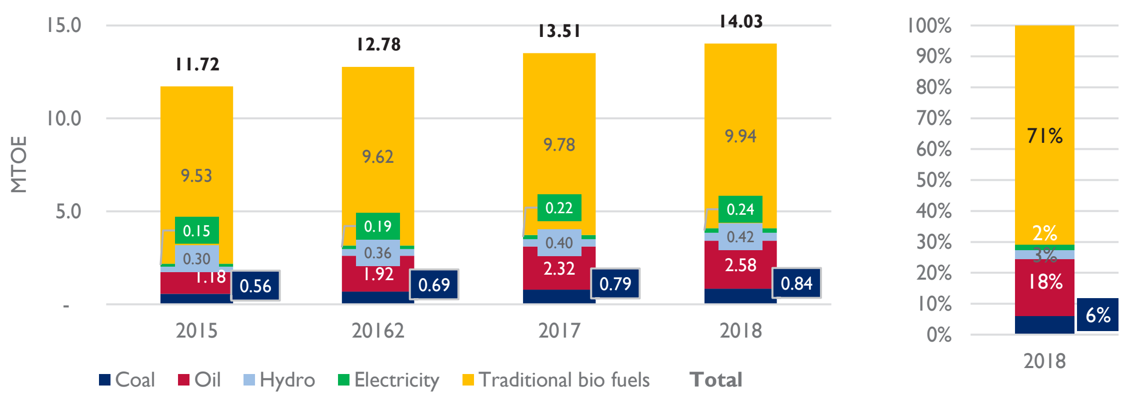
6.5 Nepal

Nepal is a landlocked country located in South Asia between China's Tibet Autonomous Region on the northern side and India on the western, southern and eastern sides. The country has a diverse topography consisting of Himalayan mountain ranges and plains. It aims to utilize its Himalayan snow fed rivers to tap hydropower for its own use and to meet the requirements of other countries also.

6.5.1 Energy consumption and supply trends

Nepal is heavily dependent on traditional bio fuels for meeting its energy supply requirements, with the share of such fuels at 71% in 2018. If only commercial (i.e. other than traditional biofuel) sources are considered, in the mix for TPES, the majority will be oil and oil products (67%, 2018).

Figure 119: Nepal - Total Primary Energy Supply



Source: International Energy Agency[184]

The TPES in physical terms is provided below.

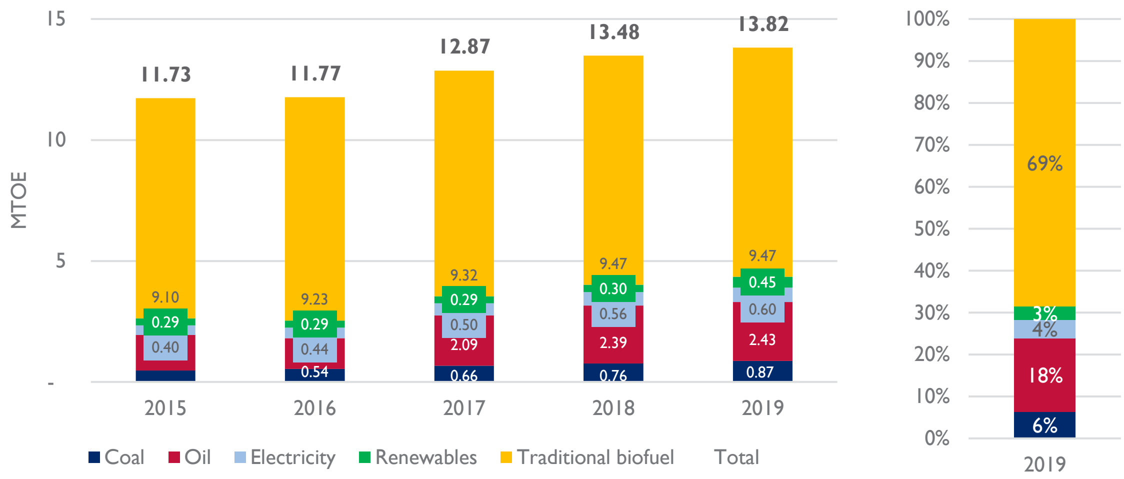
Figure 120: Nepal - TPES in physical and MTOE terms – 2018

Source	Physical Unit	Physical Amount	MTOE
Coal	TJ	35,302	0.84
Oil	TJ	108,124	2.58
Hydro	GWh	4,896	0.42
Electricity	GWh	2,791	0.24
Traditional biomass	TJ	416,248	9.94
Total			**14.03**

Source: International Energy Agency[185]

On overall energy basis, Nepal's energy supply mix is dominated by traditional biofuels (69%). However, oil and oil products, contribute to 56% of the total commercial (i.e. excluding traditional biofuels) energy consumption. In the recent years, there has been a substantial increase of the share of oil in the energy mix. The total energy consumption has grown at an annual rate of 4.2% between 2015 and 2019.

Figure 121: Nepal – Total Final Energy Consumption from commercial sources



2019 data is extrapolated for the year from initial 8 months.   Source: Ministry of Finance[186]

It may be noted that the estimates of energy consumption from traditional sources such as firewood and agricultural residue are more than twice that of the total commercial energy. In 2019, consumption from commercial sources were estimated as 4.3 MTOE, whereas consumption from traditional fuels were estimated as 9.5 MTOE.

The energy balance table is provided below.

Table 26: Nepal - Energy balance table – 2018

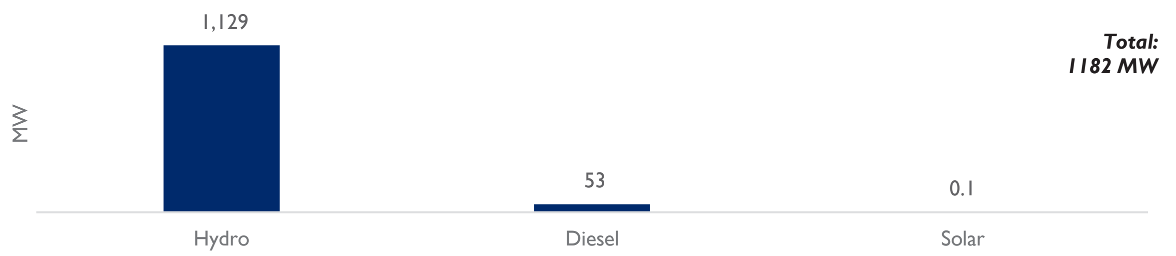
Parameters	MTOE
Primary Energy	10.38
Imports	3.79
Exports	0.00
Foreign bunkers and stock changes	0.14
Total Primary Energy Supply (TPES)	**14.03**
Transformation and losses	0.54
Total Final Energy Consumption (TFEC)	**13.48**

Source: International Energy Agency[187]

6.5.2 Electricity generation

Nepal's installed capacity of electricity is almost entirely of hydropower, with a small capacity of diesel, and negligible amount of solar power. The total hydropower potential is estimated at 83 GW, out of which 43 GW is estimated as economically feasible. Out of this, only 1.1 GW has been utilized yet.

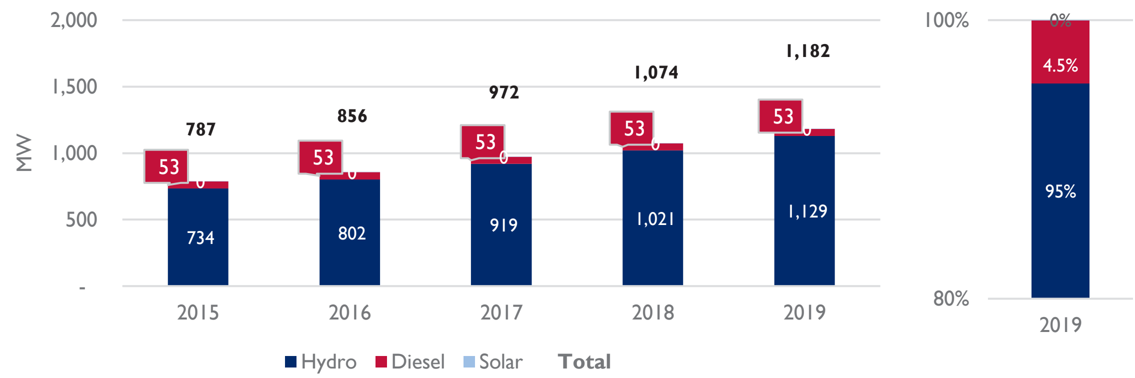
Figure 122: Nepal - Electricity Installed Capacity - 2019



Source: Nepal Electricity Authority [188]

The installed capacity has been increasing by a CAGR of 10.7% between 2015 and 2019.

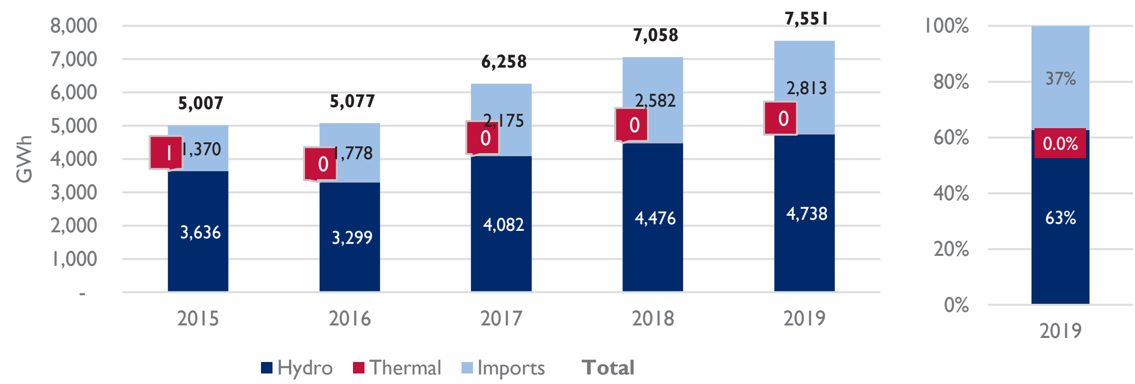
Figure 123: Nepal - Electricity installed capacity trend



Source: Nepal Electricity Authority [189]

In terms of overall energy generation, hydropower is dominant, with 63-73% of the total energy. Almost one third of electricity is imported from India. The share of imports has substantially increased, from 28% in 2014, to 37% in 2019. The imports from India was enabled mainly due to the commissioning of 400 KV Dhalkebar-Muzzafarpur line (currently charged at 220 KV) in 2016. The increase in imports from 2016 can be observed in the figure below. Aided by increased imports as one of the factors, the country has been able to manage its power system without any load shedding in the recent years.

Figure 124: Nepal - Electricity generation from fuel sources



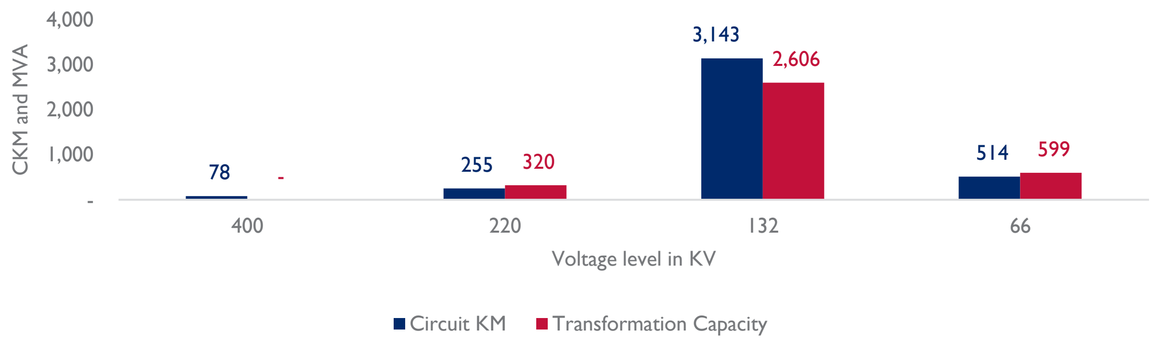
Source: Nepal Electricity Authority [190]

Nepal's plans for electricity generation augmentation is provided in its whitepaper issued in 2018, which envisages installing 15 GW of hydropower between 2019 and 2029. [191]

6.5.3 Electricity transmission and distribution

The transmission network is currently dominated by 132 KV, though more 220 KV and 400 KV network expansion is under progress.

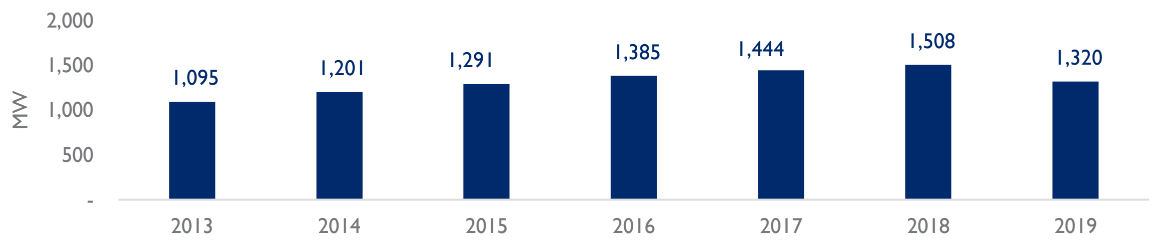
Figure 125: Nepal - Electricity transmission network - 2019



Source: Nepal Electricity Authority [192]

The peak load in the country has increased by almost 50% between 2013 and 2018, reaching 1508 MW in 2018. This has slightly come down in 2019, to 1320 MW.

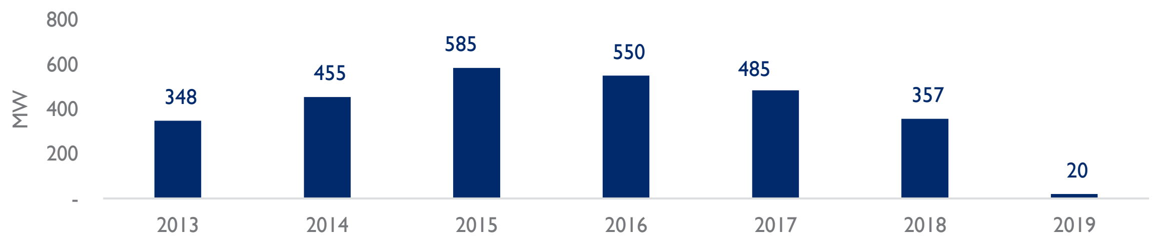
Figure 126: Nepal - Peak electricity demand



Source: Nepal Electricity Authority [193]

The country had power shortages in the past, though it has been able to bring the same down in the recent years, aided by an increase in import of power, through the 400 KV Dhalkebar – Muzaffarpur line.

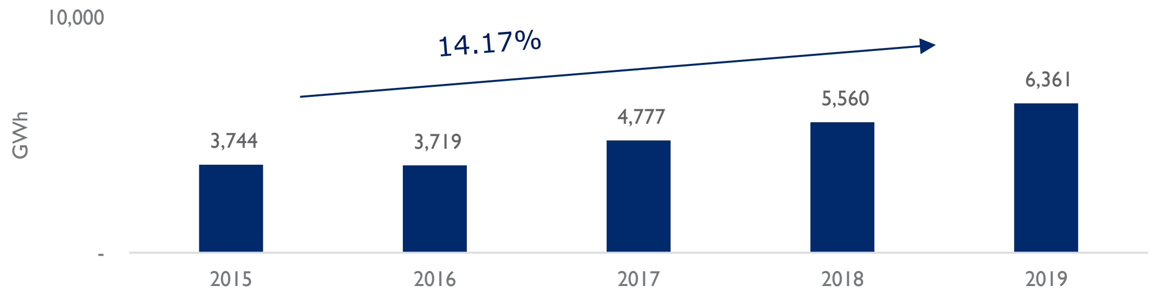
Figure 127: Demand supply gap



Source: Ministry of Finance[194]

Theelectricity sales have shown a steady increase, recording a CAGR of 14.17% between 2015 and 2019. The increase in sales is especially evident from 2017, after the commissioning of 400 KV line with India in 2016. The improved sales in 2017-2019 was accompanied by phased withdrawal of planned load curtailments for industries and other commercial consumers.

Figure 128: Nepal - Electricity Sales



Source: Nepal Electricity Authority [195]

Major transmission augmentation plans of the country is specified in the Transmission System Master Plan (TSMP) which lays down the plan for evacuation of power from upcoming hydropower projects, and the plans for cross border lines. The plan envisages an investment of 6 billion USD for construction of transmission infrastructure, including 6867 km of transmission lines, 103 substations. The plan covers six 400 kV cross border lines with India and two 400 kV cross border lines with China. [196]

- Dododhara to Bareli(India) two double circuit lines;
- Attariya to Bareli(India) double circuit;
- Phulbari to Lucknow (India);
- Butwal to Gorakhpur(India);
- Chilime 400kV to Kerung (China);
- Dhalkebar to Muzzaffarpur (India);
- Inaruwa to Purnea .(India); and
- Kimanthanka to Latse (China).

6.5.4 Energy resources and potential

Nepal does not have any considerable reserves of coal, oil and natural gas.

Figure 129: Nepal - Energy resource potential

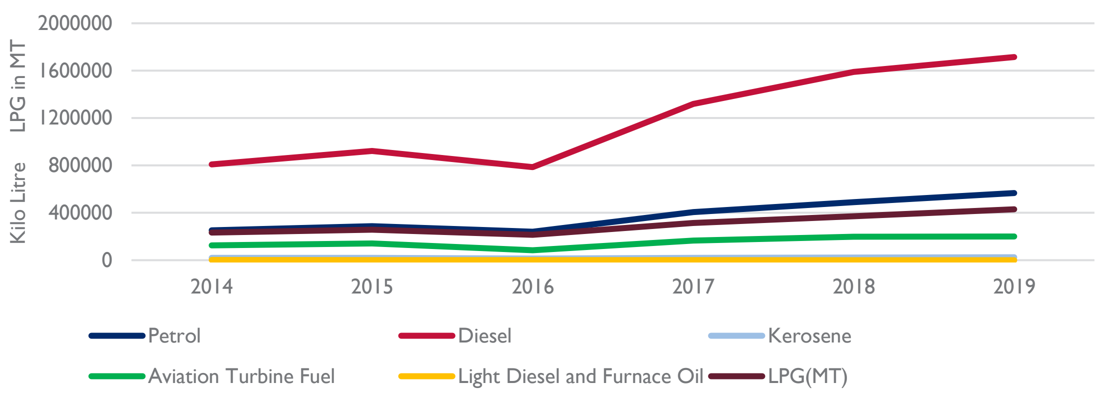
Resource	Natural gas	Oil	Coal
Unit	TCF	Million barrels	Million Tonnes
Total reserves	-	-	< 1

Source: Department of Mines and Geology [197]

Oil

Oil products and LPG are entirely imported, through Nepal Oil Corporation.

Figure 130: Nepal - Import of oil resources



Source: Nepal Oil Corporation [198]

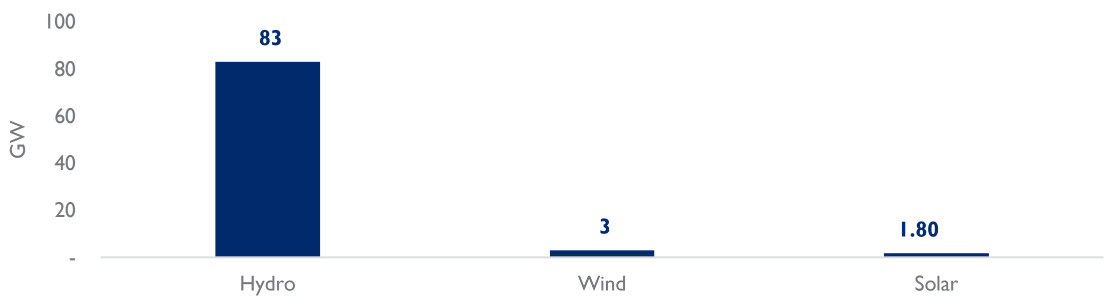
Coal

1.9 Million MT of coal was imported to Nepal in 2019.[199] There is a very minor level of production of coal, which is in the annual range of 3000 to 10,000 tonnes.[200]

Renewable Energy

Nepal's estimated hydropower potential is 83 GW, though only 42 GW is considered as economically viable. The solar potential is estimated as 1.8 GW and wind power potential is estimated as 3 GW.

Figure 131: Nepal - RE potential



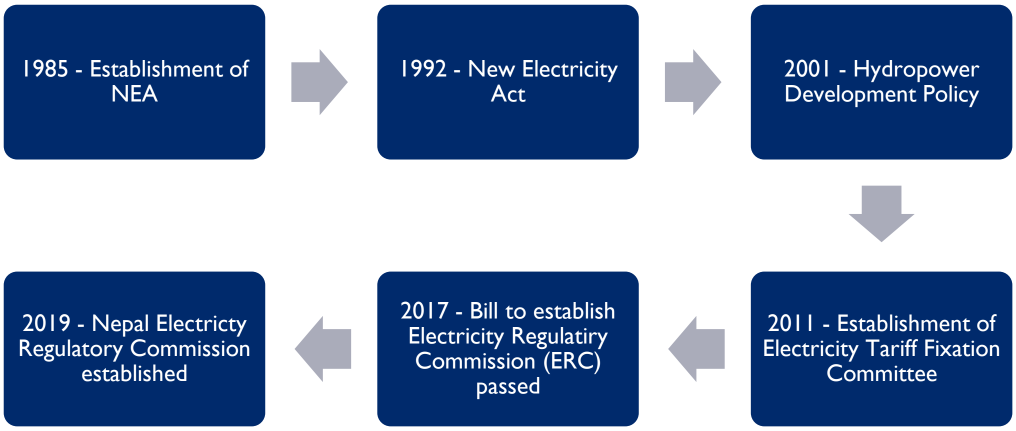
Source: Asian Development Bank, IBN [201]

6.5.5 Energy transition and reforms

Reforms

In electricity, other than the generation sector, and a small area for distribution in Butwal, the sector is operated entirely by the government owned Nepal Electricity Authority (NEA). NEA is also the single buyer in the power system. However, the sector has recently come under an independent regulatory framework under Electricity Regulatory Commission (ERC). The Government of Nepal has published the draft of a new Electricity Act, which further aims to introduce more reforms, such as introduction of trading licensees, and potential unbundling of NEA in the future. Nepal's electricity sector (NEA) is responsible for the overall system planning and cross-border transactions with India. There is a plan to take out the generation, transmission and distribution functions from NEA as part of the overall reforms.

Figure 132: Nepal - Sector reforms



Petroleum import and distribution is also under state control, through Nepal Oil Corporation (NOC). An Automatic Petroleum Pricing Mechanism (APPM) has been in place for petroleum products, since 2014, wherein the prices are revised in every 15 to 30 days on the basis of average international market prices.

Master Plans

The Government's vision for energy sector is laid out in the whitepaper issued by MoEWRI in 2019.

Table 27: Nepal's Energy Sector Whitepaper of 2019

Sl No	Area of intervention	Strategies / targets
1	Energy production	15000 MW hydropower by 2029
2	Electricity usage	Annual per-capita consumption of 1500 kWh by 2029 100% electricity access by 2024
3	Domestic transmission network expansion	East-West, Mid-Hill and River Basin Corridors to be developed at 400 KV
4	Cross border transmission lines	400 KV Butwal-Gorakhpur (India) to be completed in four years 400 KV Galchhi-Rasuwagadi-Kerung line with China to be completed in five years 400 KV Lamki-Bareli, Duhabi-Purniya and Kohalpur-Lakhnau lines with India to be developed
5	Demand Side Management	Demand management of up to 200 MW by 2022
6	Alternate energy	200 MW small scale systems to be developed with subsidy support

Source: Ministry of Energy, Water Resources and Irrigation [202]

Climate policy

The Nationally Determined Contribution of Government of Nepal (GoN) has laid down the following targets:[203]

- By 2020, Nepal intends to expand its energy mix focusing on renewables by 20% and diversifying its energy consumption pattern to more industrial and commercial sectors;
- By 2050, Nepal will achieve 80% electrification through renewable energy sources having appropriate energy mix. Nepal will also reduce its dependency on fossil fuels by 50%;
- By 2020, Nepal aims to increase the share of electric vehicles up to 20% from 2010 level;
- By 2050, Nepal will decrease its dependency on fossils in the transport sector by 50% through effective mass public transport means while promoting energy efficient and electrical vehicles; and
- Nepal will develop its electrical (hydro-powered) rail network by 2040 to support mass transportation of goods and public commuting.

Energy efficiency

For promotion of energy efficiency, the Government of Nepal had published its National Energy Efficiency Strategy in 2018. The strategies discussed includes commencement of energy efficiency standards and labelling, energy audit for large consumers, and commencement of studies to use EE to reduce imports and peak demand. As per the strategy, MoEWRI will be the responsible entity, supported by NEA and DOED. Various municipalities in Nepal have undertaken projects for installation of solar powered street lights, with some of them under PPP mode.

Nepal Electricity Authority has taken various steps towards increasing energy efficiency by implementing demand side management (DSM) activities. These include awareness campaigns for using energy efficiency appliances such as LEDs, efficiency fans, and other appliances etc. Additionally, NEA has also introduced Time-of-Day tariffs (ToD) to use price signal to activate DSM. NEA has installed ToD meters at various industrial hubs and business centers in its effort to boost energy efficiency and demand side management.[204]

Electric vehicles

On electric vehicles, various initiatives are being taken up by entities in different sectors. In January 2020, NEA has issued a tender for installation, and O&M of 50 charging stations for EVs across 9 cities. Earlier, NEA had also opened a demo charging station at its office in order to boost public interest in EVs. The Ministry of Physical Infrastructure and Transport (MOPIT) is planning a project for introduction of electric buses in Kathmandu valley.

Smart grids

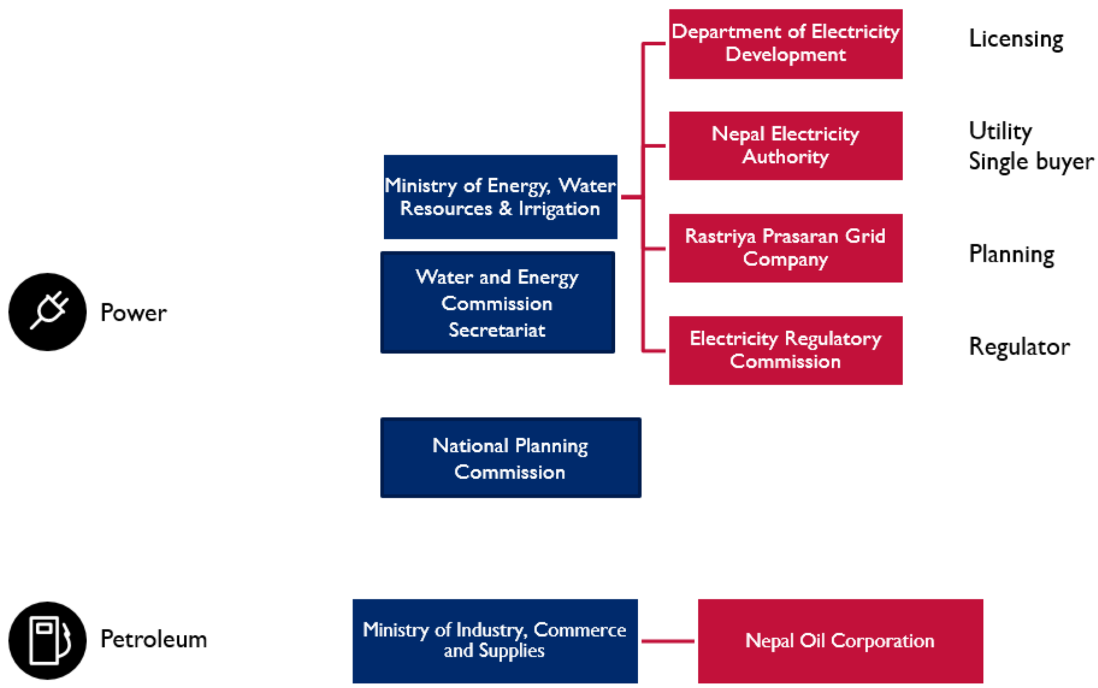
On smart grids, NEA has launched 'Kathmandu Valley Smart Metering Project' in 2017, with an initial target of installing 90,000 smart meters. NEA has also been deploying substation automation systems in its grid substations.

6.5.6 Institutional framework for regional energy cooperation

In Nepal, key policy decisions related to regional energy cooperation is taken by the Ministry of Energy, Water Resources and Irrigation (MoEWRI). Many of the bilateral energy cooperation arrangements with India, Bangladesh etc., are handled directly by the Ministry. At the operational level, the cooperation in electricity sector is handled by the Nepal Electricity Authority (NEA), which assists the MoEWRI on all matters related to regional energy cooperation in electricity. The electricity sector is regulated by Electricity Regulatory Commission. A Rastriya Prasaran Grid Company (RPGCL) has also been established by the government, for planning at 400 KV transmission level and above.

Licenses in electricity sector, including electricity import and export licenses, are granted by the Department of Electricity Development (DOED) which functions under MoEWRI. Meanwhile, the Water and Energy Commission Secretariat (WECS) assists the Government of Nepal (GoN) in the formulation of policies and planning of projects in the water and energy resources sector. The role of WECS includes rendering opinion, advice and recommendation on the bilateral and multilateral issue relating to water resources and energy.

Figure 133: Nepal - Institutional framework for regional energy cooperation



Source: Ministry of Energy, WECS, National Planning Commission, Ministry of Industry [205]

The petroleum sector comes under the Ministry of Industry, Commerce and Supplies. The operational activities, such as the import of petroleum products and LPG are undertaken by the Nepal Oil Corporation (NOC), which works under the oversight of the Ministry.

The National Planning Commission (NPC) is the specialised and apex advisory body of the Government of Nepal for formulating a national vision, development policy, periodic plans and sectoral policies for overall development of the nation. It is headed by the Prime Minister. The five year plans of NPC also covers the plans related to energy sector.

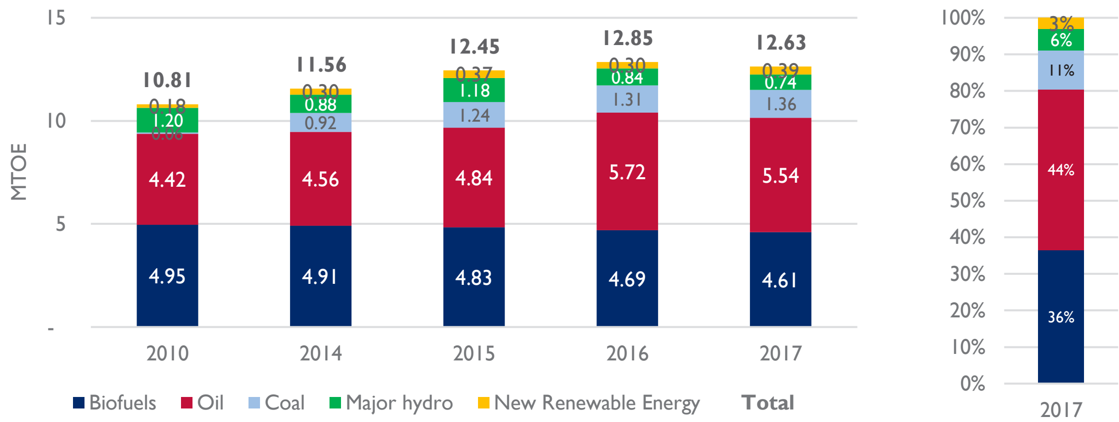
6.6 Sri Lanka

Sri Lanka (formerly Ceylon) is an island nation south of India in the Indian Ocean. Its diverse landscapes range from rainforest and arid plains to highlands and sandy beaches. Sri Lanka spreads across 65,610 sq km and has a population of about 21.8 million.

6.6.1 Energy consumption and supply trends

Primary energy supply in Sri Lanka is dominated by petroleum and biomass. The energy supply has increased at a CAGR of 3% between 2014 (11.6 MTOE) and 2017 (12.6 MTOE). The share of petroleum in the mix can be seen to be rising every year. Due to use in power generation, coal has also become a significant energy supply source in Sri Lanka.

Figure 134: Sri Lanka – Total Primary Energy Supply



Source: Sri Lanka Sustainable Energy Authority [206]

The TPES in physical terms and MTOE is provided below.

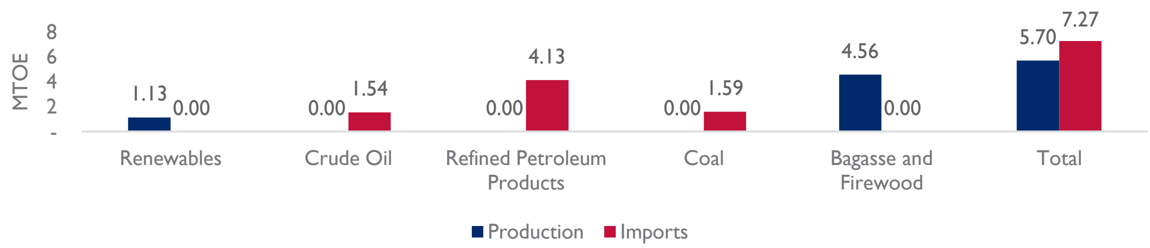
Table 28: Sri Lanka - TPES in physical terms and MTOE - 2017

Source	Physical Unit	Physical Amount	MTOE
Coal	KT	2,157	1.36
Petroleum	KT	5,269	5.54
Large hydro	GWh	8,584	0.74
Renewables	GWh	4,500	0.39
Biomass	KT	12,110	4.61
Total			**12.63**

Source: Sri Lanka Sustainable Energy Authority [207]

Being an island with limited resources, the country is heavily dependent on imports to meet its energy needs. In 2017, imported energy resources contributed to 57% of the overall primary energy supply. The entire crude oil and coal requirements are met through imports.

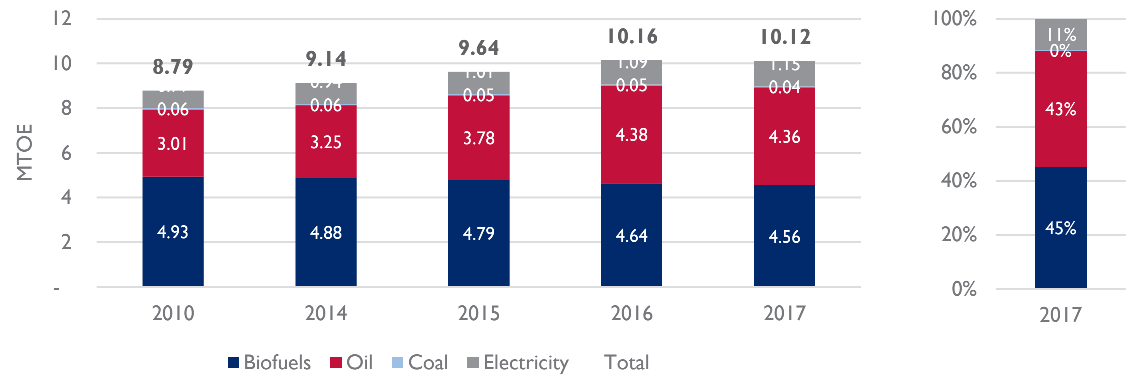
Figure 135: Sri Lanka - Energy imports



Source: Sri Lanka Sustainable Energy Authority [208]

In the final energy consumption, after traditional biofuels (45%, 2017), the oil products have the largest share of 43%.

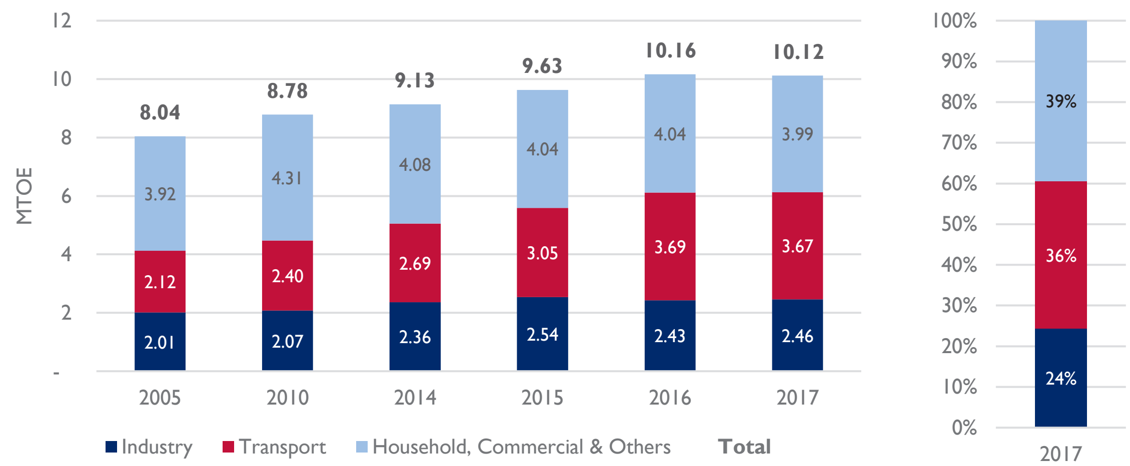
Figure 136: Sri Lanka - Total Final Energy Consumption



Source: Sri Lanka Sustainable Energy Authority [209]

Most of the energy consumption is by the household and commercial sectors (39%), followed by transport (29%) and industry (24%) as on 2017. The share of transport can be seen to be improving in the recent years, in comparison to the other sectors.

Figure 137: Sri Lanka - Sector wise energy consumption



Source: Sri Lanka Sustainable Energy Authority [210]

The energy balance of Sri Lanka for 2017 is provided below:

Table 29: Sri Lanka - Energy Balance - 2017

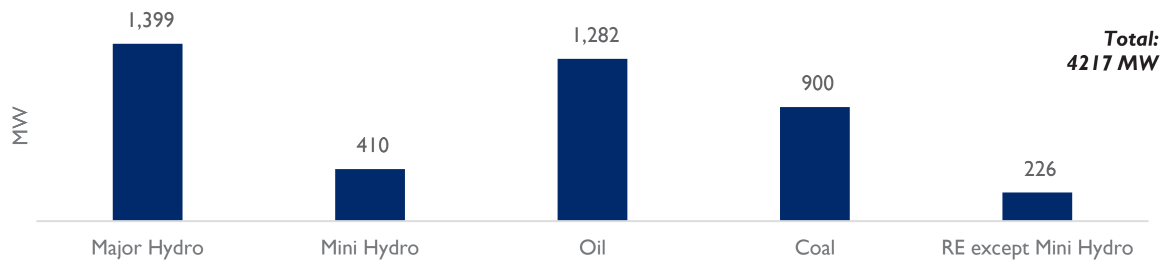
Parameters	MTOE
Primary Energy	5.7
Imports	7.3
Exports	-
Foreign bunkers and stock changes	-0.3
Total Primary Energy Supply (TPES)	**12.6**
Transformation	-2.3
Own uses and losses	-0.2
Total Final Energy Consumption (TFEC)	**10.1**

Source: Sri Lanka Sustainable Energy Authority [211]

6.6.2 Electricity generation

Sri Lanka has a diverse mix of electricity generation capacity, with 48% of it based on hydro and renewable energy sources. Since hydro is dependent on monsoon, the country maintains a substantial share of oil based power plants.

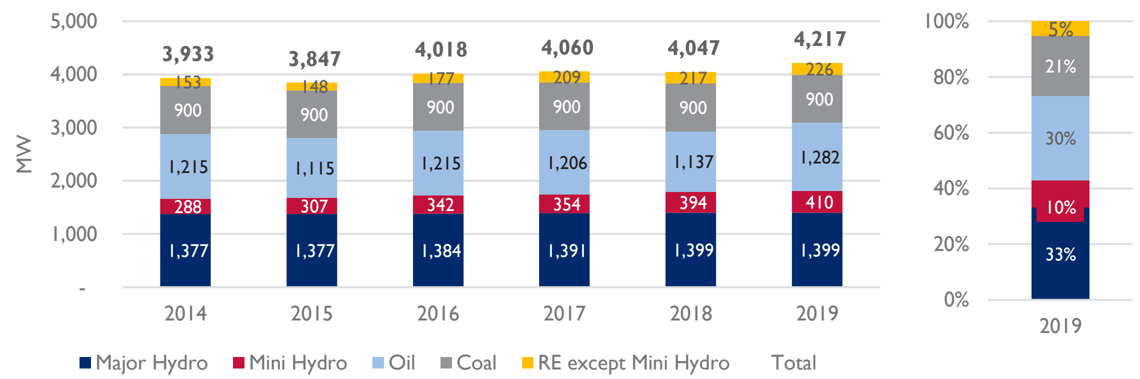
Figure 138: Sri Lanka - Electricity Installed Capacity - 2019



Source: Ceylon Electricity Board [212]

Most of the capacity addition in the past years have been on renewable energy, oil and mini hydro points, with coal capacity remaining constant for over five years, and only slight increase in large hydro capacity.

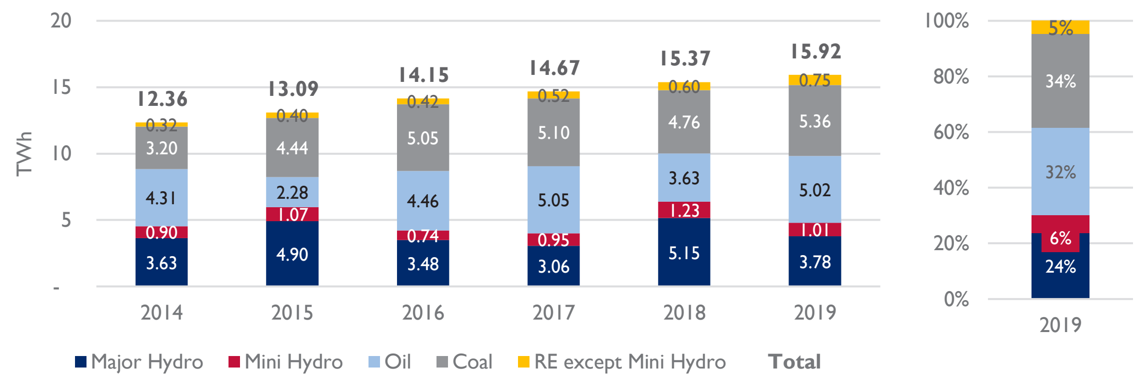
Figure 139: Sri Lanka - Trend of installed capacity



Source: Ceylon Electricity Board [213]

In terms of electricity generation, a complementary pattern can be observed between hydro and oil sources. In the years when generation from hydro power has increased, decrease in generation from liquid fuels can be observed. It can be seen that when hydropower has increased in 2015 and 2018, the share of oil has also correspondingly reduced. In comparison, generation from coal has been mostly on similar levels between 2015 and 2018, though the same also increased in 2019, while the installed capacity has remained the same.

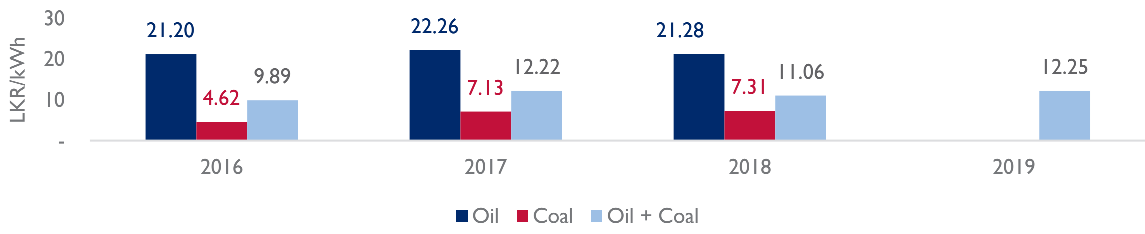
Figure 140: Sri Lanka - Electricity Generation based on fuel sources



Source: Ceylon Electricity Board [214]

The cost of electricity generation is substantially higher for oil based power plants, when compared with coal power plant.

Figure 141: Sri Lanka - Cost of electricity generation of CEB power plants



Source: Ceylon Electricity Board [215]

CEB's Long Term Generation Expansion plan has envisaged significant RE and thermal additions, along with thermal retirements for future years. Between 2020 and 2035, 3.5 GW of renewable energy (including large hydro) and 5.7 GW of thermal power capacity is planned to be added.

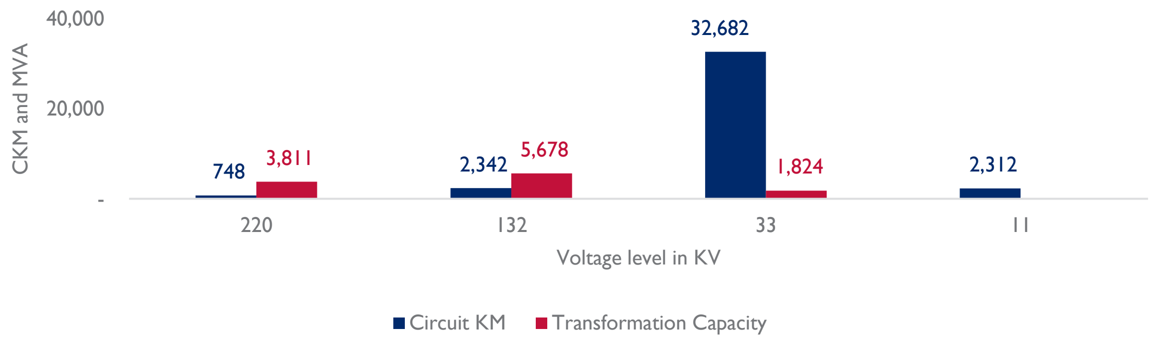
Year	RE addition [MW]	Thermal addition [MW]	Thermal retirement [MW]
2020	140	445	30
2021	292	525	471
2022	230	396	290
2023	250	863	572
2024	190	300	68
2025	145	300	62
2026	140	600	96
2027	155		
2028	355		
2029	355		
2030	355	300	
2031	175		
2032	175	496	196
2033	160	600	357
2034	205	300	
2035	180	600	300
Total	**3,502**	**5,725**	**2,442**

Source: Ceylon Electricity Board [216]

6.6.3 Electricity transmission and distribution

The country's transmission network is built mainly on 220 KV, 132 KV and 33 KV voltage levels.

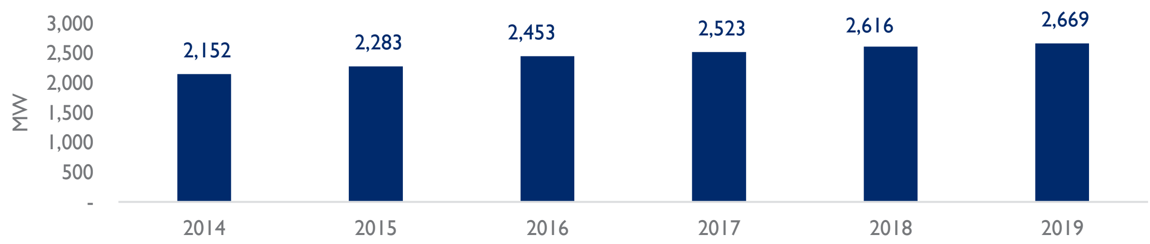
Figure 142: Sri Lanka - Transmission network - 2019



Source: Ceylon Electricity Board [217]

The peak demand has increased from 2152 MW in 2014 to 2669 MW in 2019.

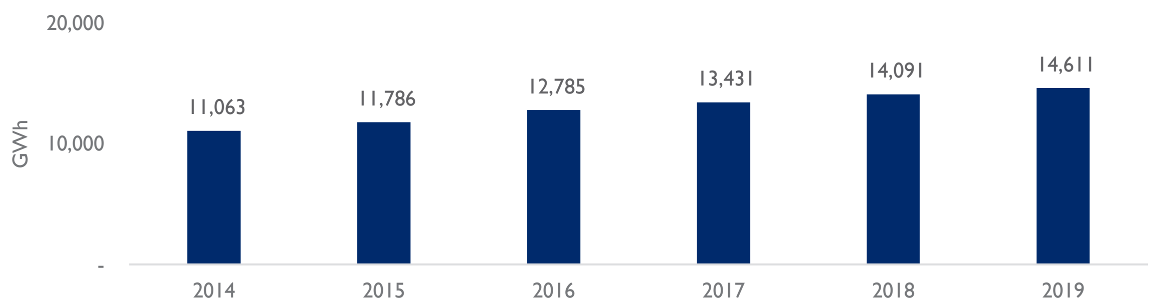
Figure 143: Sri Lanka - Peak demand



Source: Ceylon Electricity Board [218]

The electricity sales have grown at a CAGR of 5.72% between 2014 and 2019.

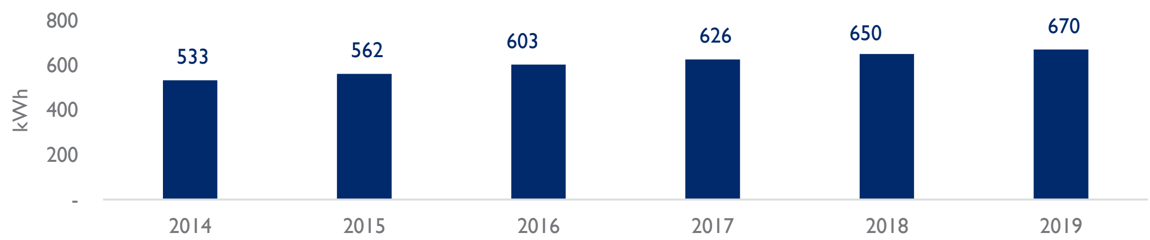
Figure 144: Sri Lanka - Electricity Sales



Source: Ceylon Electricity Board [219]

Sri Lanka has reported 100% electrification, and a steady increase in per capita electricity consumption, which grew at a CAGR of 4.7% between 2014 and 2019.

Figure 145: Sri Lanka - Per capita electricity consumption



Source: Ceylon Electricity Board [220]

As part of the transmission development plan, CEB has planned the following for the power sector up to 2027, at a cost of LKR 279 billion (USD 1,811 million):[221]

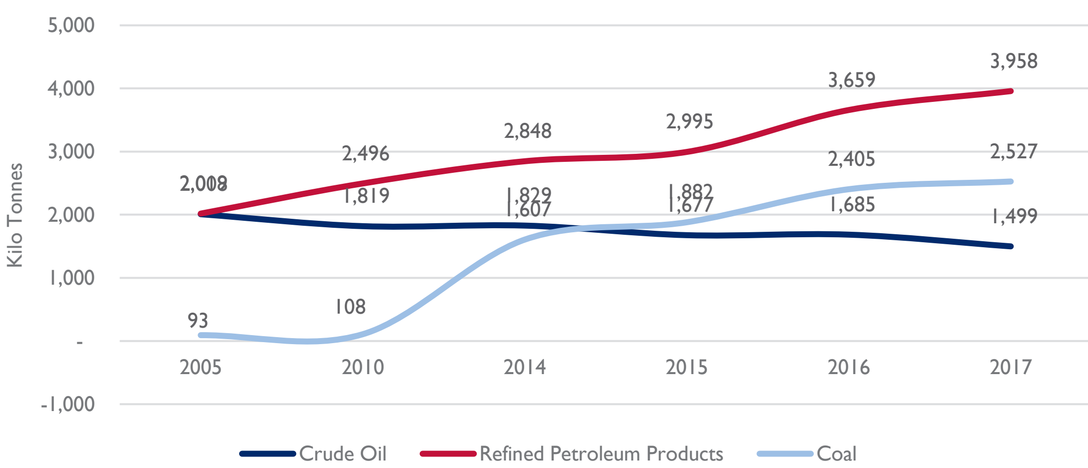
1. Transmission line (new construction): Construction of 100 kms of 400 kV lines, 907 kms of 220 kV lines and 867 kms of 132 kV lines.
2. Transmission line (capacity enhancement): Enhancement of 100 kms of 220 kV lines, and 544 kms of 132 kV lines.
3. Grid substations (new construction):
    a. 4300 MVA of 220/132 kV substations
    b. 1647 MVA of 220/33 kV substations
    c. 320 MVA of 220/22 kV substations
    d. 2391 MVA of 132/33 kV substations
    e. 1026 MVA of 132/11 kV substations
4. Grid substations (augmentation): The plan envisages augmentation of 327 MVA of 132/33 kV station, and 63 MVA of 132/11 kV station.

6.6.4 Energy resources and potential

Sri Lanka does not have any considerable proven reserves of coal, oil and natural gas. However, exploration activities are underway for oil and gas fields, and therefore there could be discoveries of proven reserves in the future.

Sri Lanka imports its entire coal and crude oil requirement, as there is no commercial production of these resources in the country. The country also imports refined petroleum products. The coal imports have started on account of the commissioning of Lakvijaya power plant, which was commissioned in 2011.

Figure 146: Sri Lanka - Import of coal, oil and gas



Source: Sri Lanka Sustainable Energy Authority [222]

Renewable energy

As per ADB estimates, almost all the economic potential has already been developed for hydropower generation in large scale power plants. Most of the major hydropower schemes are associated with Sri Lanka's two main rivers—Mahaweli and Kelani, on which 1,370 MW of large hydro and 20.5 MW of small hydro have been developed by the CEB. About 350 MW of small hydropower plants have been developed by private small power producers (SPPs), while 247 MW of committed power plants are in various stages of development by CEB. However, there is solar and wind power potential of 11.6 GW.

Figure 147: Sri Lanka - RE potential

Source: Asian Development Bank[223]

6.6.5 Energy transition and reforms

Reforms

The Sri Lankan electricity sector is licensed and regulated by the Public Utilities Commission of Sri Lanka (PUCSL). The state owned and vertically integrated Ceylon Electricity Board (CEB) continues to perform generation, bulk supply and distribution functions, along with acting as single buyer. In some of the urban areas, electricity is supplied by Lanka Electricity Company (LECO), which buys power from CEB. Private sector participation is allowed in the generation function

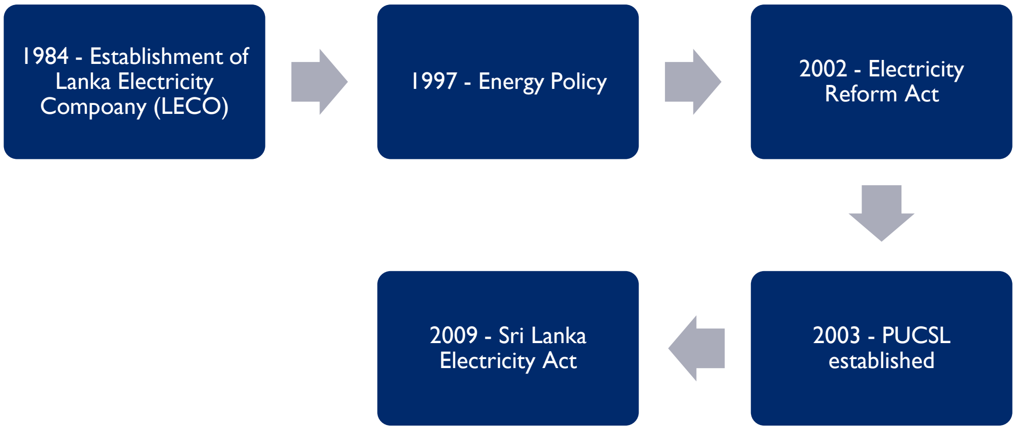
PUCSL was intended to regulate the petroleum sector also, though the supporting legislation for the same has not been passed yet. The downstream market of petroleum sector is also operated mostly by the state owned Ceylon Petroleum Corporation (CPC). There is also private sector participation in the form of Lanka IOC PLC which handles many of the retail outlets. The pricing of petroleum is closely controlled by the Government.

Before independence, the power sector in Sri Lanka was owned and operated by a government department. However, in 1969, the management and operation of the sector was formally transferred to CEB, a public sector undertaking, constituted by the Government of Sri Lanka that operated as a vertically-integrated monopoly regulated by the Ministry of Power and Energy. CEB, a bundled utility, carried out all three functions of electricity generation, transmission and distribution, along with retail supply, with no competition at any level. While the creation of a separate utility to manage the day-to-day functioning of the sector was some improvement over the previous model, the fault line of this model became visible in the form of pricing inefficiencies, high transmission and distribution losses, perceived structural and managerial weaknesses and operational inefficiencies within the monolithic power utilities. These inefficiencies were some of the key drivers of the power sector reforms in Sri Lanka.

The reforms have been carried out in two distinct phases. The first phase of power sector reforms was carried out during 1982-2008. This period witnessed the establishment of a state-owned distribution company, Lanka Electricity Company; the introduction of some administrative changes in the management of CEB and, finally, structural reforms, with the enactment of the Electricity Reform Act, No. 28 and the Public Utilities Commission Act, No. 35, to regulate the sector.

The second phase of power sector reforms was carried out from 2009 onwards with the implementation, that is, the operationalisation of the Electricity Reform Act, No. 20. The revised Act allowed the Power Sector Utilities Commission to finally operate as the power sector regulator, but it authorised less restructuring of CEB than had been originally proposed in the 2002 Electricity Reform Act. Under the revised structure, the three separate functions (generation, transmission and distribution) of CEB were not spun off as separate entities with an independent ownership structure and management. Instead, a single-buyer model was introduced, with the CEB transmission entity as the single buyer. As a result, CEB now holds a total of six power sector licences—a generation licence for about 66 per cent of all generating capacity in the grid; a transmission licence for 100 per cent of transmission and for 100 per cent of bulk supply in accordance with the single-buyer model; and four distribution licences that cover approximately 90 per cent of power consumers.

Figure 148: Sri Lanka - Sector reforms



Master plans

The government's energy policy is published in the National Energy Policy and Strategies document of 2019. [224] The document lays down the following strategies:

Table 30: Sri Lanka's Energy Policy, 2019

Policy Pillars	Implementing Strategies
Assuring Energy Security	Diversity in energy resources used in electricity generation will be ensured A liquefied natural gas(LNG) terminal of optimum size and technology would be established at the most suitable location Percentage installed power generation capacity from a single imported fuel shall not exceed 50% of the total installed firm capacity Viable cross-border electricity transmission and cooperation with countries in the region will be pursued on the basis of multilateral power pool operation
Providing Access to Energy Services	Access to electricity using either on-grid or off-grid sources and to modern petroleum products will be ensured to all citizens in the country Smart grid technologies will be introduced, and smart metering will be deployed for enhanced customer experience, and to automate power system management, reducing manual intervention where such interventions are uneconomical
Providing Energy Services at the Optimum Cost to the National Economy	Power plants identified in the Long-Term Generation Expansion Plan will be implemented as scheduled.

Policy Pillars	Implementing Strategies
Improving Energy Efficiency and Conservation	The national energy efficiency improvement and conservation programme will be further strengthened engaging all stakeholders in household, industrial and commercial sectors. Energy efficiency improvement and conservation will be promoted through minimum energy performance standards and labelling of appliances, and by introducing green procurement processes in state and private sector organisations. A strategic plan for street lighting will be formulated to ensure proper management of street lighting that will enhance the safety of road users, and to contribute to energy conservation with a better aesthetic sense. Automated demand response technologies will be considered as a main demand-side management strategy. Smart technologies, including smart buildings and complete conversion to smart metering will be ensured to convey price signals to customers, altering the demand profile to reduce the overall cost of supply.
Enhancing Self Reliance	Oil and natural gas resources of the country will be explored. Renewable energy resources will be exploited based on a priority orderarrived at, considering economics, technology and quality of each resource.
Caring for the Environment	Impacts to the environment in the context of climate change due to the construction and operation of energy sector facilities will be minimised. Waste to energy projects will be favourably considered.
Enhancing the Share of Renewable Energy	Renewable energy investments for electricity generation will be realised through a competitive scheme. Distribution infrastructure will be upgraded with smart grid technologies to facilitate renewable energy-based distributed generation. Energy storage solutions will be encouraged for firming intermittent renewable sources, voltage and frequency regulation, local grid support, peak shaving and improving grid resilience.
Strengthening Good Governance in the Energy Sector	All sub sectors in the energy industry will be brought under respective regulatory framework. Digitalisation of the energy sector entities using an enterprise resource planning platform will be taken as a priority, spanning the whole length of the value chain from smart meters, addressable appliances and smart grids that allows further adoption of new technologies such as artificial intelligence (AI), internet of things (IoT) and distributed ledgers to drive efficiency, transparency and optimisation of asset utilisation.
Securing Land for Future	Best sites to locate large scale renewable energy infrastructure such as wind and solar farms would be identified in advance and marked on a master plan.

Policy Pillars	**Implementing Strategies**
Energy Infrastructure	
Providing Opportunities for Innovation and Entrepreneurship	Sri Lankan enterprises will be encouraged to engage in energy sector infrastructure development potential offered by vehicle energy storage systems (ESS) will be studied considering ESS as a local standby energy storage device, deploying those as an automated demand response (ADR) option and a load profile management too. Small scale on-grid distributed and off-grid stand-alone applications using renewable energy with local value addition will be encouraged as an economic development thrust.

While the above mentioned policy refers to a macro-level overview, specific targets are laid out in Sri Lanka Energy Sector Development Plan, Renewable Energy Master Plan, and Nationally Determined Contributions.

Sri Lanka's specific nationally determined contributions[225] for the energy sector include:

NDC 1: Establishment of large scale wind power plants of 514 MW;

NDC 2: Establishment of 115 MW of solar power plants;

NDC 3: Establishment of 105 MW of biomass power plants;

NDC 4: Establishment of 176 MW of mini hydro power plants;

NDC 5: Introduction of Demand Side Management (DSM) activities;

NDC 6: Strengthening sustainable energy related policies with a view to increasing the share of renewable energy from the existing 50%, to 60% in 2020; and

NDC 7: Converting existing fuel oil based power plants to LNG.

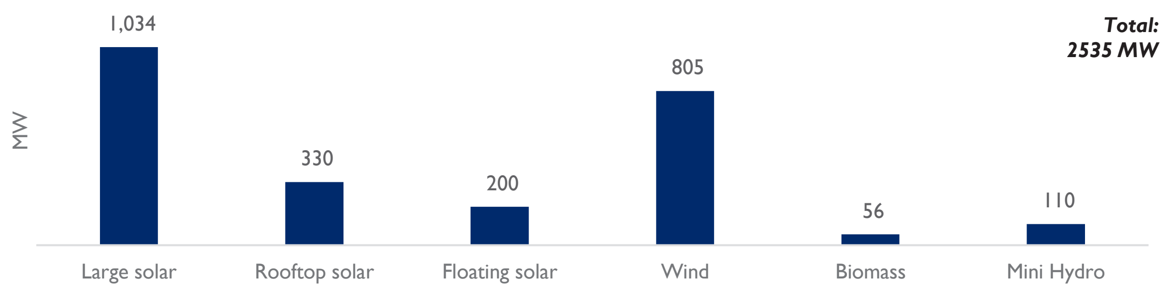
The earlier Sri Lanka Energy Sector Development Plan of 2015[226] had set the following energy sector targets:

1. To make Sri Lanka an energy self-sufficient nation by 2030.
2. Increase the share of electricity generation from renewable energy sources from 50% in 2014 to 60% by 2020 and finally to meet the total demand from renewable and other indigenous energy resources by 2030.
3. Increase the electricity generation capacity of the system from 4,050 MW to 6,400 MW by 2025.
4. Generate a minimum 1,000 MW of electricity using indigenous gas resources discovered in Mannar basin by 2020.
5. Increase generation capacity of low cost thermal power plants fired by natural gas and biomass to 2,000 MW to reduce the generation costs and to diversify generation mix by 2020.
6. Provide affordable electricity coverage to100% of the people of the country on a continuous basis before end 2015.
7. Reduce the technical and commercial losses of the electricity transmission and distribution network from 11% to 8% by 2020.
8. Reduce annual energy demand growth by 2% through conservation and efficient use.
9. Reduce the petroleum fuel use in the transport sub-sector by 5% by introducing alternative strategies such as efficient modes of transport and electrification of transport by 2020.

10. Produce the total petroleum product demand of the country through our own refinery by 2025.
11. Upgrade quality of Gasoline and Diesel to EURO IV and EURO III respectively by 2018.
12. Further enhance the quality and reliability of electricity and fuel supply.
13. Broadening energy sector investment windows to include bonds, debentures, public private partnerships and other such novel financial instruments.
14. Reduce the carbon footprint of the energy sector by 5% by 2025.

Similarly, RE targets are laid out in the Government's RE Development Plan. It aims to have solar capacity of 1564 MW, wind power of 805 MW, biomass power of 56 MW and mini hydropower plants of 110 MW between 2019 and 2025. The solar power plants are planned as utility scale, rooftop solar and floating solar separately.

Figure 149: Sri Lanka RE capacity expansion plans for 2019-25



Source: Sri Lanka Sustainable Energy Authority [227]

Other efforts

The National Energy Policy and Strategies document of 2019 has stated the Government's support towards energy efficiency, energy conservation, smart grids, energy storage etc.

Compact fluorescent lamps (CFLs) are already under a legally enforced energy performance standard, and a performance label. Energy efficiency building code has been in practice since 2002. PUCSL issued its Utility-Driven Demand Side Management (DSM) Regulations in 2016. As per these regulations, the distribution licensees are required to submit their DSM Master Plan and DSM Programme to PUCSL for approval.

6.6.6 Institutional framework

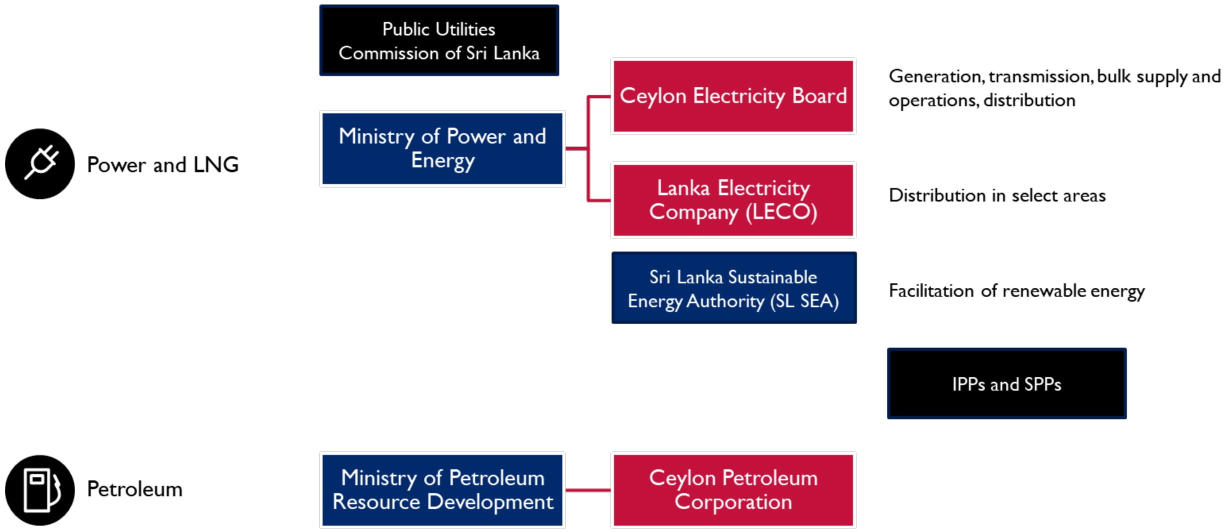
In Sri Lanka, the Ministry of Power, Energy and Business Development is responsible for the overall energy policy. The Ministry also supervises the state owned energy entities such as Ceylon Electricity Board (CEB) and Lanka Electricity Company (LECO). The Ministry also oversees decisions relating to LNG, as the same is intended mostly for power generation.

Since CEB is the single buyer, and also the transmission utility, activities related to proposed India – Sri Lanka electricity transmission interconnection is also being undertaken by it, under the direction and oversight of the Ministry. CEB is also the joint venture counterpart for joint venture Generation projects with India, China and Japan.

The Public Utilities Commission of Sri Lanka (PUCSL) is the infrastructure regulatory commission empowered to regulate the electricity, bunker and lubricating oil industries. The Sri Lanka Electricity Act, No. 20, of 2009 (subsequent amendment in 2013) mandates the Commission to promote competition and determine transmission pricing in a way that it provides an efficient service to the consumers. Currently Sri Lanka does not have CBET with any country.

The Ministry of Petroleum Resources Development oversees exploration of gas and petroleum, and supervises the state owned entities in oil and gas sector, such as Ceylon Petroleum Corporation (CPC). The Ministry is vested with overseeing the functions of import, refining, storage, distribution and marketing of petroleum-based products and natural gas. For the import of petroleum products, which is mostly through CPC, there is a Special Standing Cabinet Appointed Procurement Committee (SSCAPC) and a Special Technical Evaluation Committee (TEC).

Figure 150: Sri Lanka - Institutional framework



Source: Ministry of Power and Energy, Ministry of Petroleum Resource Development[228]

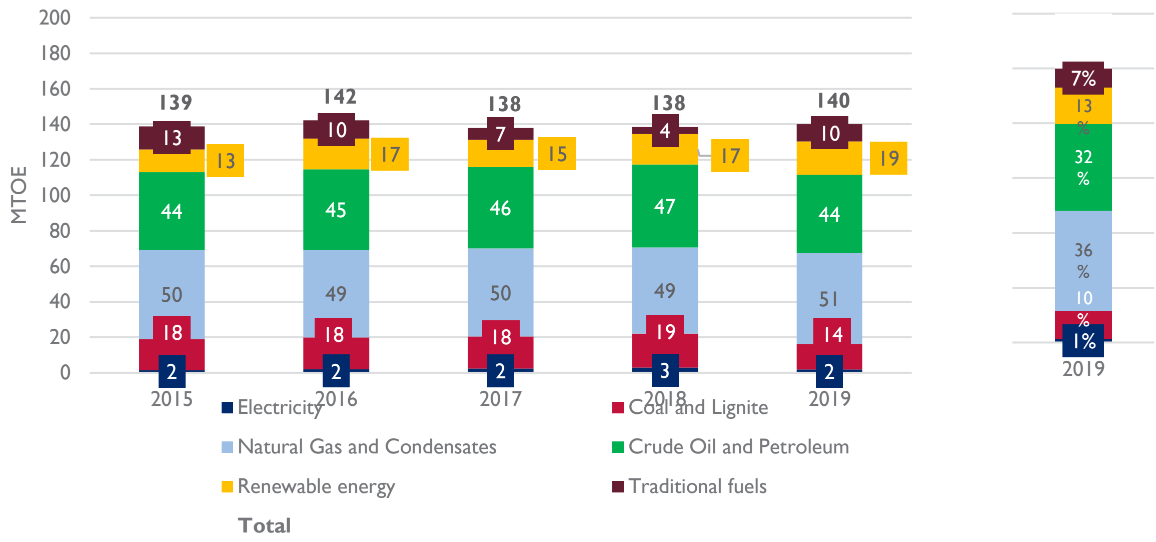
6.7 Thailand

Thailand is located in the heart of the Southeast Asian region. The country is spread across 513,120 sq km, comparable to the size of France and has a land area bigger than that of Japan. Thailand is divided into five regions and has 75 provinces. It is the most developed economy in the BIMSTEC region, in terms of parameters such as per-capita GDP.

6.7.1 Energy consumption and supply trends

Total Primary Energy Supply in Thailand was 140 MTOE in 2019. The TPES trend for Thailand is illustrated below. TPES is dominated by natural gas (36%), followed by crude oil / petroleum (32%). These two sources together contribute 68% of the total TPES. The overall consumption has been increasing at a very moderate CAGR of 0.2% between 2015 (138.9 MTOE) and 2019 (140 MTOE).

Figure 151: Thailand – Total Primary Energy Supply



Source: Ministry of Energy, Government of Thailand [229]

The TPES data in physical terms and MTOE for 2019 is tabulated below.

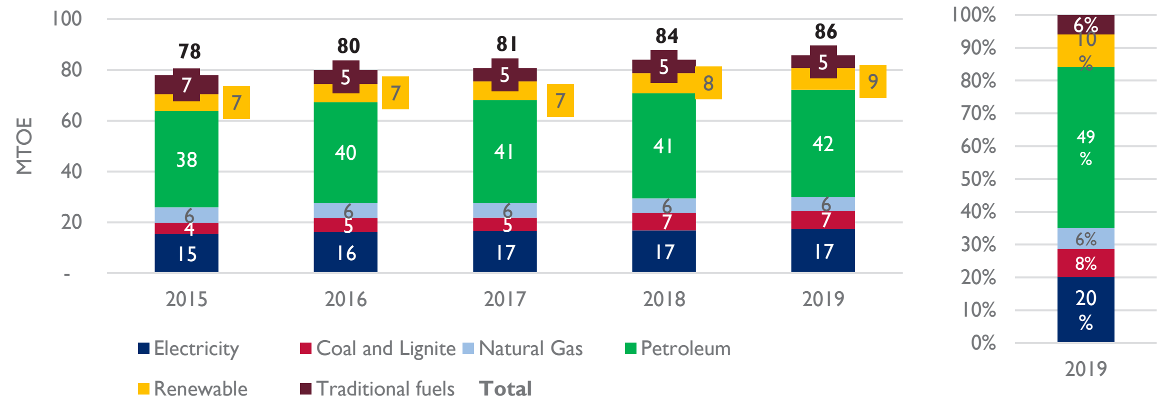
Figure 152: Thailand - TPES in physical terms - 2019

Source	Physical Unit	Physical Amount	MTOE
Electricity (Import)	GWh	22,665	2
Coal and Lignite	'000 Tonnes	31,534	14
Natural Gas	MMScf	1,891,245	46
Condensates	Million litre	6,858	5
Crude Oil and Petroleum	Million litre	51,667	44
Renewable energy	TJ	781,713	19
Traditional fuels	TJ	407,311	10
Total			140

Source: Ministry of Energy, Government of Thailand [230]

The Total Final Energy Consumption (TFEC) grew at a CAGR of 2.4%, from 78 MTOE in 2015 to 86 MTOE in 2019. The share of petroleum (oil/petroleum products) is the highest, at 49%, followed by electricity (20%). The use of petroleum and electricity has been increasing, whereas use of traditional fuels have shown a declining trend.

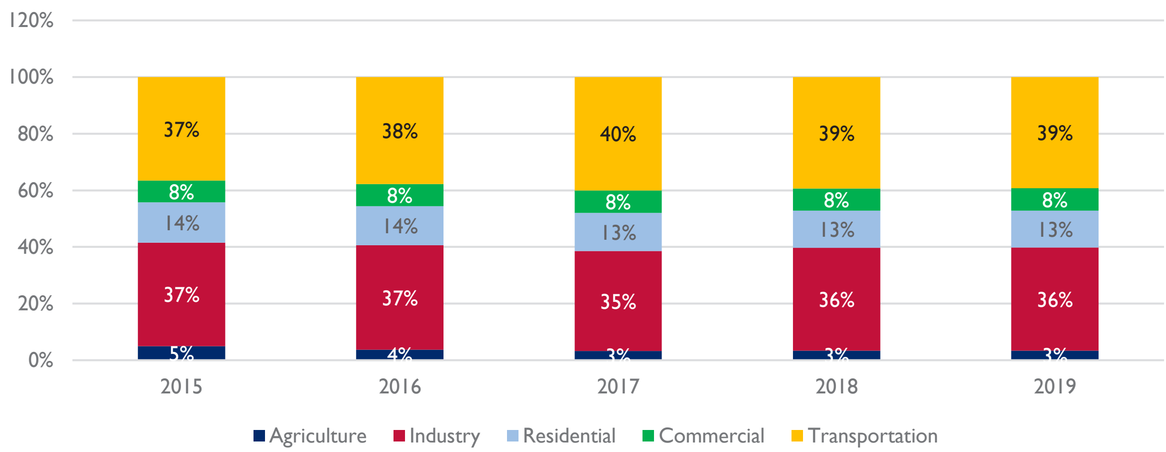
Figure 153: Thailand – Total Final Energy Consumption



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [231]

Bulk of the final energy (72-76%) is consumed by the transport and industrial sectors. The relative share of these sectors have been mostly unchanged in the past years. However, there is a decrease in share of agriculture, which was 5% in 2015, and 3% in 2019.

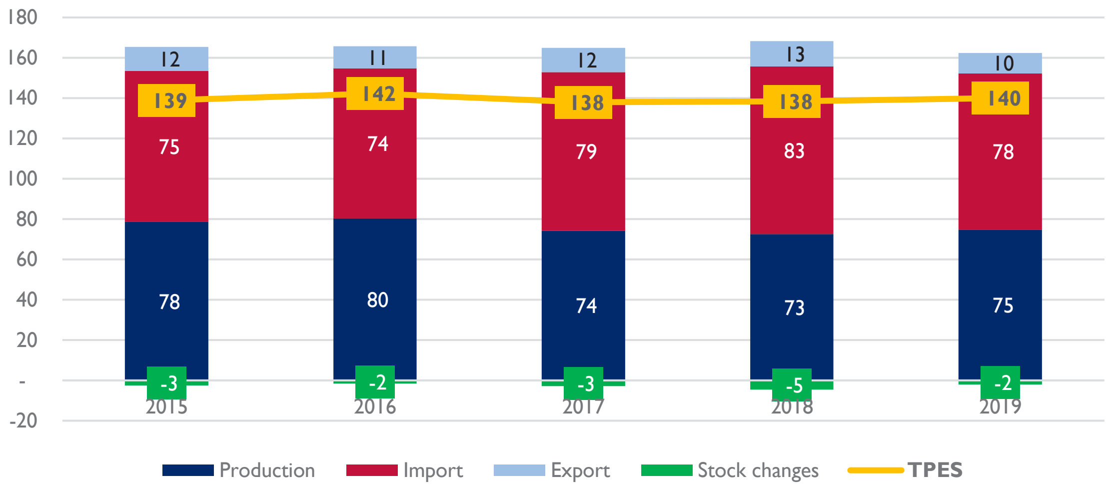
Figure 154: Thailand - Primary Energy - Sector wise consumption



Source: Ministry of Energy, Government of Thailand [232]

Coal, crude oil / petroleum, natural gas and electricity are imported in to the country. Thailand is a net importer of electricity. During 2019, 56% of TPES was met through imports. The imports have been increasing from 2015 to 2019. The most substantial import is crude oil / petroleum Natural gas is also imported through pipelines from Myanmar, from offshore gas fields near Myanmar – Thailand border. Electricity is imported from Laos and Malaysia.

Figure 155: Thailand - Energy production, imports and exports



Source: Ministry of Energy, Government of Thailand [233]

The energy balance of Thailand for 2019 is provided below:

Table 31: Thailand - Energy Balance - 2019

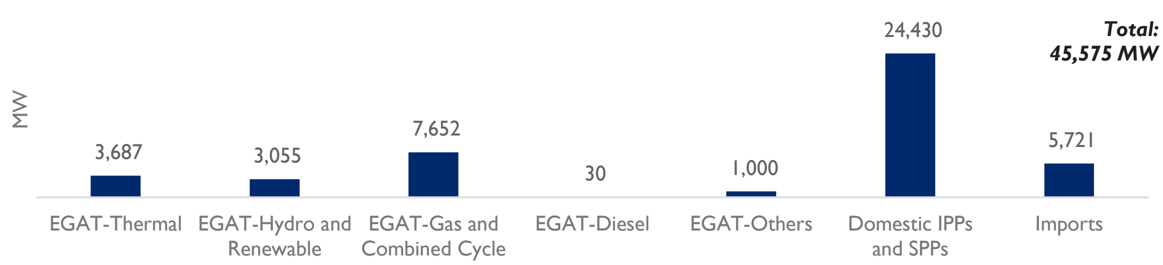
Parameter	MTOE
Production	75
Import	78
Export	10
Stock changes	-2
Total Primary Energy Supply (TPES)	**140**
Transformation, own uses and losses	54
Own uses and losses	**86**
Total Final Energy Consumption (TFEC)	75

Source: Ministry of Energy[234]

6.7.2 Electricity generation

As on February 2020, Thailand's installed capacity of electricity was 45,575 MW, inclusive of imports of 5721 MW. The state owned Electricity Generating Authority of Thailand (EGAT) owns one third of the capacity, and is also the single buyer in the system. Most of EGAT's generation fleet is gas based combined cycle power plants.

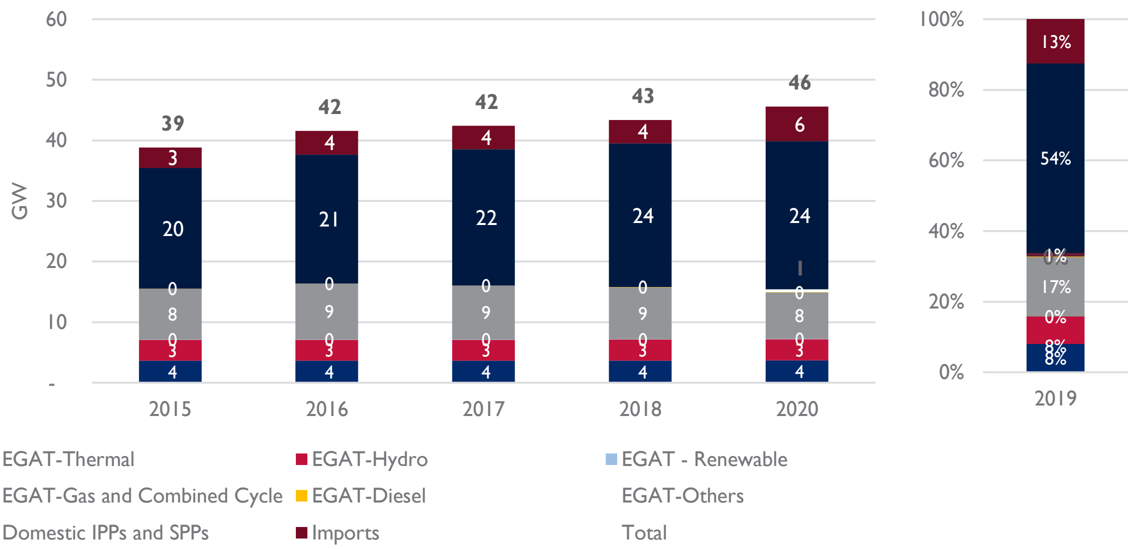
Figure 156: Thailand - Installed Capacity of Electricity - 2020



As on Feb 2020 *Source: Electricity Generating Authority of Thailand* [235]

A notable aspect in Thailand's electricity generation is the large share of private participation. Apart from EGAT's own generation, EGAT procures power from IPPs and small power producers (SPP). SPPs are renewable energy plants, most of which are covered under a feed-in-tariff. Based on installed capacity, the share of private sector is 54%. The import of electricity is from hydropower plants in Laos, and through an interconnection with Malaysia.

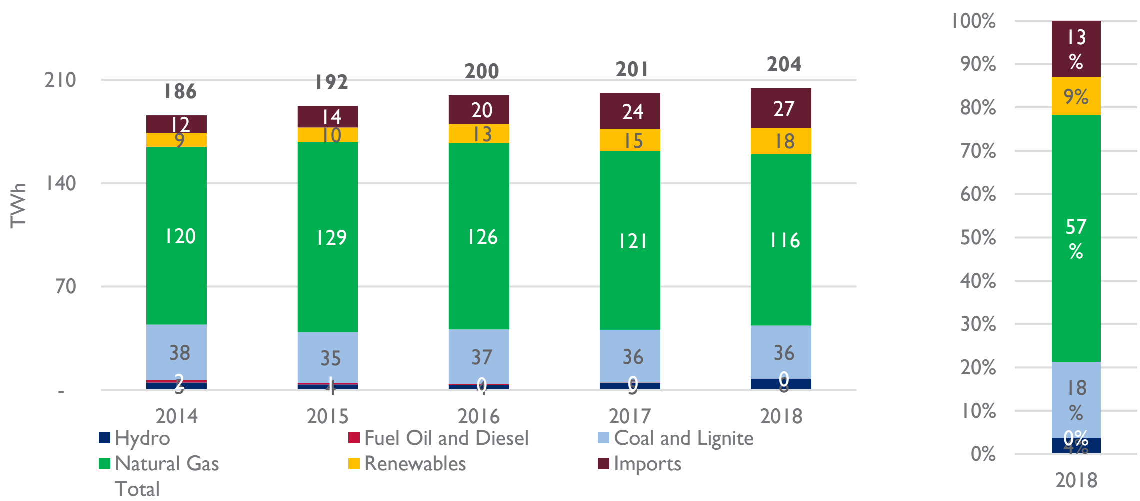
Figure 157: Thailand - Trend of installed capacity



Source: Electricity Generating Authority of Thailand [236]

The generation mix is dominated by natural gas, followed by coal and lignite power plants. In 2018, 57% of energy was generated from natural gas based power plants, and 18% from coal and lignite power plants. While the energy from gas and coal based have shown a downward trend, energy generation from renewables and imports have been increasing.

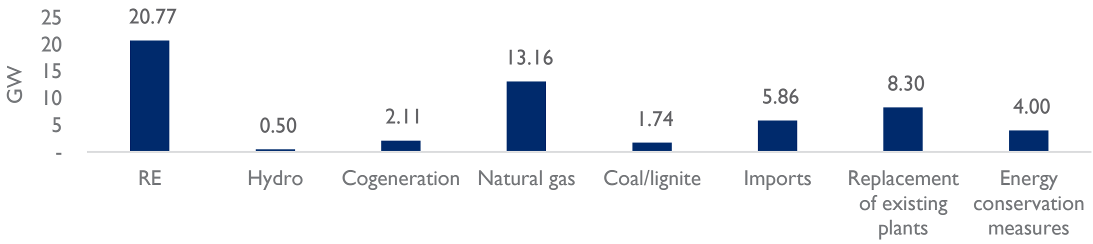
Figure 158: Thailand - Electricity generation by fuel – 2019



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [237]

Thailand's Power Development Plan, PDP2018 aims to increase the power generation capacity to 77.2 GW by 2037 (74 GW by 2035), by adding 56.4 GW new capacity, and retiring 25.3 GW between 2018 and 2017. Bulk of the new capacity is expected to be from renewable energy power plants.

Figure 159: Thailand - Generation capacity expansion planned for 2018-2037

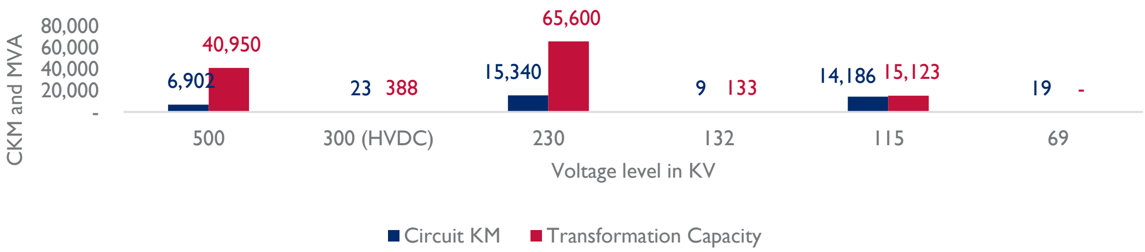


Source: Ministry of Energy [238]

6.7.3 Electricity transmission and distribution

The transmission network in the country is mainly consisted of 500 KV, 230 KV and 115 KV voltage levels. The 300 KV HVDC line is a cross border interconnection with Malaysia. The network also consists of multiple interconnections with Laos, to import power from hydropower plants.

Figure 160: Thailand - Electricity Transmission Network



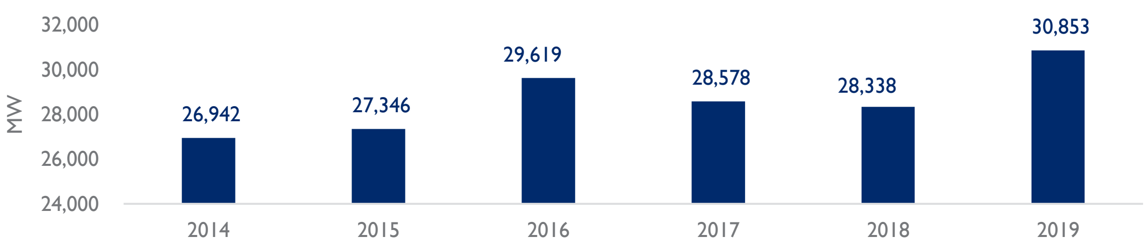
Source: Electricity Generating Authority of Thailand [239]

Thailand maintains cross border interconnections with Lao PDR, Cambodia and Malaysia. A list of such interconnections is provided below:

- 500 kV Nam Theun 2 HPP (Lao PDR) - Roi Et 2 (Thailand);
- 230 kV Theun Hinboun HPP – Thakhek (Lao PDR) – Nakhon 2 (Thailand);
- 230 kV Huoay Ho HPP (Lao PDR) – Ubon 2 (Thailand);
- 230kV/500 kV Na Bong (Lao PDR) – Udon 3 (Thailand);
- 500 kV Hongsa TPP (Lao PDR) - Nan (Thailand) - Mae Moh 3 (Thailand);
- Multiple 115 KV lines with Lao PDR (Laos) and Cambodia; and
- 300 KV Thailand-Malaysia HVDC Interconnection.

The peak demand in the system has increased from 27 GW in 2014, to nearly 31 GW in 2019. This forms 72% of the installed capacity during 2019.

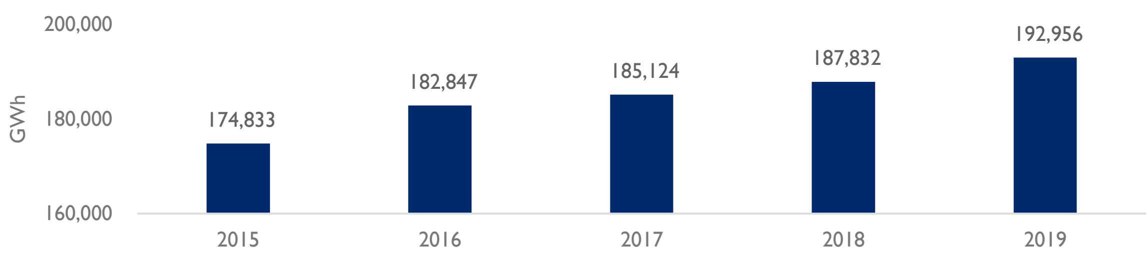
Figure 161: Thailand - Peak demand



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [240]

The electricity sales have recorded a modest CAGR of 2.5% between 2015 and 2019.

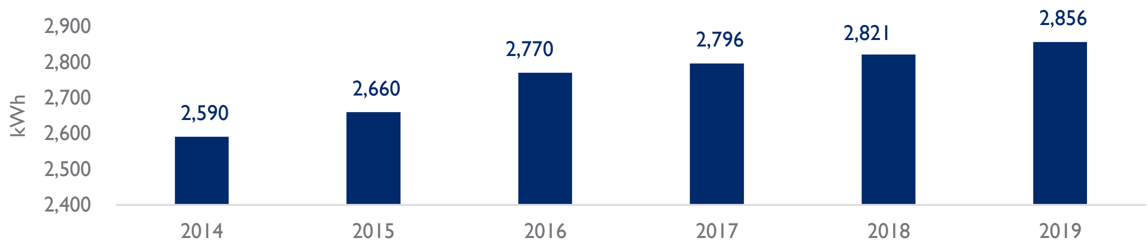
Figure 162: Thailand - Electricity sales



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [241]

Thailand has achieved 100% electricity access.[242] The country also does not seem to have any substantial shortage in electricity, and there are no reports of any major load shedding and restrictions in the recent past. The country also has a higher electricity per capita consumption, when compared with most BIMSTEC Member States.

Figure 163: Thailand - Per capita electricity consumption



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [243]

To meet its growing electricity demand, Thailand has 17 transmission system development projects under construction and other 11 projects in studying process. [244] Some of the major transmission expansion projects are listed below.

Table 32; Thailand - Transmission expansion projects

Name	Cost (Million Baht)	Scheduled completion
Transmission System Expansion and Renovation Project Phase 1: Transmission Line (RLP1)	9,850	2023
Transmission System Development Project in the Area of Loei, Nong Bua Lam Phu, and Khon Kaen Provinces for Power Purchase from Lao PDR (LNKP)	12,060	2021
Transmission System Expansion and Renovation Project Phase 2 (RTS2)	21,900	2023
Transmission System Improvement Project in Eastern Region for System Security Enhancement (TIPE)	12,000	2023
Bulk Power Supply for the Greater Bangkok Area Phase 3 (GBA3)	12,100	2021
Transmission System Expansion Project Phase 12 (TS12)	60,000	2022
Transmission System Improvement Project in Western and Southern Regions to Enhance System Security (TIWS)	63,200	2023
Transmission System Development Project for the Northeast Region, Lower North Region, Central Region, and Bangkok Metropolitan for System Security Enhancement (TIEC)	94,040	2030

Name	Cost (Million Baht)	Scheduled completion
Transmission System Development Project for the Upper Northern Region for System Security Enhancement (TIPN)	12,240	2021
Transmission System Development Project for the Replacement Project of South Bangkok Power Plant Phase I (SBR1)	1090	2020
Transmission System Improvement Project in Lower Southern Region to Enhance System Security (TILS)	35,400	2024
Transmission System Improvement Project in Lower Southern Region to Enhance System Security (TILS)	784	2020
Transmission System Development Project for Pha Chuk Hydropower Plant (PCHP)	212	2020

Source: EGAT[245]

6.7.4 Energy resources and potential

Thailand has reserves of gas, oil and lignite. Gas reserves include those at Myanmar – Thailand Joint Development Area.

Figure 164: Thailand - Energy resource potential

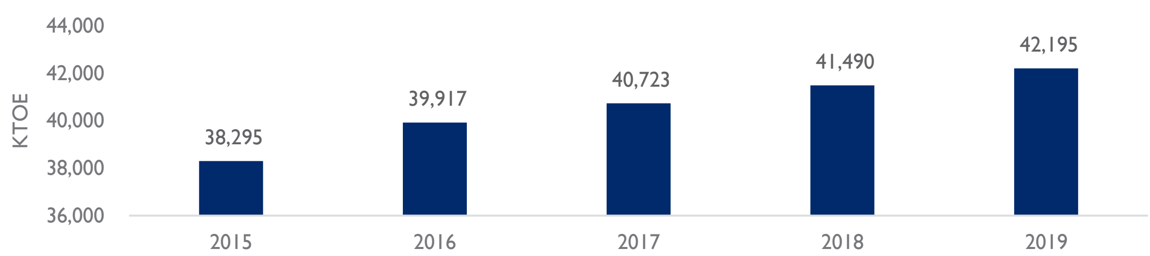
Resource	Natural gas	Crude Oil and Condensates	Lignite
Unit	TCF	Million barrels	Million Tonnes
Total reserves in beginning of 2019	11.15	649	
Production in 2019	1.83	83	
Remaining reserves	9.3	566	1063

Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand, BP Statistical Reviw [246]

Oil

Oil consumption in Thailand has increased at a CAGR of 2.45% from 2015 to 2019. More than 90% of the oil is met through imports.

Figure 165: Thailand - Oil – Consumption



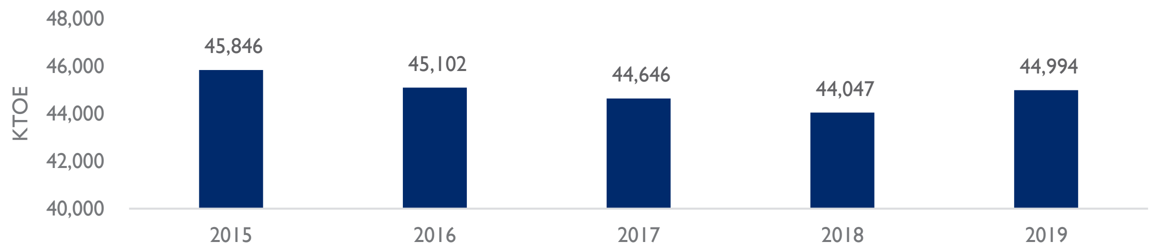
Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [247]

Even though bulk of the crude oil is imported, Thailand is a net exporter for some of the refined petroleum products such as diesel, kerosene and fuel oil.

Natural Gas

In Thailand, energy consumption from gas had been decreasing gradually from 2015 to 2018, though the trend has shown a slight reversal in 2019. The reduction in energy from gas has been mostly on account of reduction in production, as imports have only increased between 2015 and 2019.

Figure 166: Thailand - Gas - Consumption



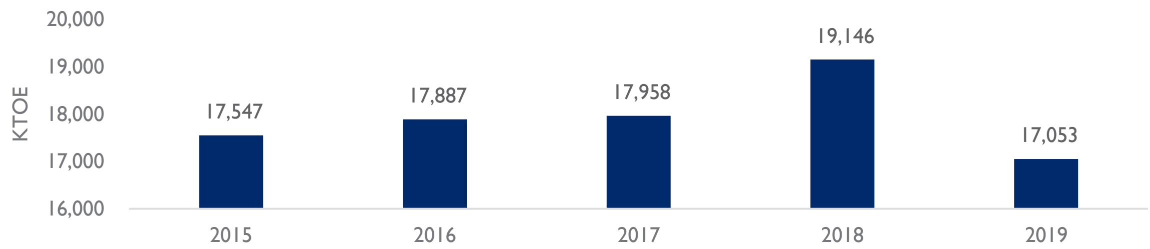
Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [248]

Among the imports, LNG has shown an increased trend between 2015 and 2019. LNG import was only to the tune of 3041 KTOE in 2015, which has increased to 5898 KTOE in 2019, i.e. a CAGR of 18%.

Coal

While lignite is produced domestically, higher quality coal is also imported.

Figure 167: Thailand - Coal – Consumption



Source: Energy Policy and Planning Office, Ministry of Energy, Government of Thailand [249]

Renewable Energy

As per the estimates of IRENA, Thailand has solar and wind power potential of 23 GW.

Figure 168: Thailand - RE potential

Source: IRENA[250]

6.7.5 Energy transition and reforms

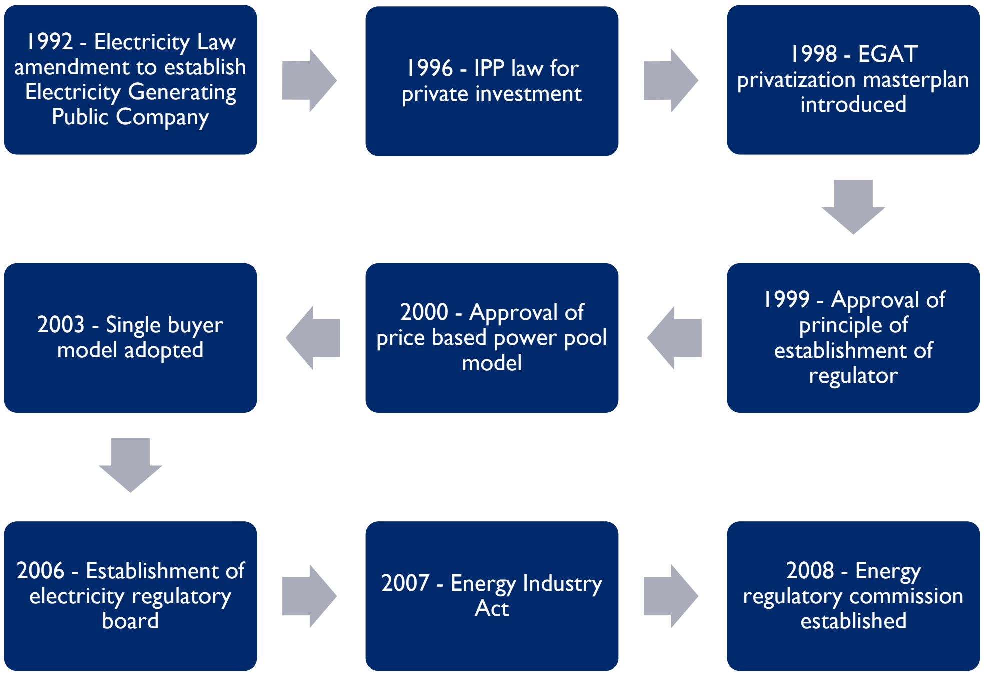
Energy transition and reforms

Thailand's energy supply is heavily dependent upon the import of crude oil and natural gas, which exposes it towards more import dependency and higher tariffs. However, Thailand is targeting to increase the share of renewable energy consumption to 30% by year 2036, under its Alternative Energy Development Plan (AEDP) 2015.[251] Higher RE penetration in the grid will reduce dependence of Thailand upon import of fossil fuel.

The first level of reforms in energy sector of Thailand was undertaken in the 1990s. The next wave of reforms was undertaken pursuant to the Energy Industry Act of 2007. The Act clarified in detail about the role of various institutions in the energy sector, and also led to the establishment of an Energy Regulatory Commission (ERC).[252]

In January 2018, the National Energy Reform Committee issued an Energy Reform Plan, which will reform Thailand's energy production and consumption by promoting renewable energy and good governance in the energy sector. The plan has reform components such as opening up of LNG business, deregulation of distributed power generation and implementation of building energy codes.[253]

Figure 169: Thailand - Sector reforms



Masterplans

In the end of 2014, Thailand's Ministry of Energy launched five strategic plans, named as the Thailand Integrated Energy Blueprint (TIEB). TIEB consists of five long-term plans – the Energy Efficiency Plan (EEP 2015); Power Development Plan (PDP 2015); Alternative Energy Development Plan (AEDP 2015); Natural Gas Supply Plan (Gas Plan 2015); and Oil Supply Management Plan (Oil Plan 2015).

The Thailand Power Development Plan was developed by the Ministry of Energy, and endorsed by the National Energy Policy Council on 14 May 2015. The plan emphasized on improving power system reliability by reducing dependence on natural gas power generation, increasing a share of coal power generation via clean coal technology, importing power from neighboring countries, and developing renewable energy.[254] A revised version of the plan was approved in 2018.

EEP 2015 set the target of energy intensity reduction of 30 percent by 2036 (with the base year of 2010) in four major economic sectors including industry, commercial and governmental buildings, residential and transportation.

Climate Policy

Thailand has formulated a National Strategic Plan on Climate Change 2008-2012 and the Climate Change Master Plan 2015-2050, providing a framework for measures and actions in the long-term. The Climate Change Master Plan has laid out a vision to achieve climate-resilient and low-carbon growth in line with a sustainable development path by 2050, and has been approved by the Cabinet. The plan includes the following strategies:

- Building climate resilience into national development policy by integrating directions and measures in all sectors at both national and sub-national levels to ensure country's adaptability to climate change;
- Creating mechanisms to reduce GHG emissions, and leading to sustainable low carbon growth;

- Building readiness of master plan implementation by enhancing potential and awareness of all development partners; and
- Developing database, knowledge, and technology to support climate change adaptation and sustainable low carbon growth.

As part of its NDC submitted to United Nations Framework Convention on Climate Change (UNFCCC), Thailand has committed to reduce its greenhouse gas emissions by 20 percent from the projected business-as-usual (BAU) level by 2030. The level of contribution could increase up to 25 percent, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under UNFCCC.[255]

Energy efficiency

The Energy Efficiency Plan (EEP), ratified by the National Energy Policy Council (NEPC) in 2015, aims at an **energy intensity reduction target of 30% by 2036**, compared with 2010 levels. The plan envisages interventions such as building energy efficiency codes, energy efficient appliance standards, equipment labelling etc. for improvements in energy efficiency.

Electric vehicles

In March 2020, the Government of Thailand announced its plans to make Thailand a regional hub for electric vehicles by 2025. The targets include producing 60,000 electric vehicles by 2022, construct more charging stations and offer financial incentives. [256]

Smart grid

The Government is also implementing a Smart Grid plan for 2017-21, in which EGAT, and the utilities Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA) work on various smart grid and energy storage pilot projects.

Thailand's Smart Grid Development Plan is spread over multiple phases leading up to 2036. It includes initiatives such as micro-grids, distributed generation, substation automation, implementation of Advanced Metering Infrastructure (AMI), energy storage management for integrate solar rooftops, electric vehicles integration, and intelligent street lighting etc. It envisages a range of pilot projects as a foundational step for carrying out future large scale integration followed by optimization of solutions, and full scale operation by 2036.[257] A Smart Grid system pilot is planned for Mae Hong Son district consists of 3 sub-projects – Residential level, smart signage and electric car charging station, and intelligent street light.

6.7.6 Institutional framework

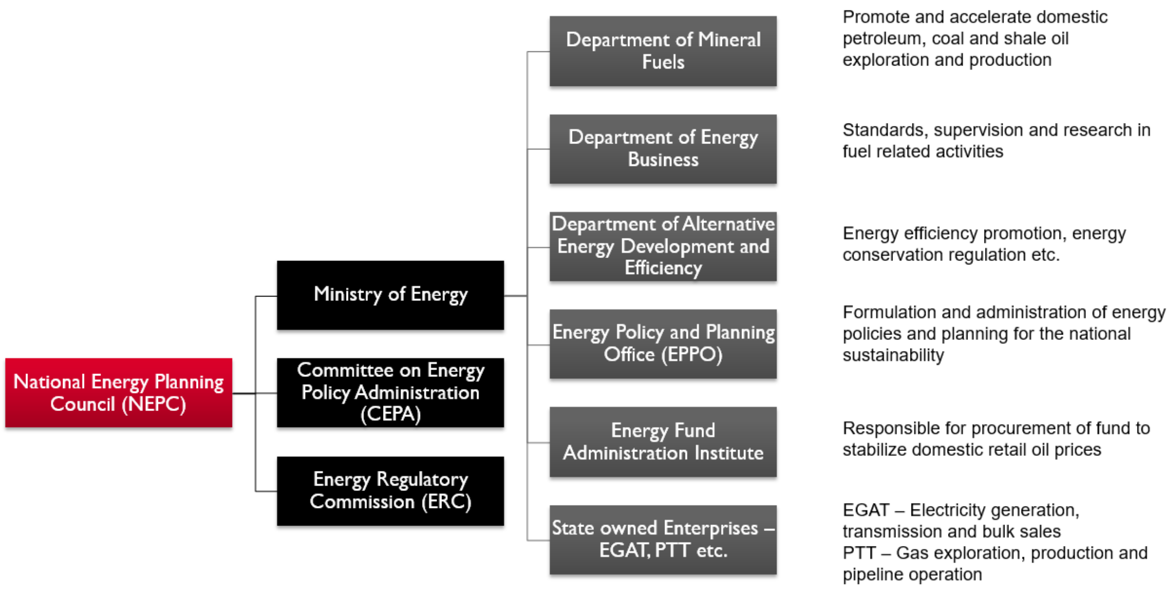
In Thailand, the most important decisions related to energy sector are taken by the National Energy Policy Council (NEPC) which is chaired by the Prime Minister. NEPC is the key decision maker on all energy policies, plans and activities in Thailand. A Committee on Energy Policy Administration (CEPA), chaired by the Minister of Energy, assists NEPC.

The Ministry of Energy (MOE) proposes and implements all policies related to energy. MOE also has control over the energy-related State Owned Entities (SOE) such as EGAT. The Energy Policy and Planning Office (EPPO) is responsible for recommending national energy policies and plans. The Energy Regulatory Commission (ERC) regulates energy industry operations in compliance with the policy framework of the government.

Thailand follows a single-buyer model, with EGAT as the single vertically-integrated utility, holding and running part of the generation, the entire transmission system and a part of the retail market. Apart from its own generation, EGAT purchases power from IPPs and SPPs and it imports power from other countries as well in order to serve domestic electricity requirements.

While bulk supply consumers buy power directly from EGAT, smaller commercial and residential consumers purchase power from MEA and PEA, the two distribution companies of Thailand. Very Small Power Producers (VSPPs) sell electricity directly to MEA and PEA. Real-time coordination between EGAT, MEA and PEA is managed through various regional dispatch control centres, as well as a single national control centre.

Figure 170: Thailand - Institutional framework



Source: Friedrich-Ebert-Stiftung[258]

Key decisions such as import of power, and import of LNG are taken with the approval of NEPC. The 'Power Development Plan' for Thailand is also approved by NEPC.

7 BIMSTEC Energy Outlook 2035

7.1 Modelling framework for Energy Outlook 2035

7.1.1 Objectives

The BIMSTEC Energy Outlook 2035 provides the long-term forecast i.e. 2020-2035, for overall energy usage in the BIMSTEC region along with energy transition patterns at the individual country level. Key energy parameters considered include final energy consumption, electric power demand, electricity sales, electricity mix, investment requirements and cross border electricity trade (CBET).

7.1.2 Assumptions

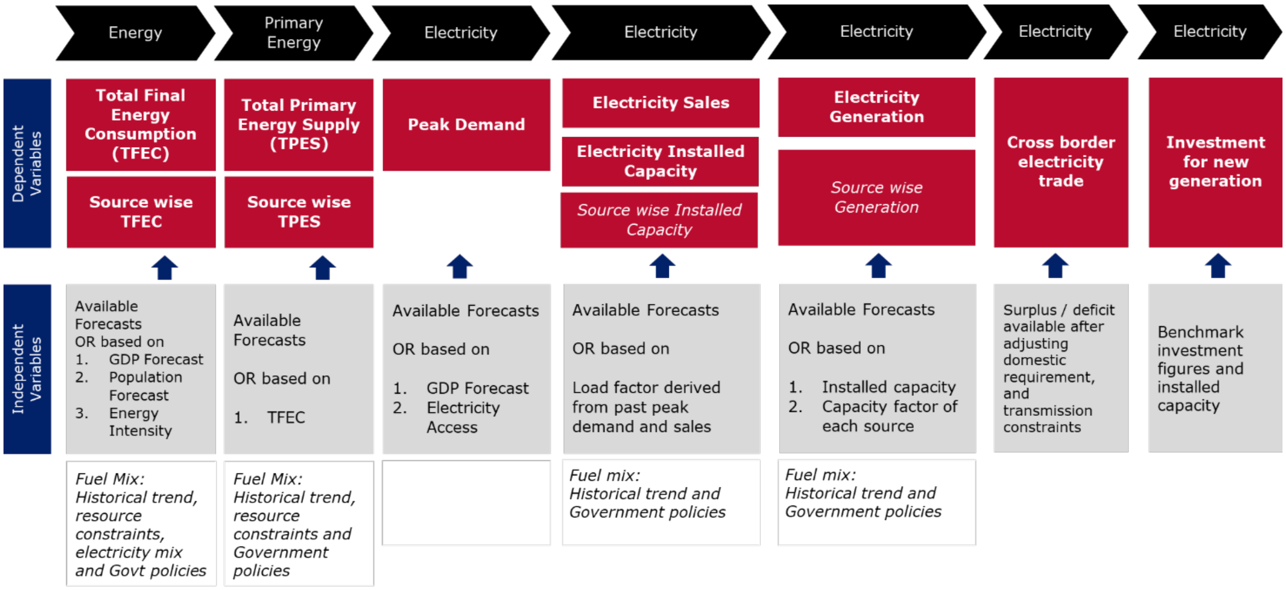
The outlook uses the future outlook data of utilities / Governments as long as they are publicly available. However, in the absence of such information, the outlook is estimated using a set of assumptions. A summary of general assumptions used across the model is shown below to help better understand the overall approach and methodology:

1. In the absence of separate publicly available (from utility/government) forecasts on Total Final Energy Consumption (TFEC), TFEC can be estimated based on a regression relationship with GDP and Population, subject to statistical significance of these variables derived based on past trends.
2. In the absence of separate publicly available (from utility/government) forecasts on Total Primary Energy Supply (TPES), TPES can be estimated based on a regression relationship with TPEC.
3. In the absence of separate publicly available (from utility/government) forecasts on GDP, future GDP can be estimated based on past growth rate. However available credible forecasts such as that of ADB will also be used.
4. In the absence of separate publicly available (from utility/government) forecasts on Population, future Population can be estimated based on past growth rate.
5. As long as available, peak demand will be as per publicly available (from utility/government) estimates of respective countries. In the absence of separate publicly available (from utility/government) forecasts on peak demand, peak demand can be estimated based on a regression relationship with GDP, population and (in case of countries with low electricity access) electricity access.
6. Publicly available (from utility/government) peak demand projections of the countries are assumed to have already considered the impact of energy conservation and demand side management (DSM) measures.
7. In the absence of utility/government estimates on future electricity sales, the same will be estimated from peak demand under the assumption that average load factor of the country, will continue to be the same as that of average of past years.
8. Capacity utilization factor / plant load factor of each generation source can be estimated based on past trends.
9. Investment for new electricity generation is estimated based on global benchmark figures.
10. Impact of Covid-19 is assumed to be temporary, and therefore not considered.
11. Electricity consumption on account of new electric vehicles is assumed to be in addition to the sales estimated by the utility for the future. For estimation of electricity consumption per electric vehicle, a consumption of 0.20 kWh/km, and daily average distance of 20 KM is assumed. For calculating equivalent reduction in petroleum consumption, a mileage of 5.49 litre per 100 KM is assumed.

12. Unless otherwise specified for each country, EV sales is assumed as 15% of new electric vehicle sales by 2030 in base case, and 30% in alternate case, in line with IEA's Global EV Outlook report.[259]

7.1.3 Methodology

As shown in the figure below, the model uses a range of independent variables and other information to come up with the dependent variables ranging from overall energy, electricity, and CBET and energy investments etc.



In the absence of official forecasts, the Total Final Energy Consumption (TFEC) is estimated through regression analysis, considering the past relation between TFEC, GDP and population.

While GDP is utilized in all cases, population is adopted in only those cases where there is a statistical significance established for that variable. The model also has the ability to consider any planned reduction of energy intensity in the future. The Total Primary Energy Supply (TPES) is derived from TFEC through a similar regression analysis.

The peak demand is primarily sought to be based on forecasts of utility / Government, though a GDP based regression analysis is done to estimate peak demand in case such forecasts are not available. While electricity sales, installed capacity and generation requirement are also derived from utility / Government forecasts, in the limited instances when such information is not available, the same has been estimated considering past trends, and past load factor. The additional sales on account of electric vehicles is also estimated and added to the sales forecast.

For estimation of import/export of power, the difference between energy requirement and energy generation within the country is adopted. A separate analysis is thereafter undertaken, which is described in chapter 6. The investment requirement in electricity generation is estimated using benchmark / industry standard capital cost estimates for various technologies.

While the outlook is developed under a Base case, an Alternate case is also estimated, considering a high EV and RE scenario. The alternate scenario focuses on difference in energy for import / export in the backdrop of increased energy requirement due to higher consumption for electric vehicles, and the difference in emission profile of electricity generation due to increased mix of renewable energy.

The methodology is further detailed in annexure.

7.1.4 Constraints

1. The outlook projections primarily rely on forecasts prepared by the utilities / Government. As most of these forecasts were prepared in previous years, it may not necessarily depict the latest scenario.
2. Impact of EVs are considered only in consumption, and not in peak demand, as the coincidence of peak demand timings and EV demand is not known.
3. As the data source varies from country to country, there could be variations in terminologies / groupings which cannot be made uniform. For example, Bangladesh and Thailand considers import MW in their installed capacity, whereas India does not.
4. The focus was on arriving at the outlook for 2035. For some of the variables, the target for 2035 is reconciled with the projections of utilities / Governments. It is possible that the trajectory followed by the variable between 2020 and 2035, which is considered in this report varies from the trajectory considered / assumed in the source report.
5. The assessment of cross border import / export of electricity is based on deficit/surplus from annual figures. In actual scenario, differences in daily and seasonal patterns, transmission constraints and commercial constraints could cause a difference between the import / export estimated, and actual import / export.

7.2 Bangladesh

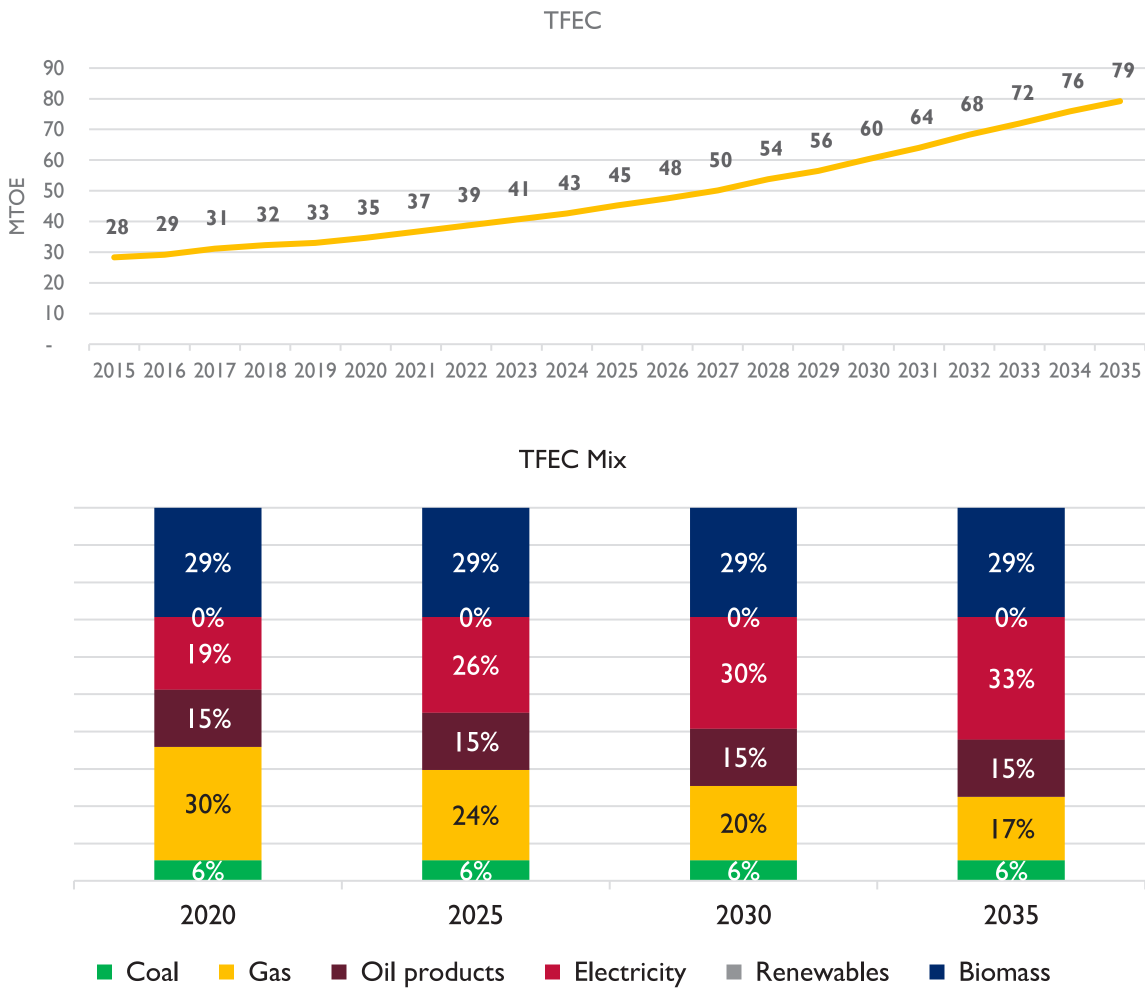
For Bangladesh, the estimation of energy outlook for 2035 is primarily based on the existing energy supply situation, as maintained by Hydrocarbon Unit of Ministry of Power, Energy and Mineral Resources, in its Energy Scenario report, annual reports of Bangladesh Power Development Board, and the government's Statistical Year Book. The following assumptions have also been considered:

- TFEC is adopted from PSMP 2016.
- TPES is calculated through regression with TFEC.
- TPES Fuel Mix for 2035 is extrapolated from PSMP Fuel Mix target for 2041
- Nuclear Energy is estimated to be available from 2025 as per Revisiting PSMP 2016 Report
- Installed capacity additions are taken from Revisiting PSMP 2016 Report
- For nuclear power, PLF is assumed as 70%.
- Peak demand, sales and energy requirement has been adopted from Revisiting PSMP 2016 Report. The scenario which already considers energy efficiency is adopted.
- CUF of gas plants are adjusted to match the overall energy requirement and generation, after adjusting for imports.
- Investment for new generation projects are taken as per Revisiting PSMP 2016 report.

7.2.1 Energy Outlook

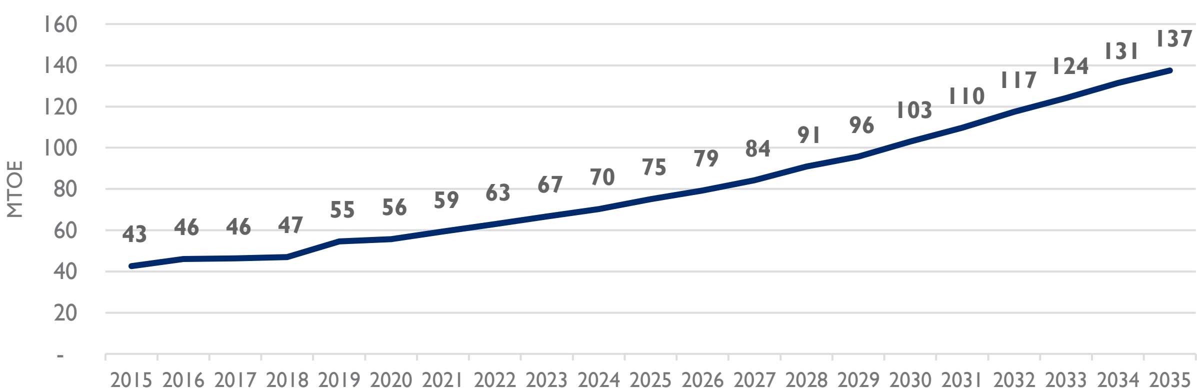
For Bangladesh, based on PSMP projections, the TFEC is expected to increase from 33 MTOE in 2019 to 79 MTOE in 2035, growing at a compound annual rate of 5.62%. The energy consumption is based on Bangladesh's Power System Master Plan. [260] The share of gas is expected to reduce to 17%, whereas share of traditional biofuels (biomass) is expected to reduce to 29%, from 31% and 32% respectively in 2015.

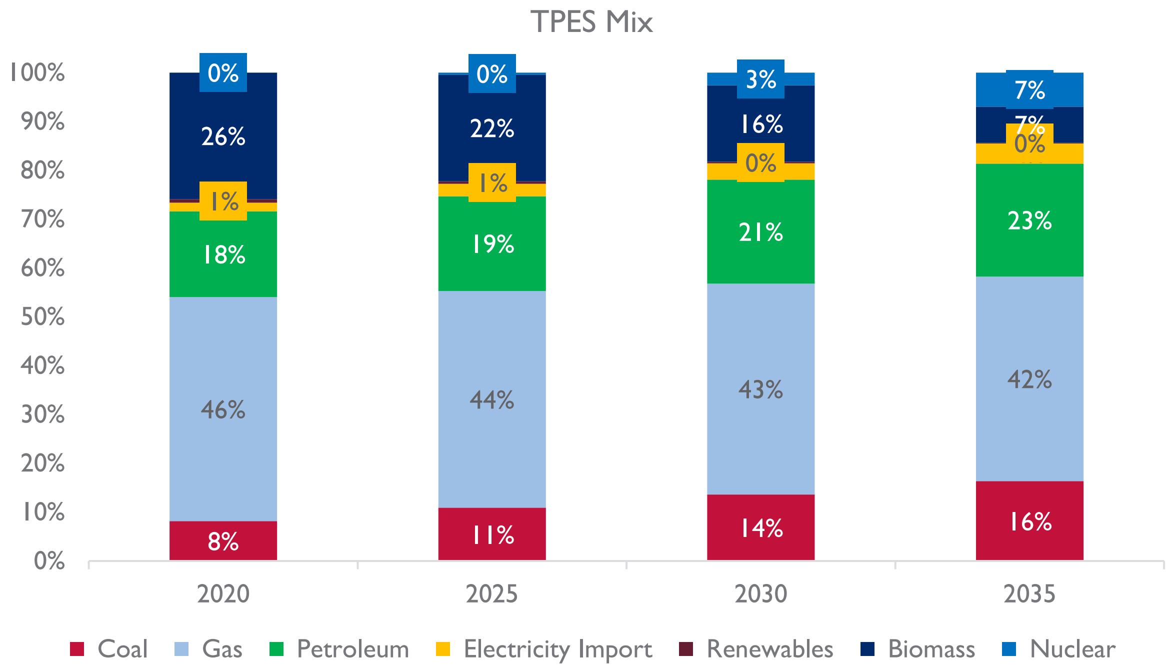
Figure 171: Bangladesh - Total Final Energy Consumption, 2035



TPES was estimated from TFEC through a regression function. Based on the same, TPES is expected to increase from 55 MTOE in 2019 to 137 MTOE in 2035, growing at a compound annual rate of 5.94%. An increase in share of non-gas sources such as coal and petroleum can be observed towards 2035, due to anticipated reduction in gas production.

Figure 172: Bangladesh – Total Primary Energy Supply, 2035

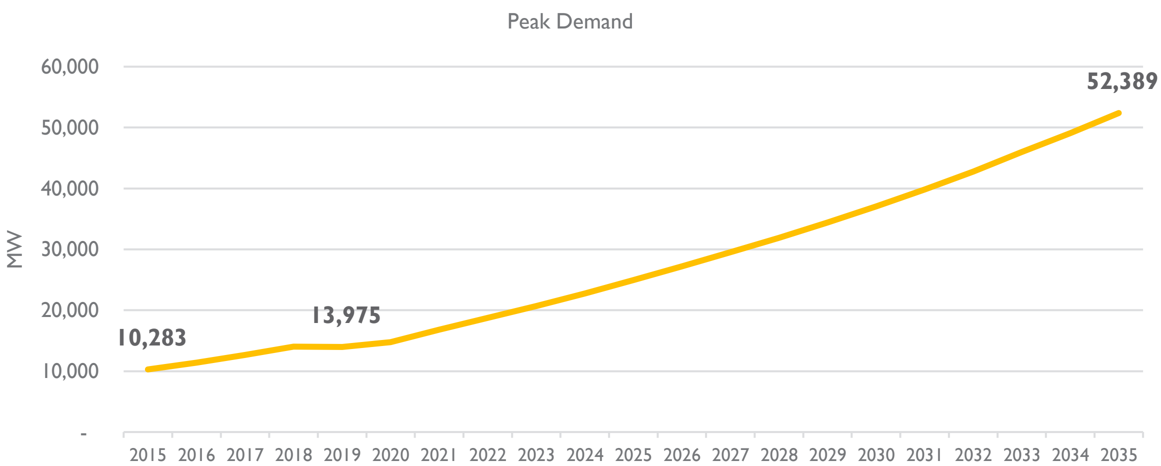




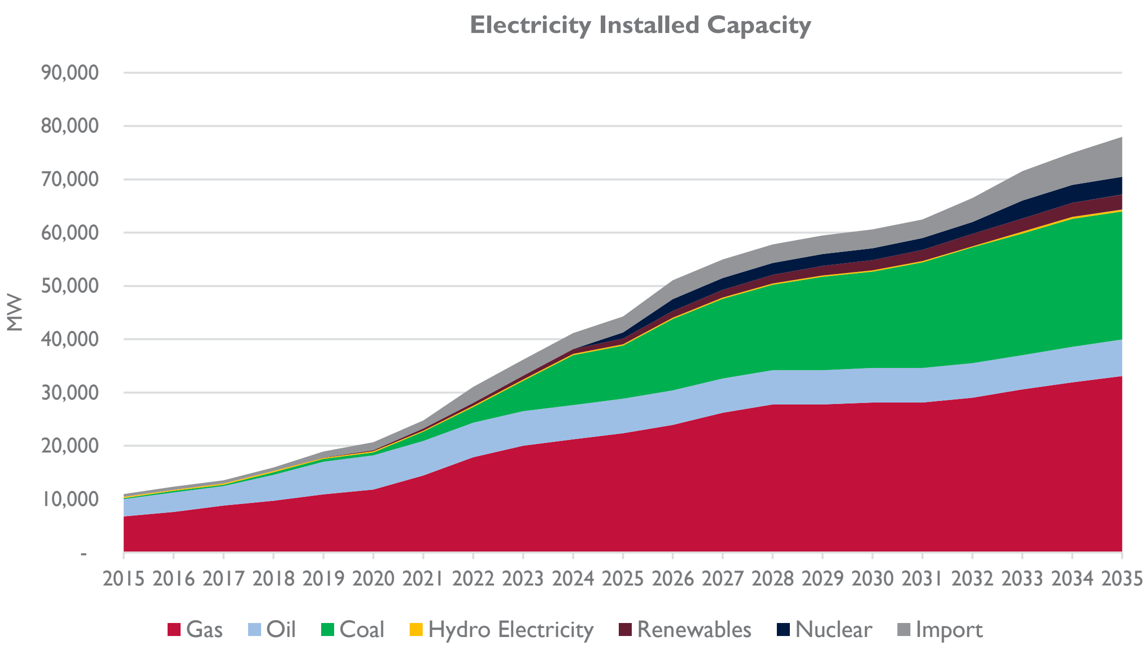
7.2.2 Electricity Outlook

The electricity outlook for Bangladesh is derived primarily from the Power System Master Plan. Based on the same, the peak demand is expected to increase from 14 GW in 2019 to 52.4 GW in 2035. The increase in demand is met mainly through an increase in capacity of thermal and nuclear power plants and imports, with the installed capacity increasing from 19 GW in 2019, to 78 GW in 2035.

Figure 173: Bangladesh - Electricity demand and capacity 2035



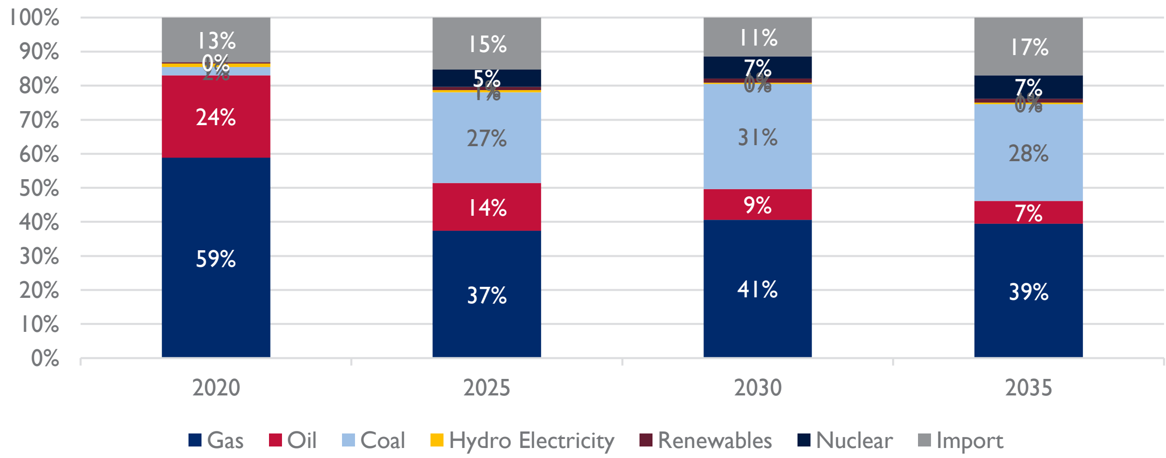
Source: Power Division[261]



Source: Power Division[262]

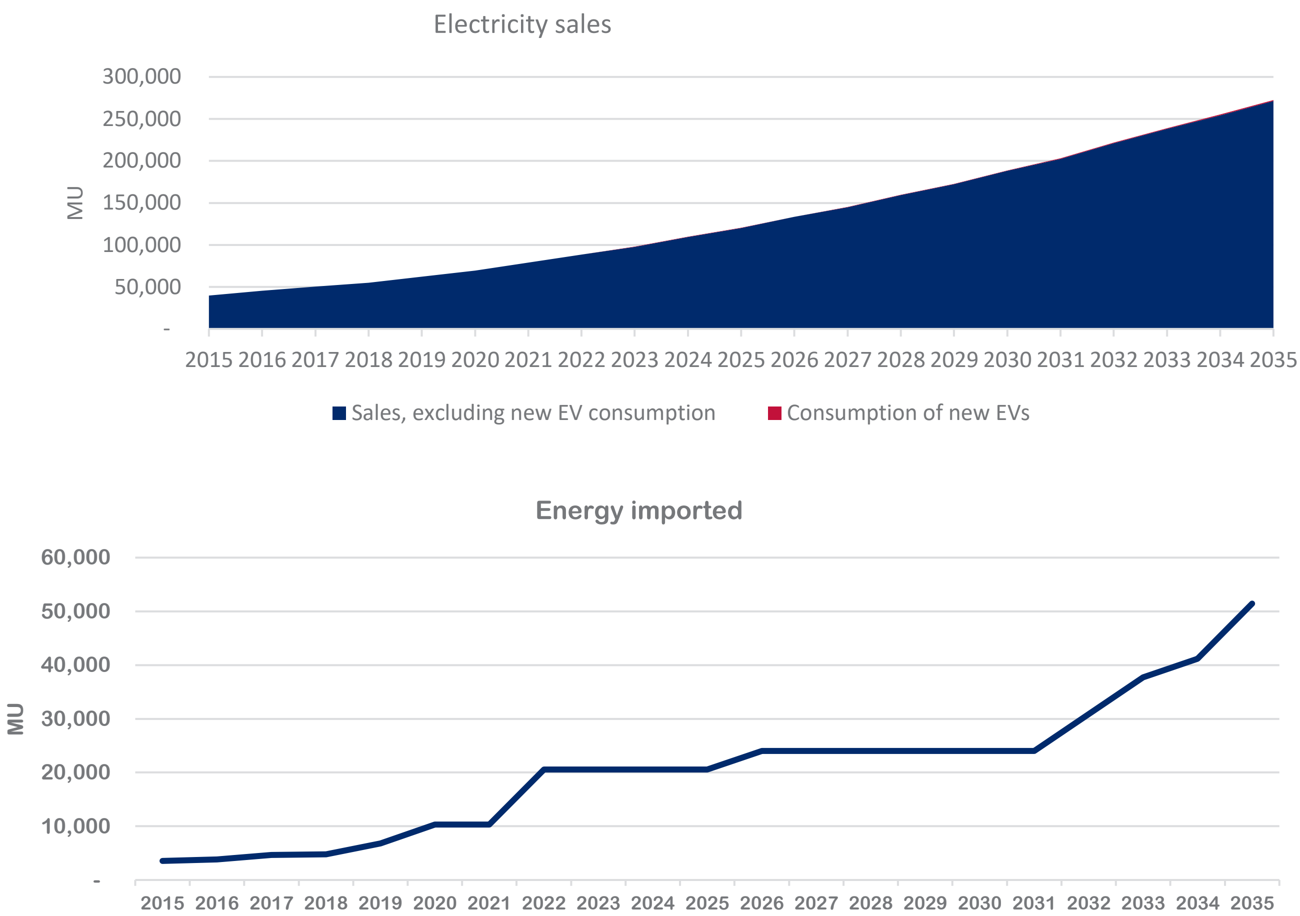
The electricity generation mix is expected to reduce its reliance on gas and oil, and shift towards other sources, especially coal, nuclear and imports.

Figure 174: Bangladesh - Electricity generation mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 0.4% by 2035. The estimate of imports show below are based on the import MW specified in the Master Plan.

Figure 175: Bangladesh - Electricity sales and cross border import / export 2035

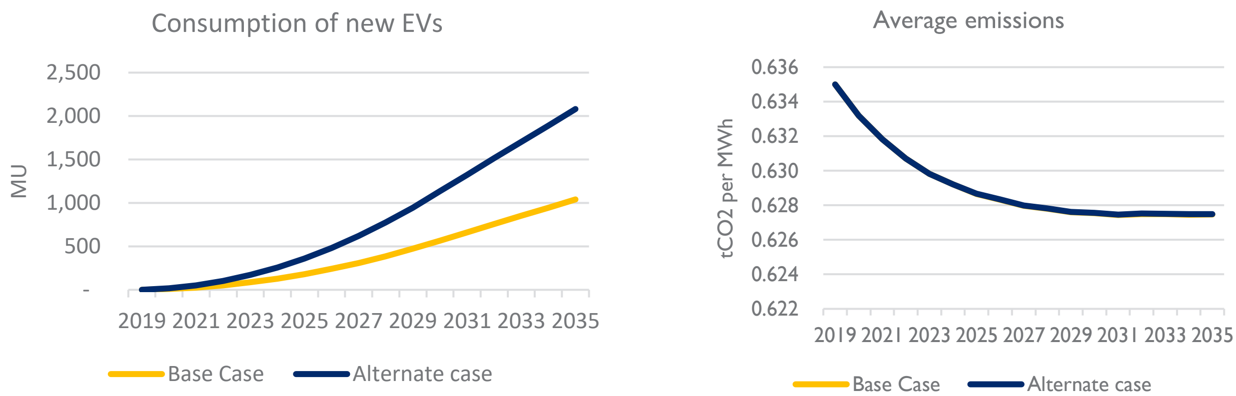


7.2.3 Alternate scenario

To consider potential differences in growth of electric vehicles, and RE expansion, an alternate scenario is computed which considers slight variation from projections of government and utilities.

The alternate scenario for Bangladesh considers EV sales as 30% of new vehicle sales at 2030. However, considering the limited land availability and associated aspects, RE is considered at the same level as that of Master Plan projections in both base and alternate scenarios. Due to this, there is no perceptible differences in imported energy and average emissions in base and alternate scenarios.

Figure 176: Bangladesh - Alternate scenario 2035



7.3 Bhutan

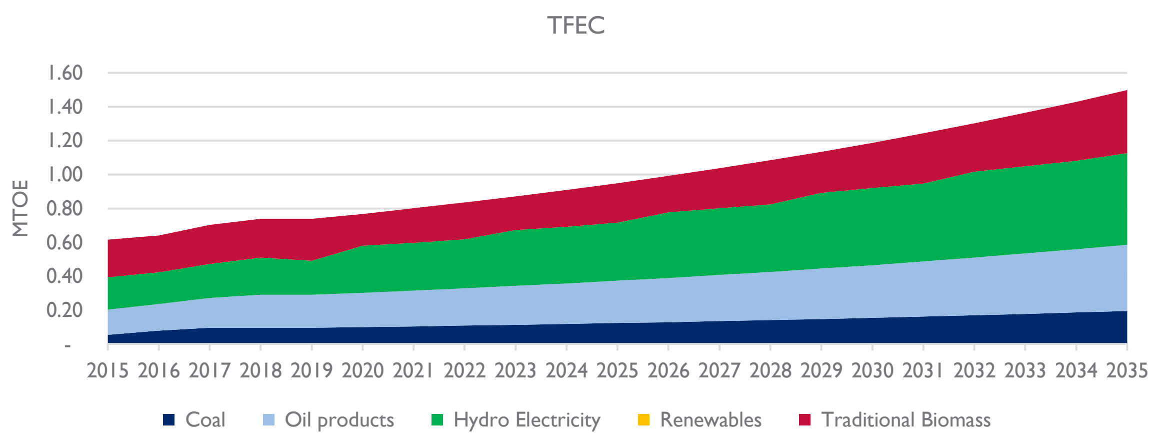
The outlook for Bhutan has been projected based on the following country specific assumptions and information:

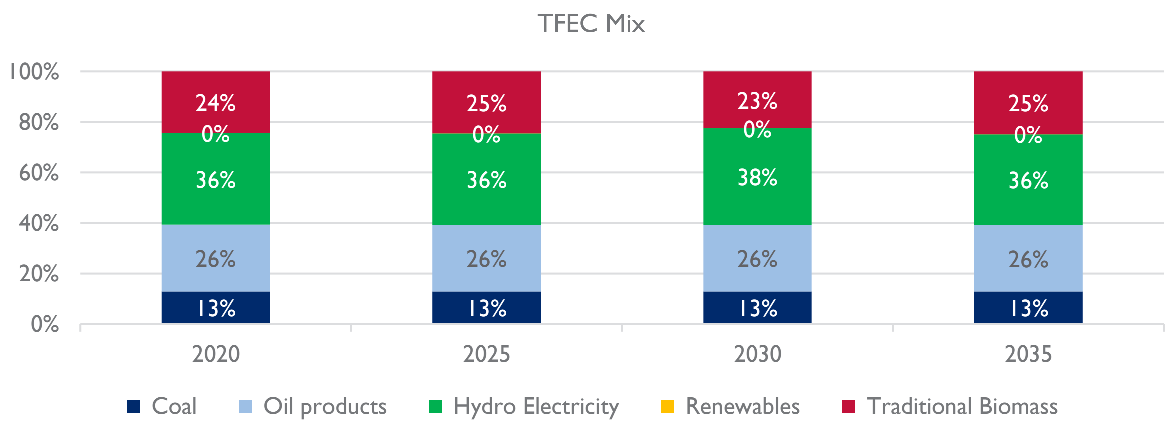
- Peak demand projection as per Bhutan National Transmission Grid Master Plan;
- Existing energy statistics as per Statistical Year Book, reports of Bhutan Power System Operator and Bhutan Power Corporation are utilized;
- Since T&D losses in 2018 are already low, at 2.77%, only a nominal annual reduction of 1% is considered for T&D loss; and
- Since Bhutan's latest publicly available (from utility/government) energy estimates does not quantify the contribution of traditional Biomass, the same is estimated based on biomass share provided in Bhutan Energy Data Directory 2015.

7.3.1 Energy Outlook

Bhutan’s TFEC is expected to increase from 0.7 MTOE in 2019 to 1.5 MTOE in 2035, growing at a compound annual rate of 4.52%. The energy consumption is based on a regression analysis of past relationship between TFEC and GDP. The share of traditional biofuels is expected to reduce to 23% by 2035, whereas hydropower is expected to be the dominant source, with 36% of TFEC in 2035.

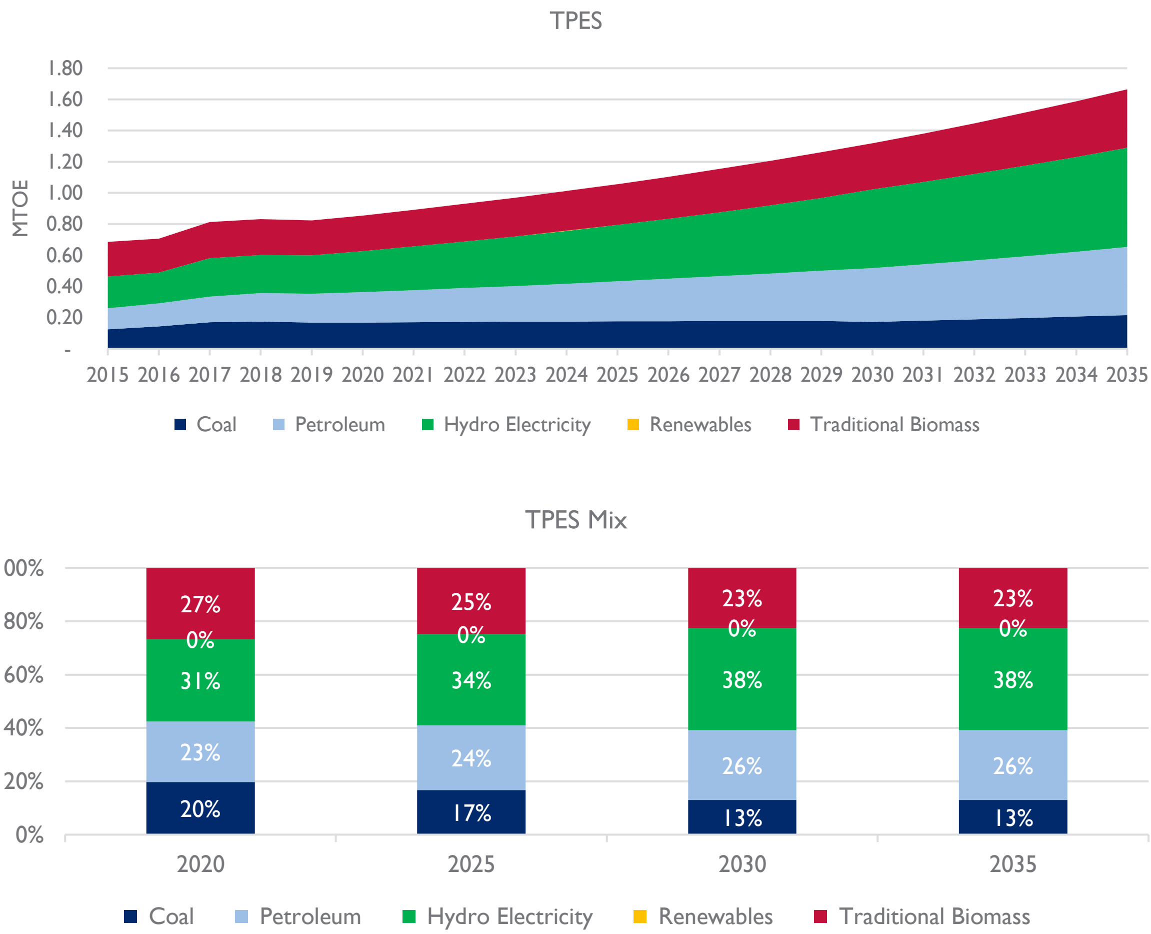
Figure 177: Bhutan - Total Final Energy Consumption, 2035





TPES was estimated from TFEC through a regression function. Based on the same, TPES is expected to increase from 0.8 MTOE in 2019 to 1.7 MTOE in 2035, growing at a compound annual rate of 4.50%. An increase in share of non-gas sources can be observed towards 2035, due to anticipated reduction in gas production. Similar to TFEC, hydropower is expected to be the major source (38%). This is followed by petroleum / oil (26%) and traditional biofuels (23%).

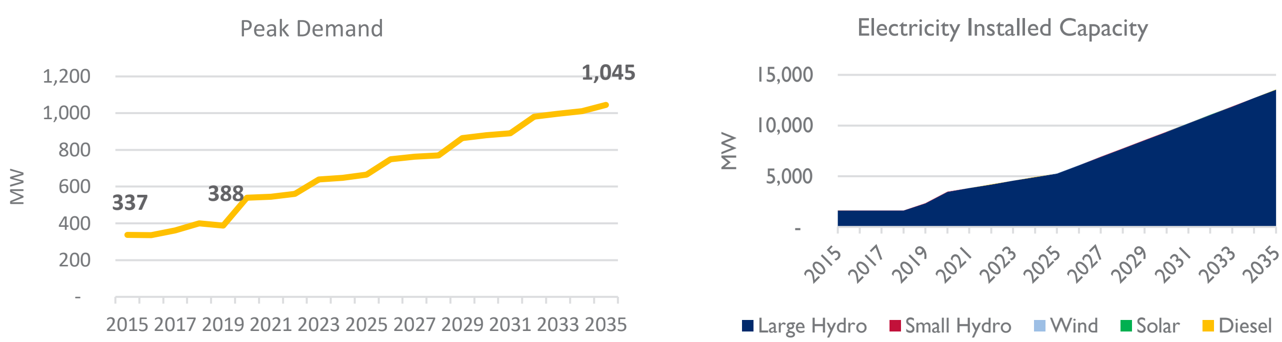
Figure 178: Bhutan – Total Primary Energy supply 2035



7.3.2 Electricity Outlook

The electricity outlook for Bhutan is derived primarily from the National Transmission Grid Master Plan. Based on the same, the peak demand is expected to increase from 0.39 GW in 2019 to 1.05 GW in 2035. The increase in demand is met mainly through an increase in hydropower plants, with the installed capacity increasing from 2.4 GW in 2019, to 13.6 GW in 2035.

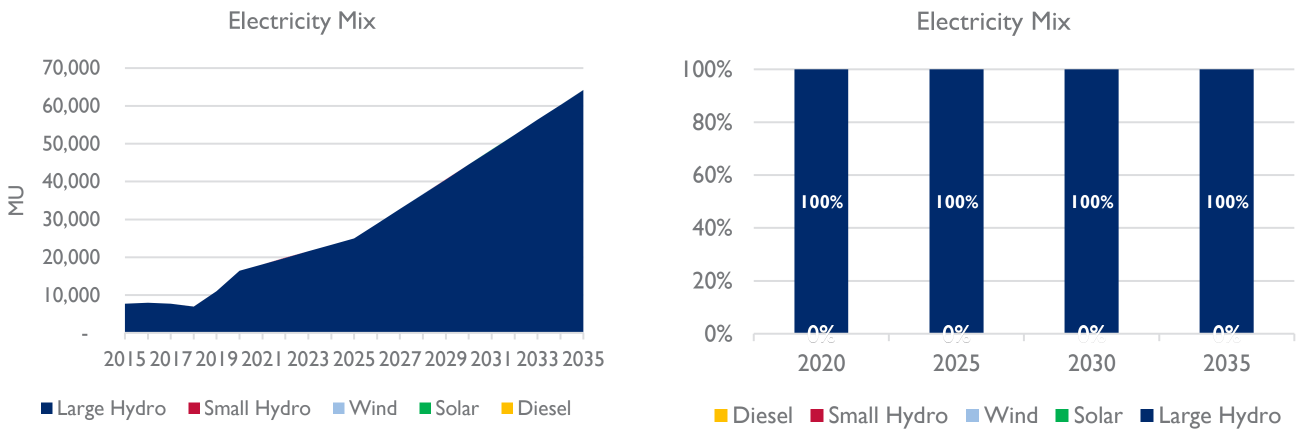
Figure 179: Bhutan - Electricity demand and capacity 2035



Source: Department of Hydropower and Power Systems [263]

The electricity generation mix is almost entirely hydropower, in line with the installed capacity.

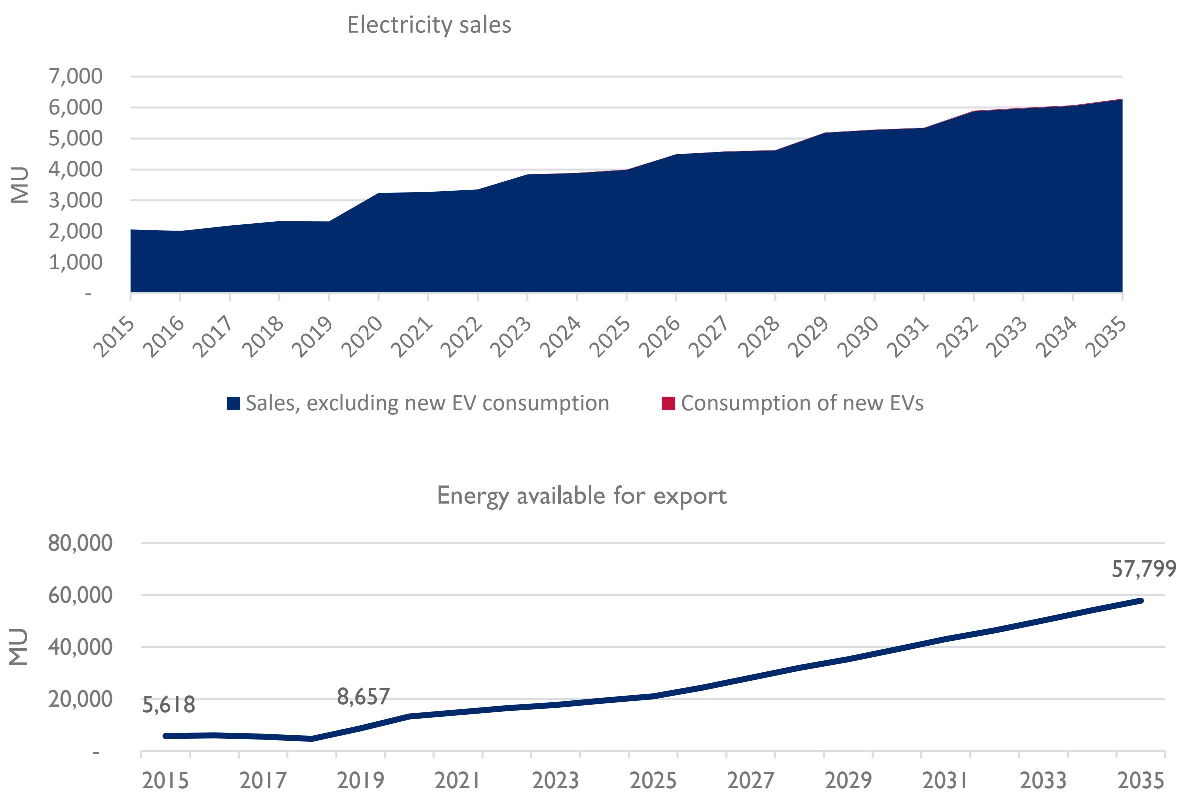
Figure 180: Bhutan - Electricity mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 0.33% by 2035. The total sale of electricity within the country is expected to more than double from the present levels, reaching 6285 MU by 2035.

Based on projected increase in hydropower capacity as per National Transmission Grid Master Plan, the exports will substantially increase over 2035, reaching 57,799 MU.

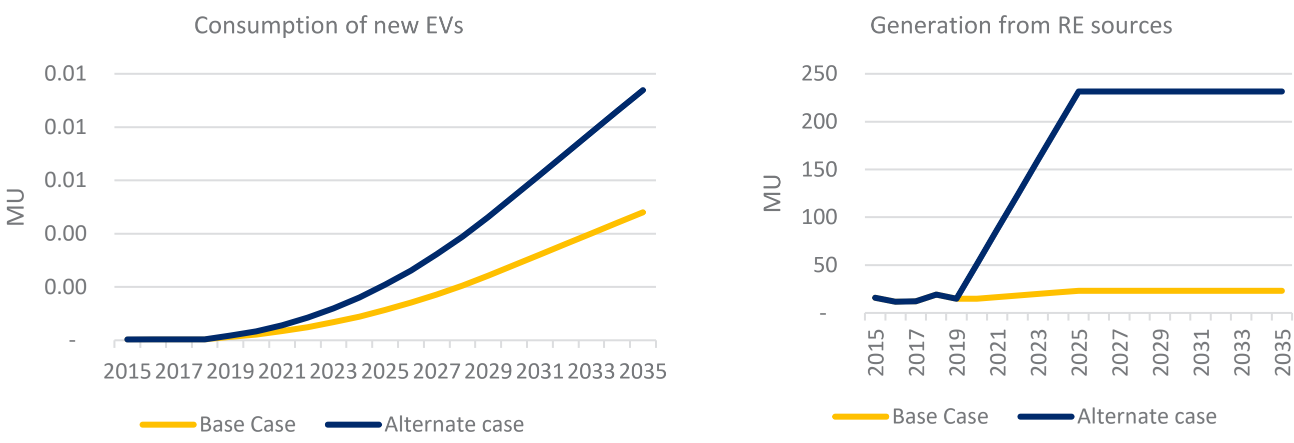
Figure 181: Bhutan - Electricity sales and cross border import/export 2035



7.3.3 Alternate scenario

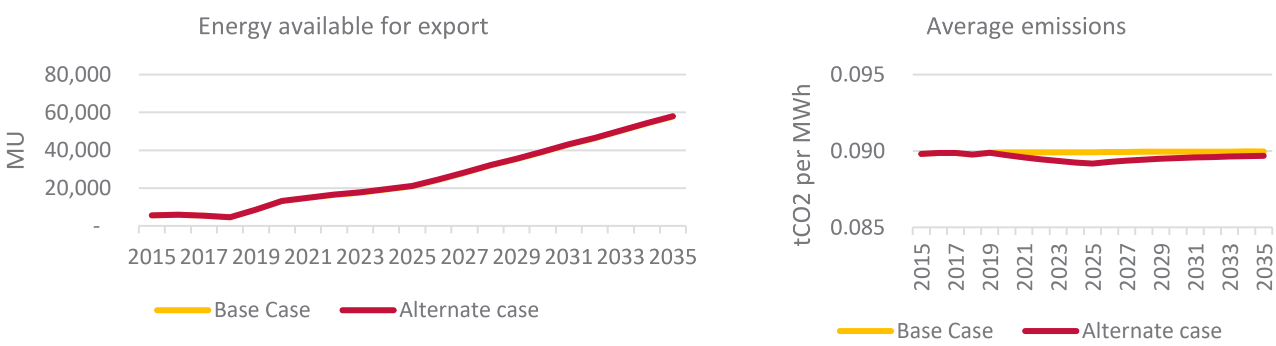
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030 (IEA Global EV Outlook) and RE capacity of 140 MW. The RE capacity of 140 MW is reported as a High-RE case scenario of Department of Renewable Energy.[264] The impact of these changes on consumption and RE share from base case is not highly visible, as the scenario does not vary significantly from base case, and the values are of smaller considering the size of the country.

Figure 182: Bhutan - Alternate scenario inputs



Considering the above alternate renewable energy scenario, the emissions and export energy is depicted below. Again, due to the lack of significant variation in scenario assumptions, the alternate scenario can be seen to be closely tracking the base case scenario, in the case of Bhutan.

Figure 183: Bhutan - Alternate scenario 2035



7.4 India

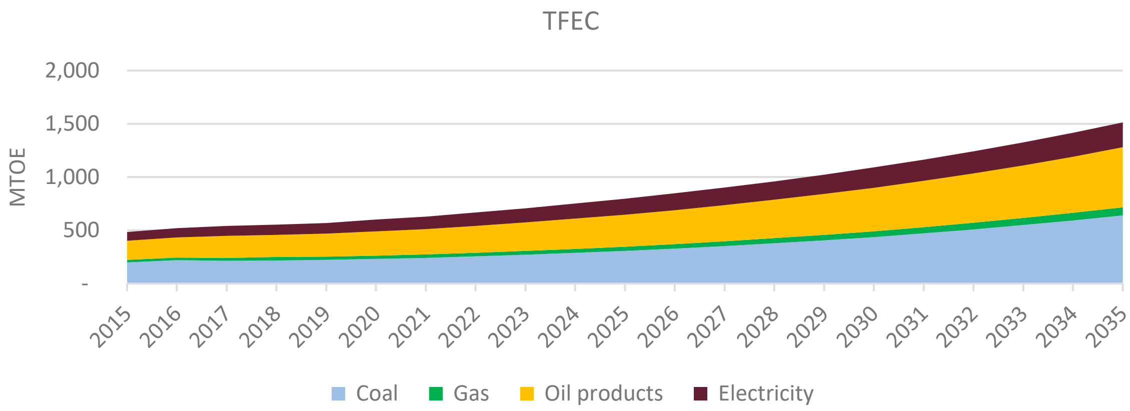
The 2035 outlook for India primarily utilizes the following set of data/information and assumptions:

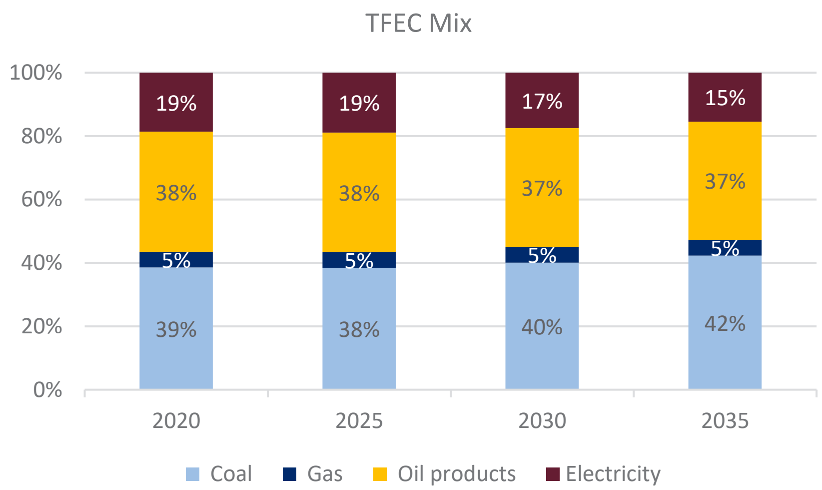
- Existing energy (MTOE) numbers as per energy statistics report of Ministry of Statistics and Program Implementation;
- CEA's Electric Power Survey for peak demand;
- CEA's study on Long Term Optimal Generation Mix for installed capacity of generation;
- TFEC forecasted through a regression with GDP; and
- TPES forecast calculated through regression with TFEC.

7.4.1 Energy Outlook

India's TFEC is expected to increase from 570 MTOE in 2019 to 1514 MTOE in 2035, growing at a compound annual rate of 6.3%. The energy consumption is based on a regression analysis of past relationship between consumption and GDP. The mix is expected to be predominantly from coal (42%) and oil (37%).

Figure 184: India - Total Final Energy Consumption, 2035

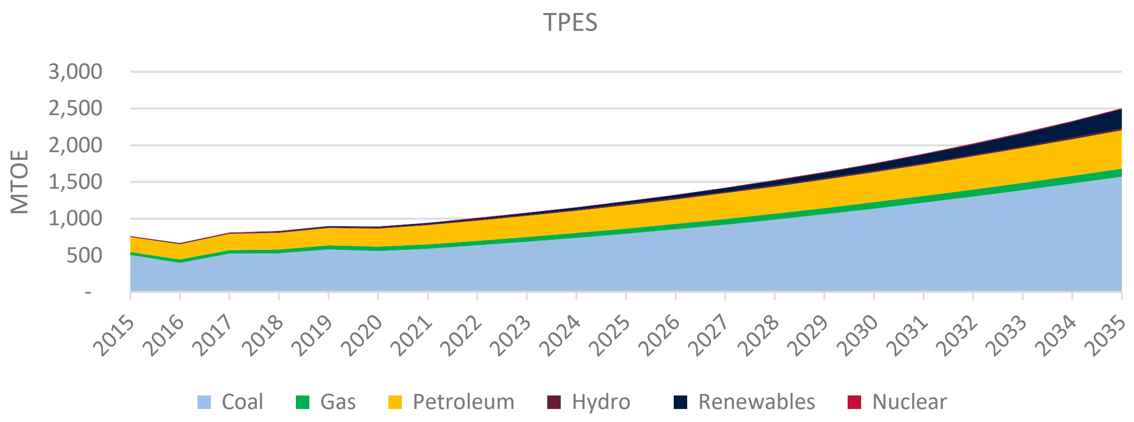


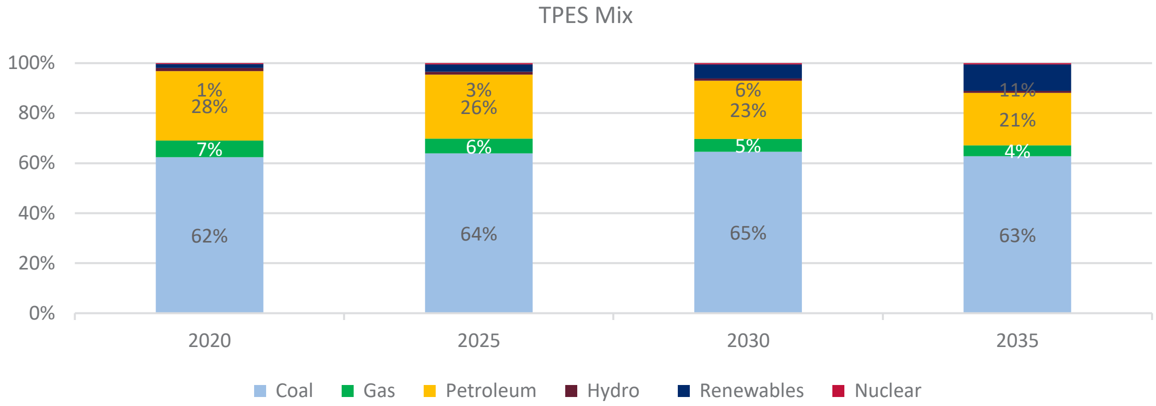


** India's energy statistics published by the Government considers only commercial energy sources, and therefore excludes traditional biofuels.*

TPES was estimated from TFEC through a regression function. Based on the same, TPES is expected to increase from 906 MTOE in 2019 to 2504 MTOE in 2035, growing at a compound annual rate of 6.56%. The high reliance on coal is expected to continue in the future also, though the share of renewables will also show an increase.

Figure 185: India – Total Primary Energy supply 2035



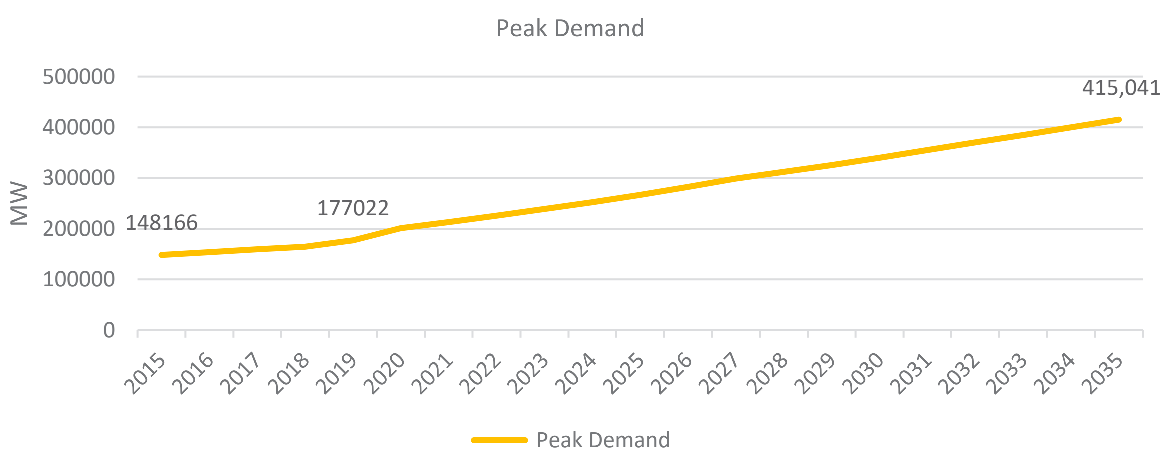


** India's energy statistics published by the Government considers only commercial energy sources, and therefore excludes traditional biofuels.*

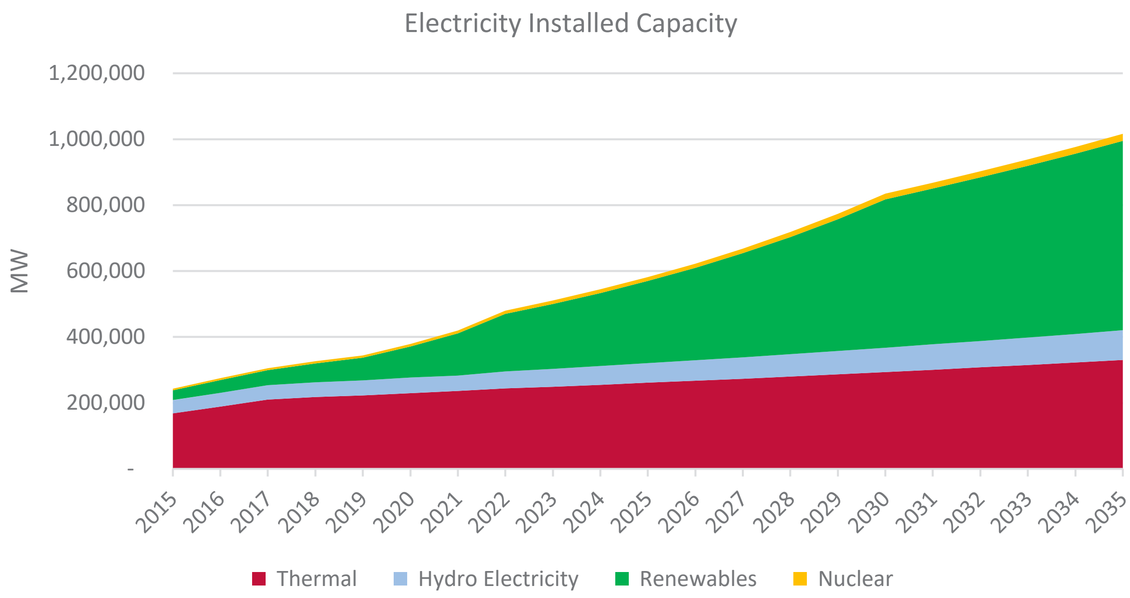
7.4.2 Electricity Outlook

The electricity outlook for India is derived primarily from the 19th Electric Power Survey.[265] Based on the same, the peak demand is expected to increase from 177 GW in 2019 to 415 GW in 2035. The increase in demand is met mainly through an increase in renewable and thermal power plants, with the installed capacity increasing from 344 GW in 2019, to 1016 GW in 2035.

Figure 186: India - Electricity demand and capacity 2035

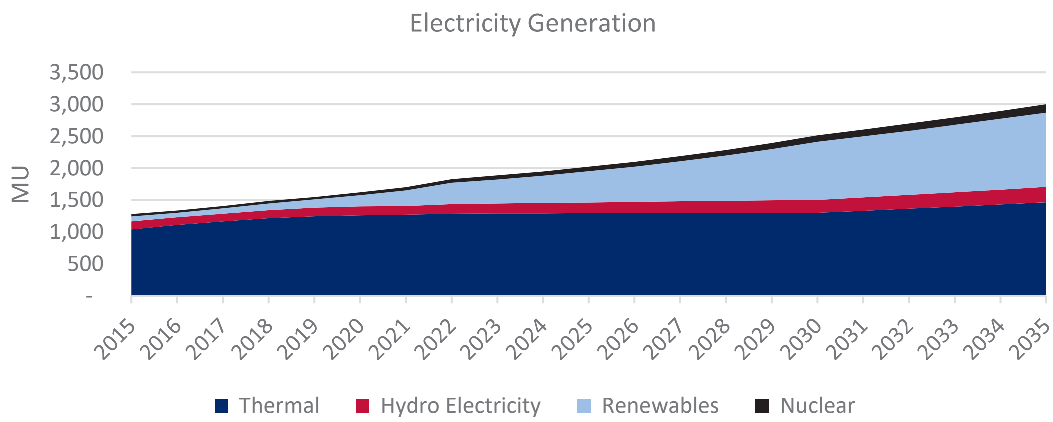


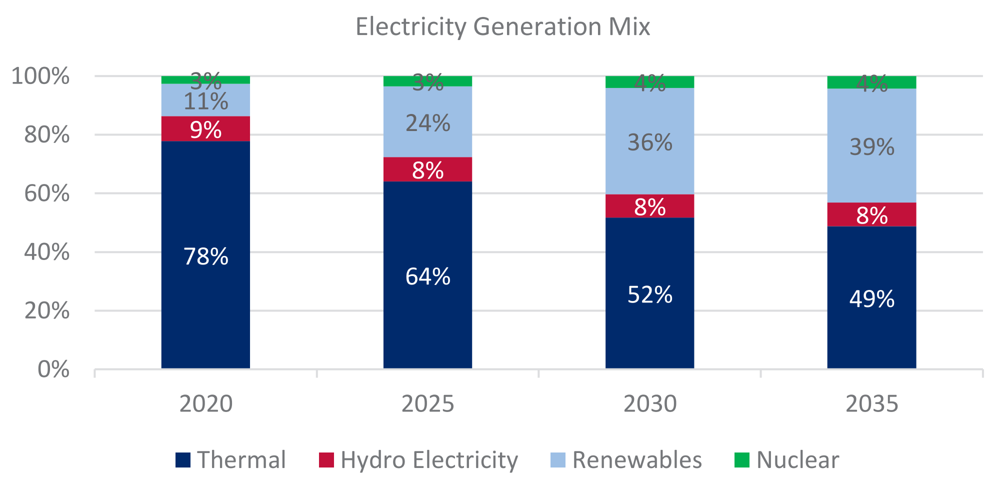
Source: CEA[266]



While the electricity generation will continue to be heavily dependent on thermal sources, a considerable increase in renewable energy is also anticipated, as can be seen below. Renewable energy generation is expected to be 39% of the total electricity generation by 2035, second only to thermal at 49%.

Figure 187: India - Electricity generation mix 2035

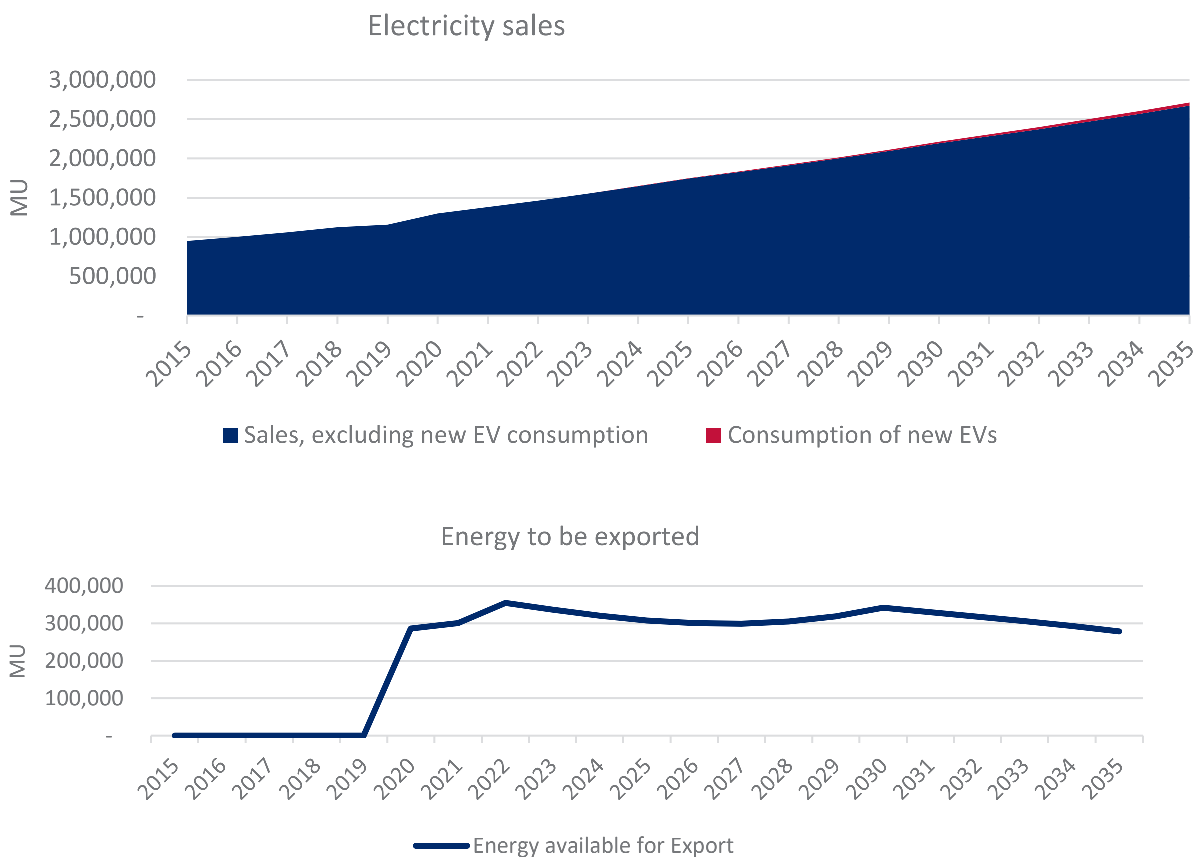




The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 1.5% by 2035.

Based on the increased generation, the overall energy surplus which can be exported is expected to reach 279 billion units by 2035.

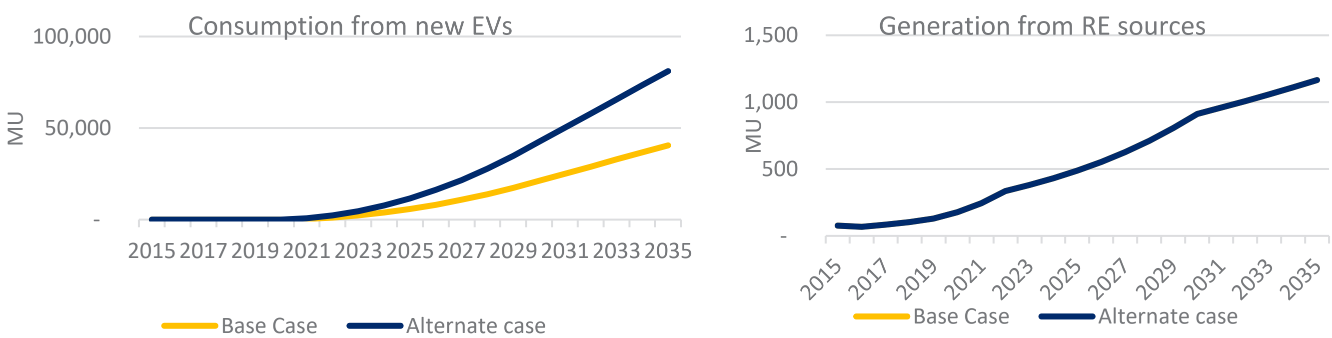
Figure 188: India - Electricity sales and energy for cross border import/export 2035



7.4.3 Alternate scenario

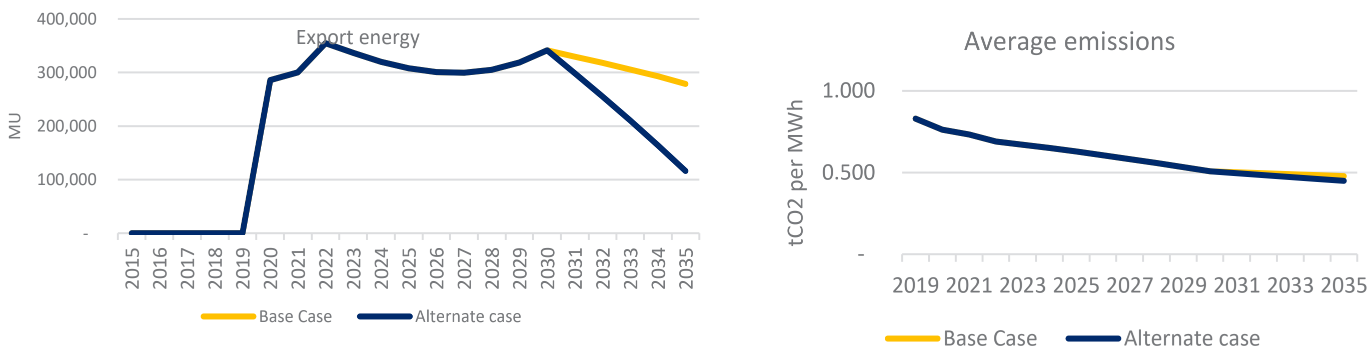
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030. This is expected to result in additional electricity consumption of nearly 40,000 MU. As the RE target is already high, no additional RE is envisaged in alternate case. Therefore there is no difference in RE generation in the alternate scenario.

Figure 189: India - Alternate scenario inputs



Considering the above, the emissions and export energy under alternate scenario is depicted below. The drop in exportable energy in alternate case from 2030 is mostly due to the impact of high EV assumption, which results in increased domestic consumption. As RE capacity is not changing, no variation in emission scenario is anticipated between base and alternate scenarios.

Figure 190: India - Alternate scenario 2035



7.5 Myanmar

The 2035 outlook for Myanmar is estimated based on the following country specific assumptions, in addition to the overall common assumption specified at the start of this section:

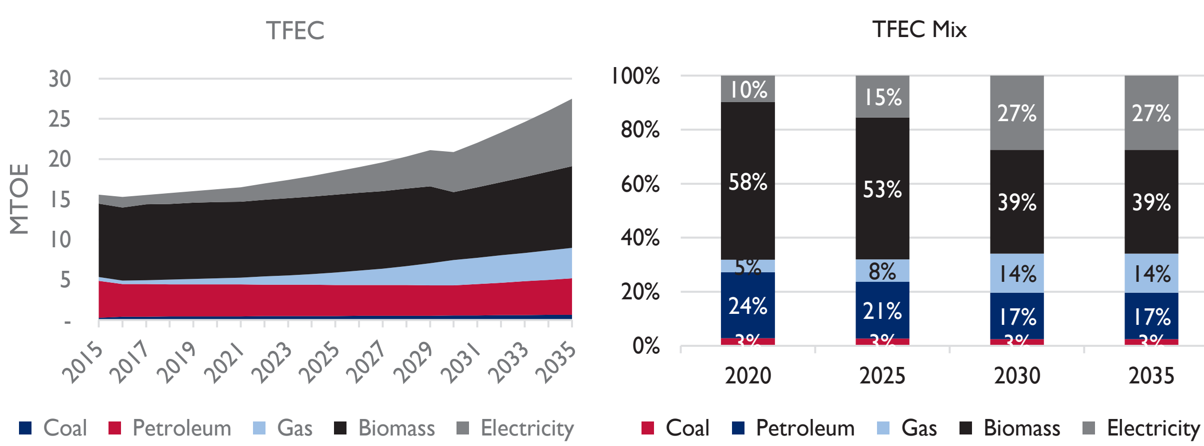
- TFEC and TPES forecasts as per Myanmar Energy Master Plan[267];
- Installed capacity expansion forecasts as per Myanmar Energy Master Plan;
- As per Myanmar Energy Master Plan, no new export plants considered other than the existing 840 MW to China;
- High RE scenario of Master Plan considered in Alternate Case.

7.5.1 Energy Outlook

For Myanmar, the TFEC is expected to increase from 16 MTOE in 2019 to 26 MTOE in 2035, growing at a compound annual rate of 3.16%. The energy consumption is based on Myanmar's Energy Master Plan. [268]

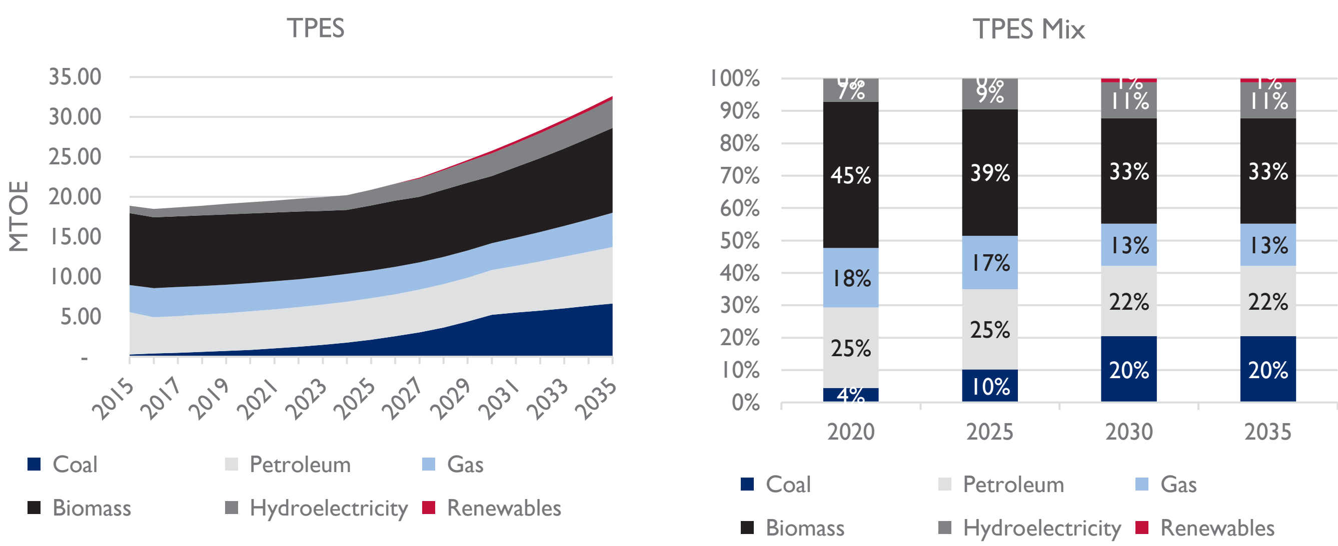
An increase in the share of electricity and decrease in the share of traditional biomass and petroleum products can be observed, mainly due to the shift to modern energy sources and electric vehicles.

Figure 191: Myanmar - Total Final Energy Consumption, 2035



TPES was also derived from estimates provided in Energy Master Plan. Based on the same, TPES is expected to increase from 19 MTOE in 2019 to 33 MTOE in 2035, growing at a compound annual rate of 3.4%. The key transition to be noted is the expected increase in share of coal to 20%.

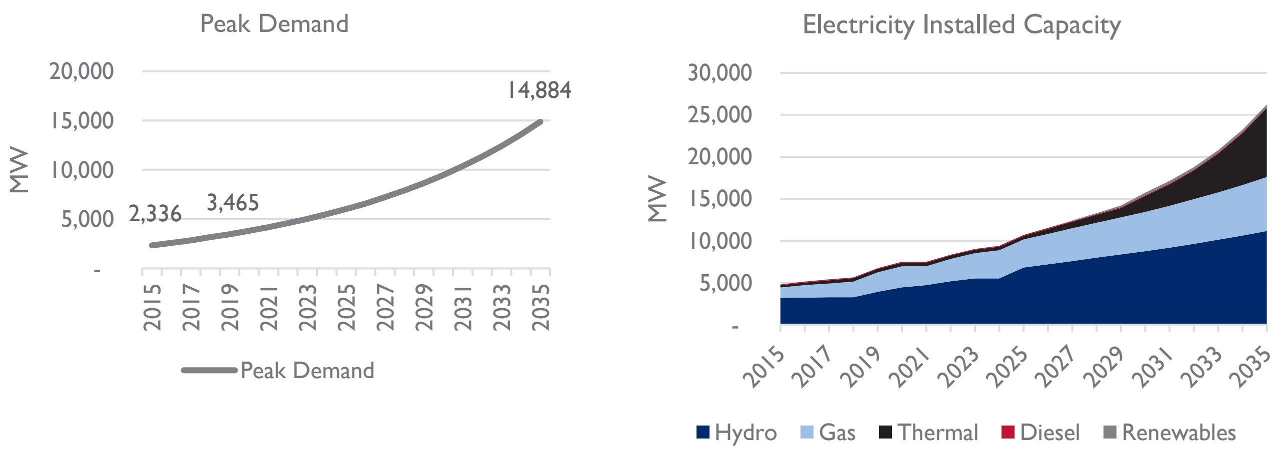
Figure 192: Myanmar – Total Primary Energy supply, 2035



7.5.2 Electricity Outlook

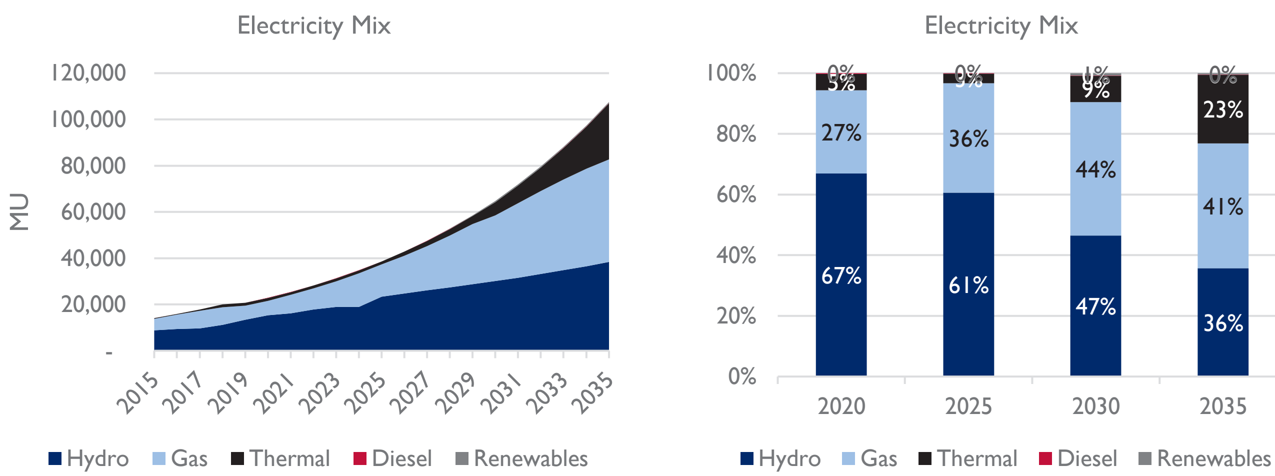
The electricity outlook for Myanmar is derived primarily from the Energy Master Plan. Based on the same, the peak demand is expected to increase from 3.5 GW in 2019 to 14.9 GW in 2035. The increase in demand is met through an increase in capacity of thermal and hydro power plants, with the installed capacity increasing from 6.7 GW in 2019, to 26.2 GW in 2035.

Figure 193: Myanmar - Electricity demand and capacity 2035



The electricity generation mix is expected to reduce its reliance on hydro, and shift towards increased renewable sources. Due to such diversification, share of hydropower is expected to drop to 36% in 2035, with gas emerging as the dominant source of electricity (41%).

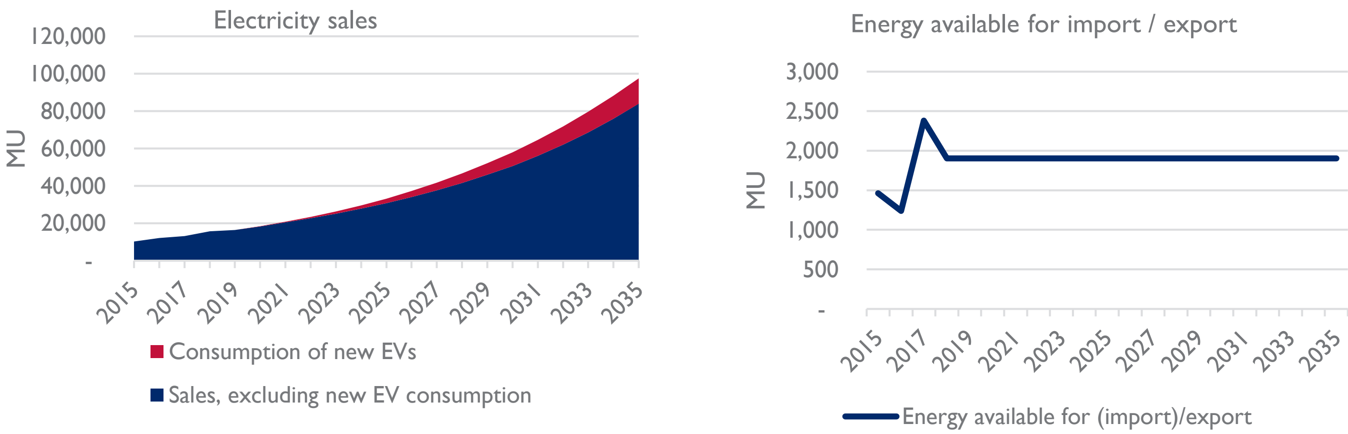
Figure 194: Myanmar - Electricity generation mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 13.9% by 2035.

As per Energy Master Plan, no new export oriented power plants are envisaged. Only the existing 840 MW of hydropower plants that supply power to China is assumed to be continuing to export.

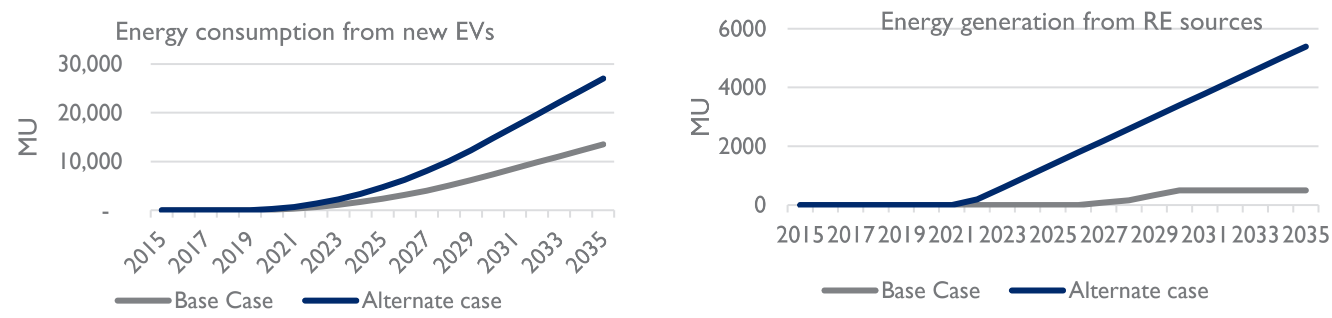
Figure 195: Myanmar - Electricity sales and cross border import/export 2035



7.5.3 Alternate scenario

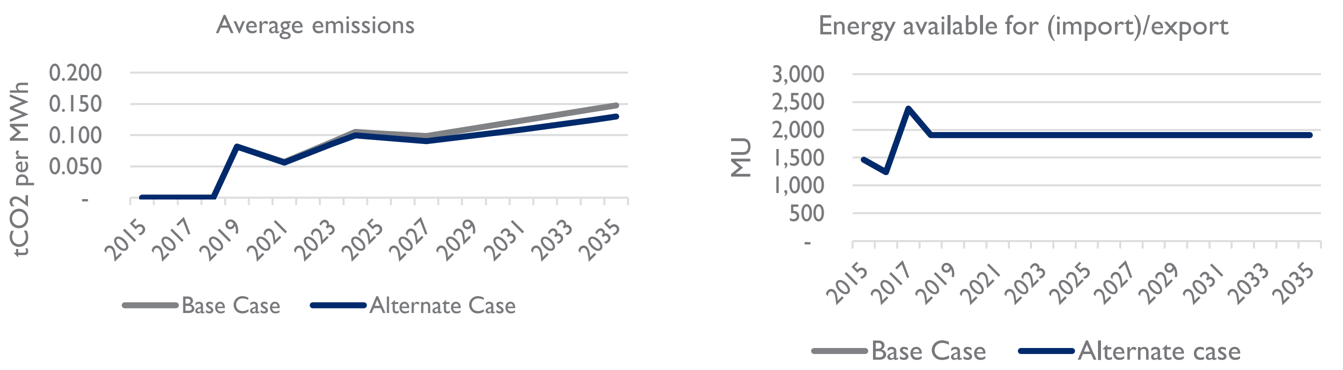
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030. The scenario also considers a higher RE share scenario from the Energy Master Plan, with 1800 MW of renewables, instead of 300 MW by 2030. Because of this, a large variation in RE generation can be observed in the alternate case.

Figure 196: Myanmar - Alternate scenario inputs



Based on the above, the change in estimated average emissions are as shown below. As the export power plants remain the same, the exportable power also remains the same between base and alternate scenarios.

Figure 197: Myanmar - Alternate scenario 2035



7.6 Nepal

The 2035 outlook for Nepal is built based on the following key information and assumptions:

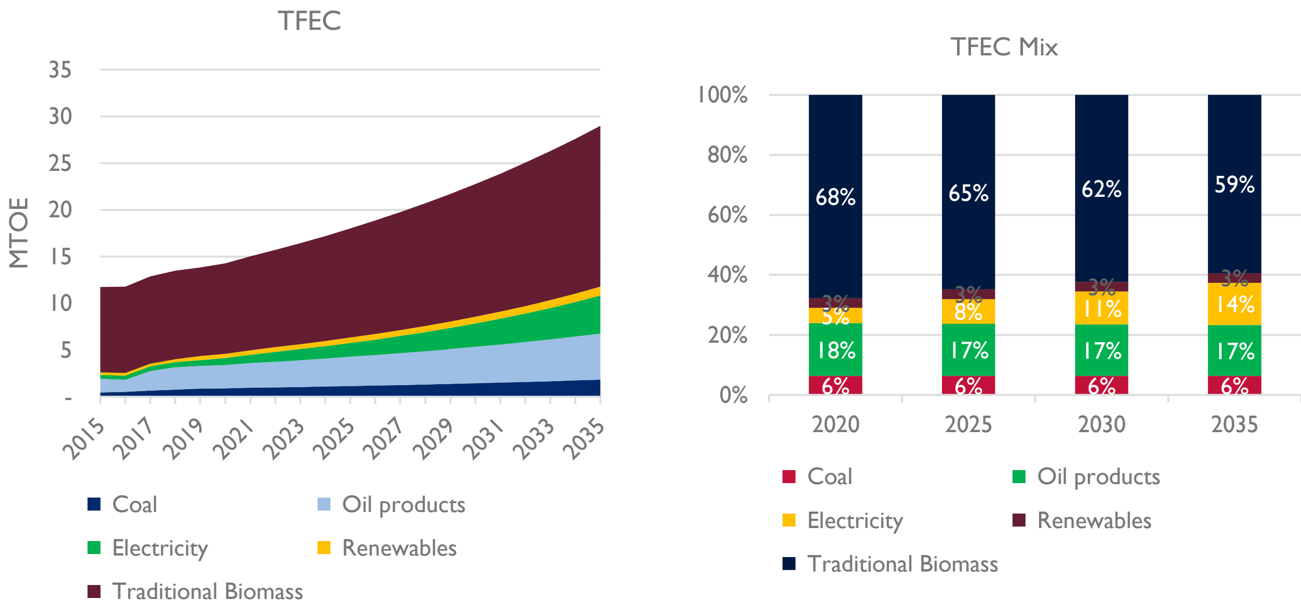
- Existing statistics as per NEA annual reports, government's statistical year book, and environmental statistics;
- RE targets for base case as per GoN whitepaper[269] and as per INDC for alternate case;
- Future demand projection as per NEA annual report; and
- Generation expansion as per GoN whitepaper.

7.6.1 Energy Outlook

For Nepal, the TFEC is expected to increase from 13.8 MTOE in 2019 to 29 MTOE in 2035, growing at a compound annual rate of 4.74%. The energy consumption was derived from GDP, considering average GDP growth of 5.4% between 2019 and 2035.

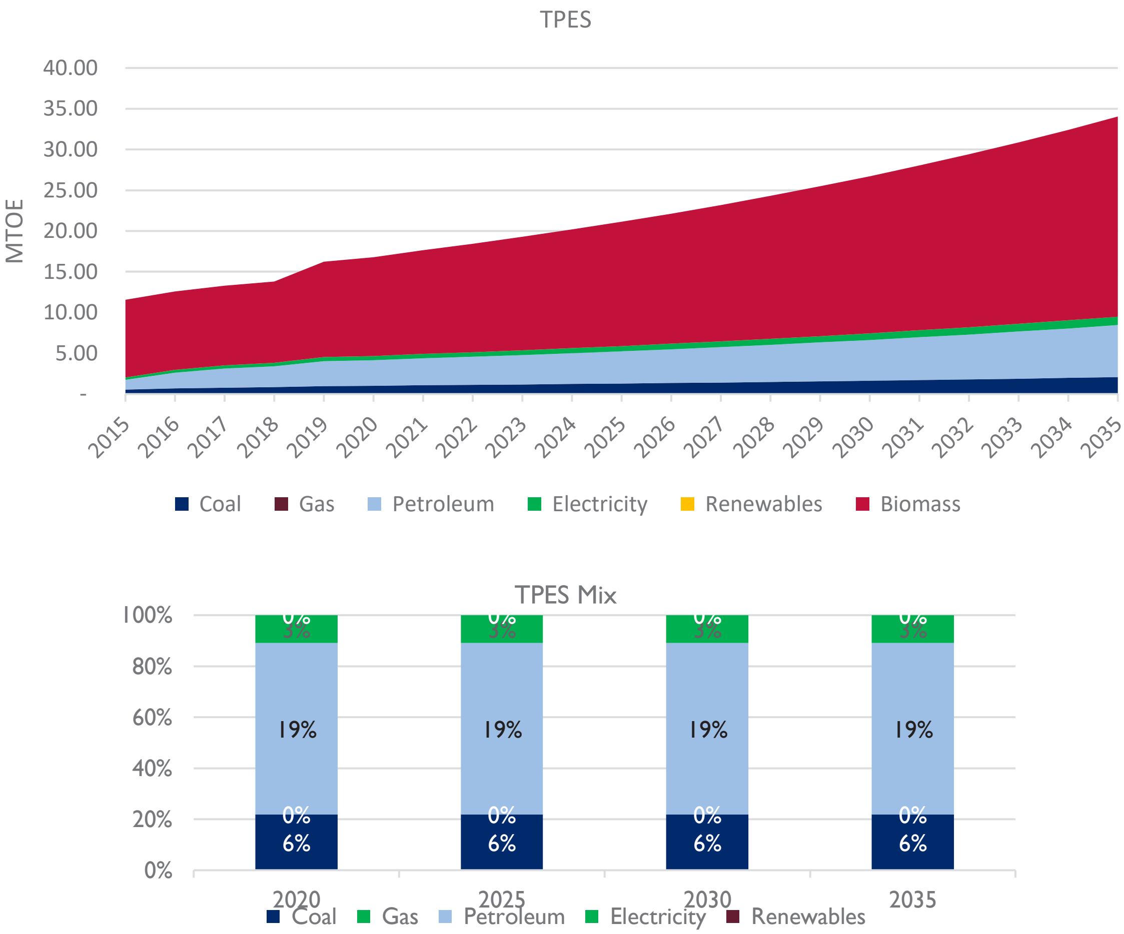
A decrease in the share of biomass, and an increase in the share of electricity can be observed, which could be mainly due to the shift from traditional energy sources to modern energy sources in rural areas.

Figure 198: Nepal - Total Final Energy Consumption, 2035



The TPES is also expected to increase from 14 MTOE in 2018 to 34 MTOE in 2035.

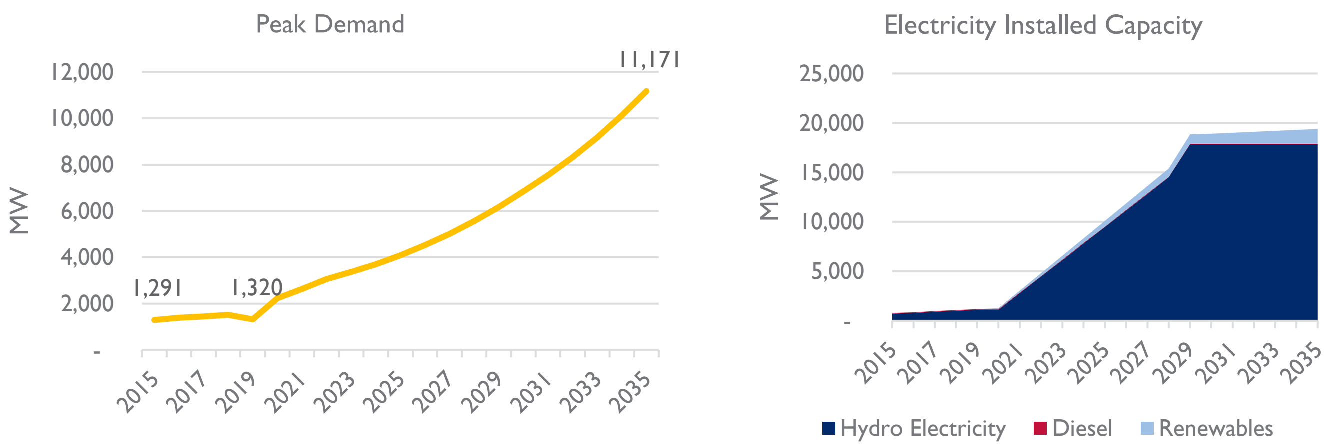
Figure 199: Nepal – Total Primary Energy Supply, 2035



7.6.2 Electricity Outlook

As per NEA's own forecasts which are available in their annual reports, the peak demand is expected to increase from 1.3 GW in 2019 to 11.2 GW in 2035. The increase in demand is met mainly through an increase in capacity of hydropower, with the installed capacity increasing from 1.2 GW in 2019, to 19.4 GW in 2035. The increase in generation capacity is estimated based on Government of Nepal's Energy Sector Whitepaper of 2018.[270]

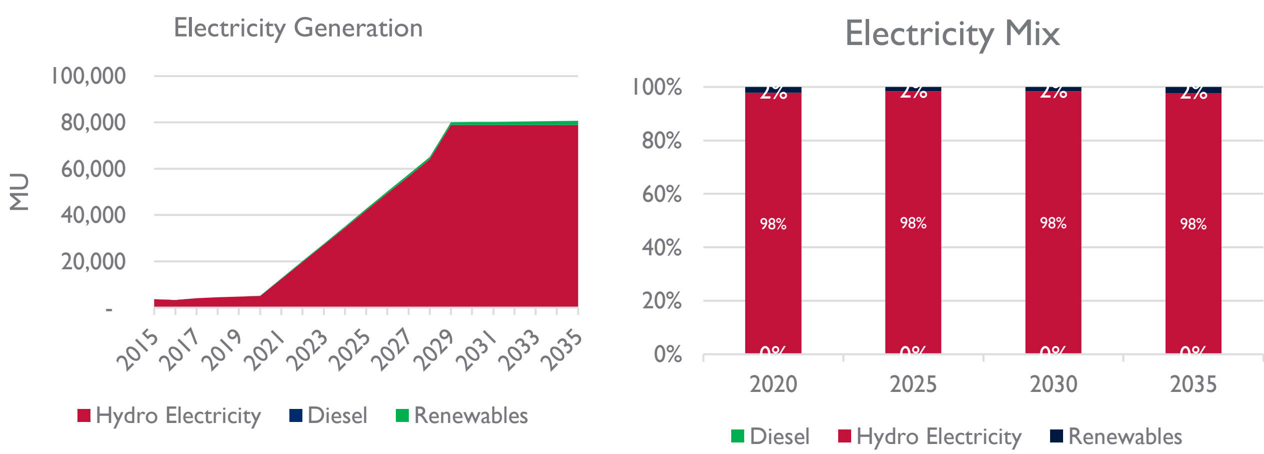
Figure 200: Nepal - Electricity demand and capacity 2035



Source: NEA [271]

The heavy reliance on hydropower for the electricity requirement is expected to continue in the future also.

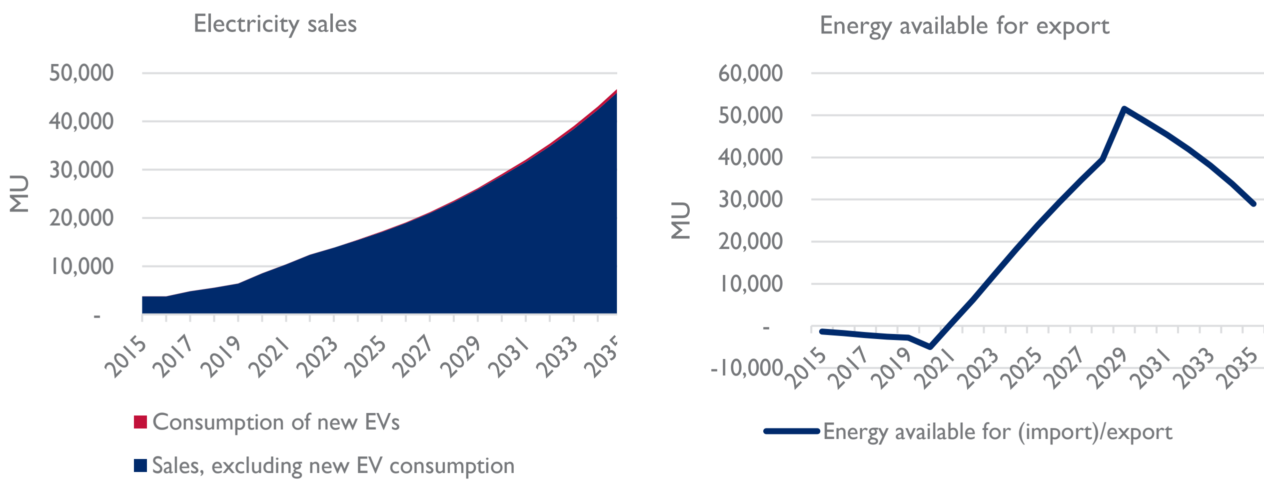
Figure 201: Nepal - Electricity generation mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 1.6% by 2035.

The country's reliance on electricity imports is expected to reverse in a couple of years, after which the country is expected to have a net surplus of electricity for export. The surplus is expected to reach 36% of annual energy generation in 2035.

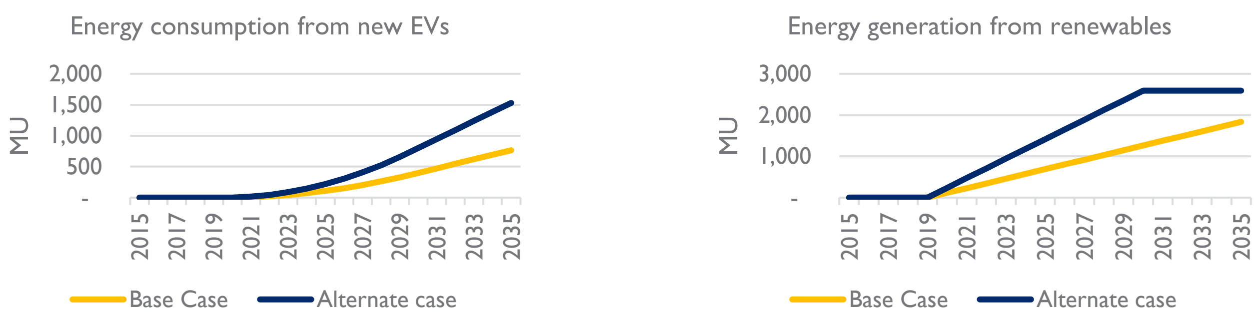
Figure 202: Nepal - Electricity sales and energy for cross border import/export 2035



7.6.3 Alternate scenario

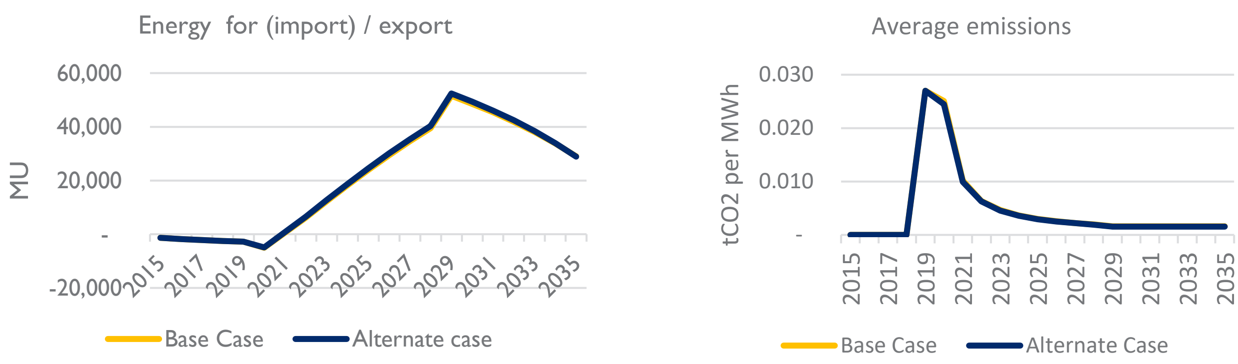
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030. The renewable energy capacity has been taken as per the Government's whitepaper in base case (930 MW by 2039), and as per the NDC target in alternate case (2100 MW by 2030).

Figure 203: Nepal - Alternate scenario inputs



Based on the above, the change in available energy for cross border trade, and estimated average emissions are as shown below. Similar to the base case scenario, the country is expected to become net exporter for energy by 2022, and thereafter the exports increasing steadily as new projects are developed. The decrease in exportable energy after 2031 is because additional generation beyond 2030 is not considered currently.

Figure 204: Nepal - Alternate scenario 2035



As the quantum of EV consumption and RE generation are not considerable, there is no perceptible difference in the alternate scenario in the case of Nepal.

7.7 Sri Lanka

The outlook projects for 2035 primarily depends on the following information / assumptions:

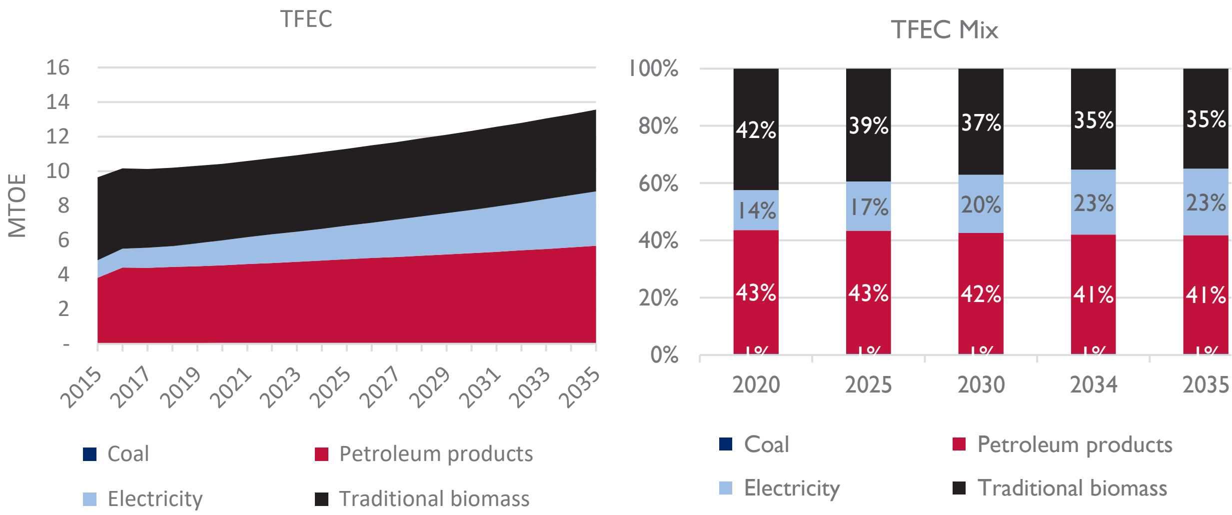
- Existing information as per CEB statistical digests, and government statistics;
- RE targets for base case as per CEB LTGEP and as 5 GW in alternate case based on ADB's RE potential estimate of 11.6 GW;
- Peak demand, sales, energy requirement and capacity expansion considered as per CEB LTGEP; and
- As CEB's LTGEP has considered India interconnection as still at feasibility stage, the same has also not been considered in this analysis.

7.7.1 Energy Outlook

Based on the outlook projections, for Sri Lanka, the TFEC is expected to increase from 10.3 MTOE in 2019 to 13.6 MTOE in 2035, growing at a compound annual rate of 1.73%. The energy consumption was derived from GDP, considering average GDP growth of 3.34% between 2019 and 2035.

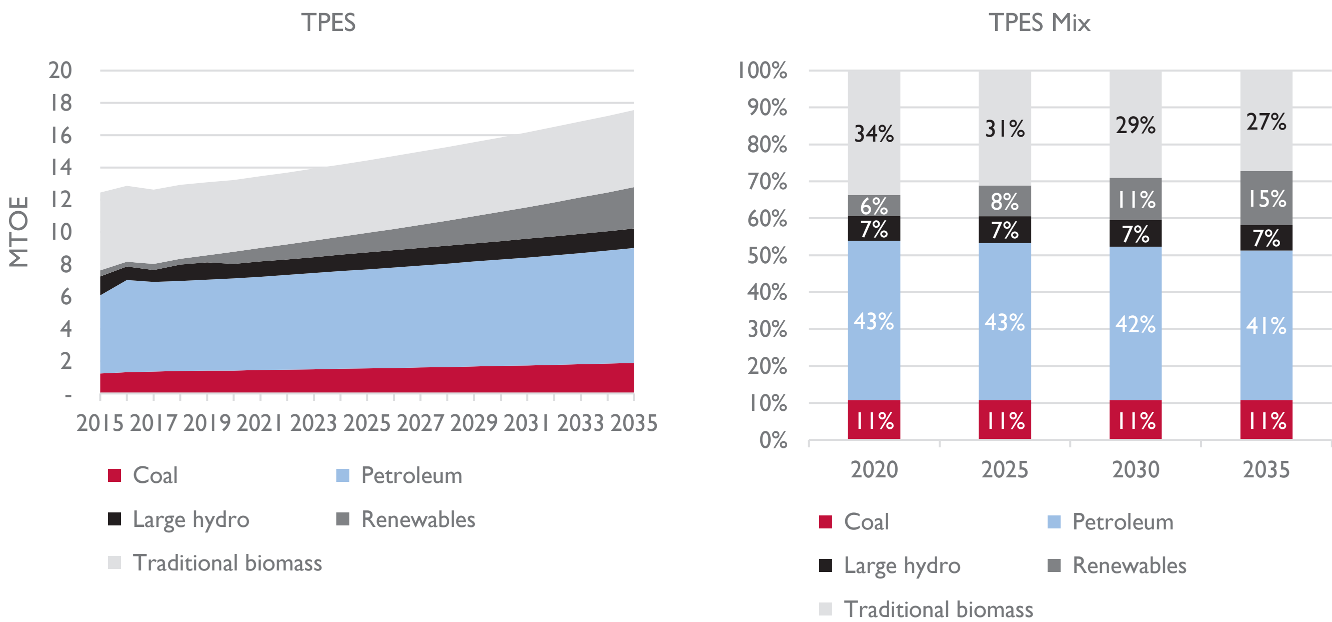
An increase in the share of electricity and slight decrease in the share of petroleum products can be observed, mainly due to the shift to electric vehicles.

Figure 205: Sri Lanka - Total Final Energy Consumption, 2035



TPES was derived through a regression relation with TFEC. Based on the same, TPES is expected to increase from 13.1 MTOE in 2019 to 17.6 MTOE in 2035, growing at a compound annual rate of 1.86%.

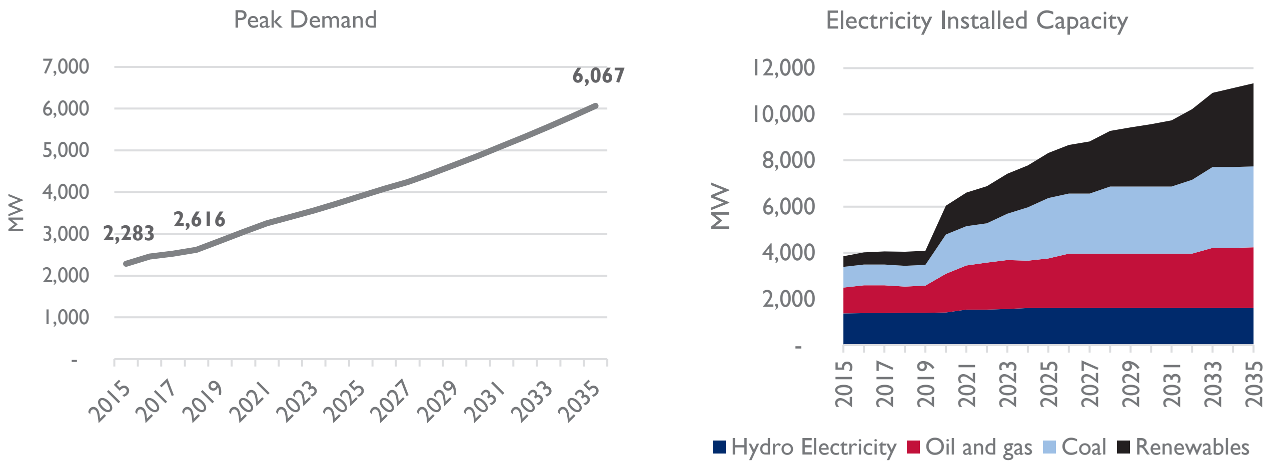
Figure 206: Sri Lanka – Total Primary Energy Supply, 2035



7.7.2 Electricity Outlook

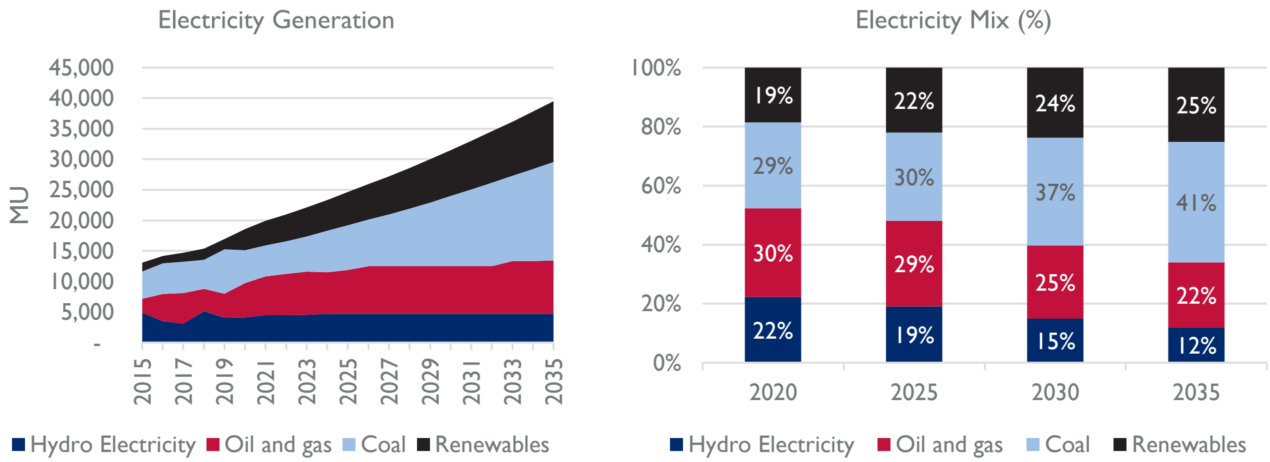
The electricity outlook for Sri Lanka is primarily dependent on CEB's Long Term Generation Expansion Plan.[272] Based on the same, the peak demand is expected to increase from 2.6 GW in 2019 to 6.1 GW in 2035. The increase in demand is met through an increase in capacity of thermal and renewable energy power plants, with the installed capacity increasing from 4.1 GW in 2019, to 11.3 GW in 2035.

Figure 207: Sri Lanka - Electricity demand and capacity 2035



The electricity generation mix is expected to reduce its reliance on hydro and liquid fuel, and shift towards increased coal and renewable sources.

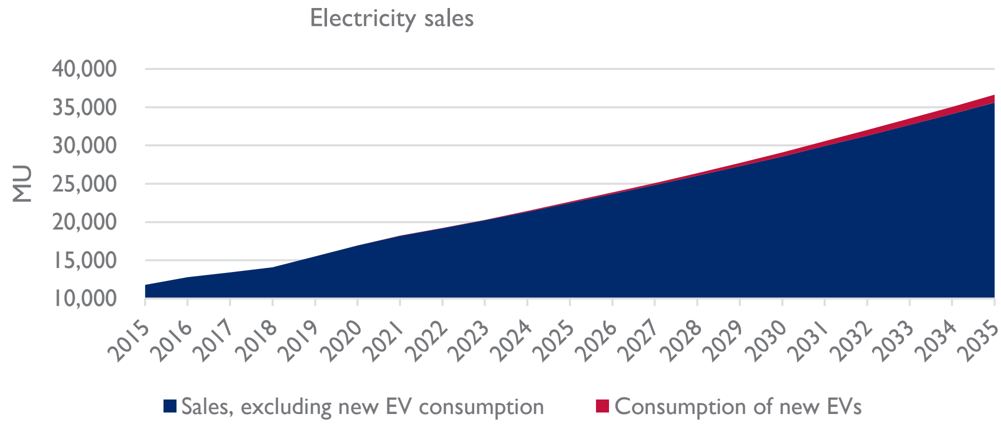
Figure 208: Sri Lanka – Electricity generation mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 2.8% by 2035.

As per CEB's Long Term Generation Expansion Plan for 2020, no import from India is considered as the line was still under feasibility study phase at the time of preparation of the plan.

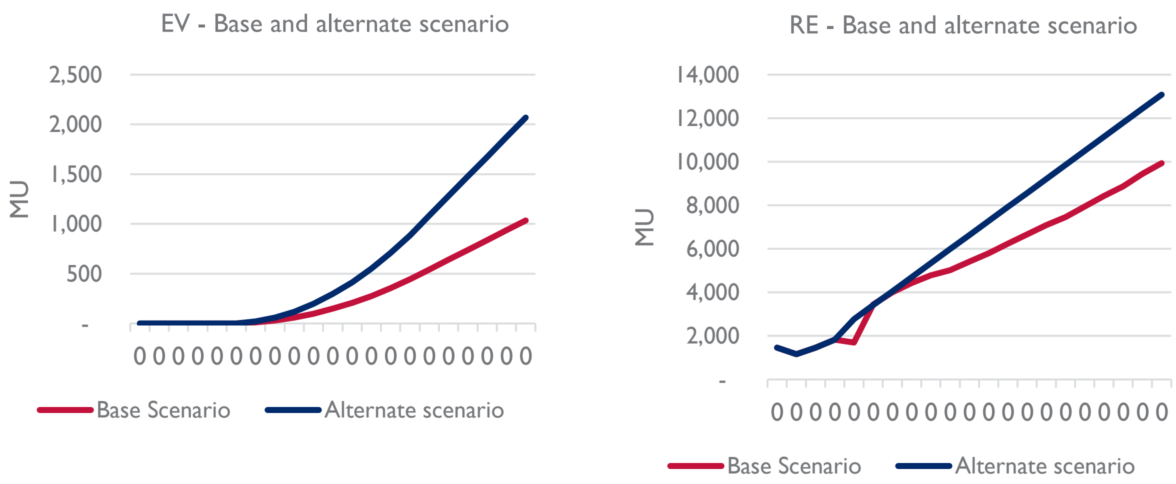
Figure 209: Sri Lanka - Electricity sales 2035



7.7.3 Alternate scenario

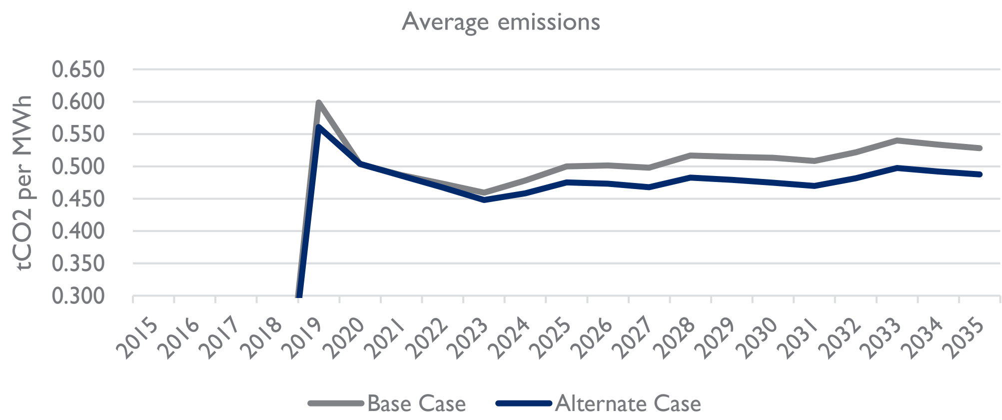
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030. The scenario also considers an RE installed capacity of 5 GW against the RE capacity of 3.6 GW considered in Long Term Generation Expansion Plan.

Figure 210: Sri Lanka - Alternate scenario inputs



Based on the above, the change in estimated average emissions are as shown below.

Figure 211: Sri Lanka - Alternate scenario 2035



7.8 Thailand

The 2035 outlook analysis for Thailand primarily depends on the following information and assumptions:

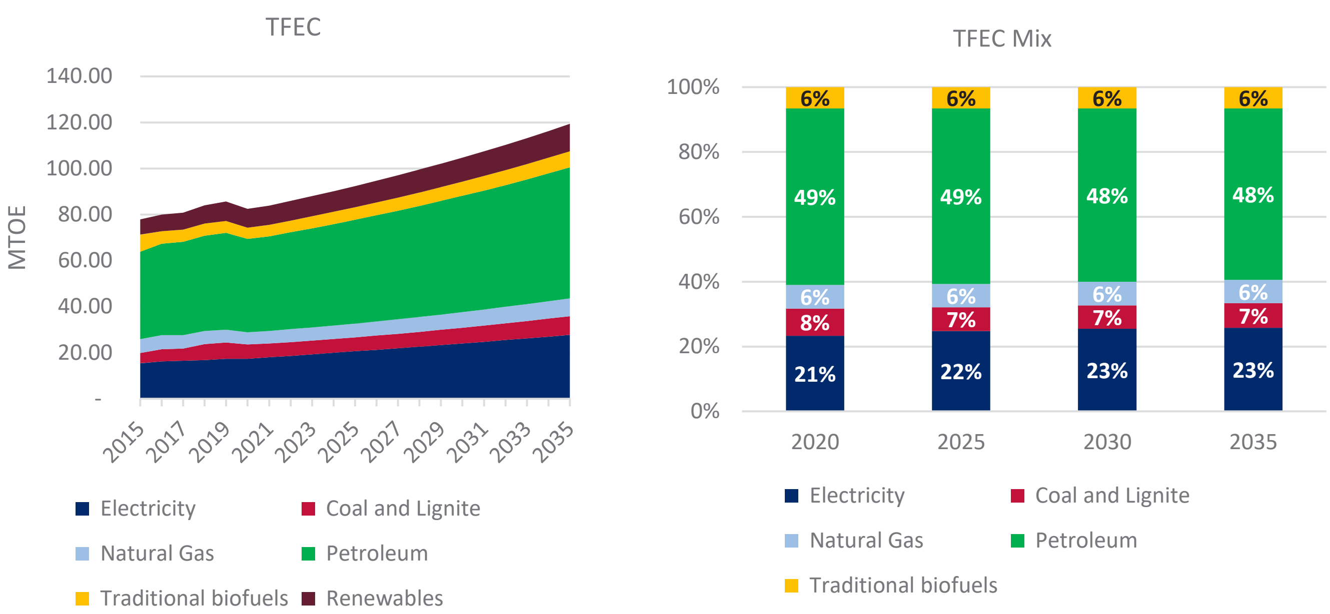
- Existing statistics as per EPPO, EGAT and government;
- Government's Power Development Plan;
- Peak electricity demand, base sales (without EV), emission per kWh and installed capacity addition considered as per Power Development Plan 2018;
- As PDP 2018 has not considered any import / export of electricity with Myanmar, the same has not been considered; and
- Alternate scenario differs from base scenario only on EV sales, as RE share is already substantial in base scenario.

7.8.1 Energy Outlook

TFEC estimates for future in case of Thailand was derived by creating a regression equation with GDP. Based on the outlook analysis, for Thailand, the TFEC is expected to increase from 86 MTOE in 2019 to 119 MTOE in 2035, growing at a compound annual rate of 2.09%. The energy consumption was derived from GDP, considering average GDP growth of 2.9% between 2019 and 2035.

A slight decrease in the share of petroleum products, and a slight increase in the share of electricity can be observed, mainly due to the shift in energy of electric vehicles.

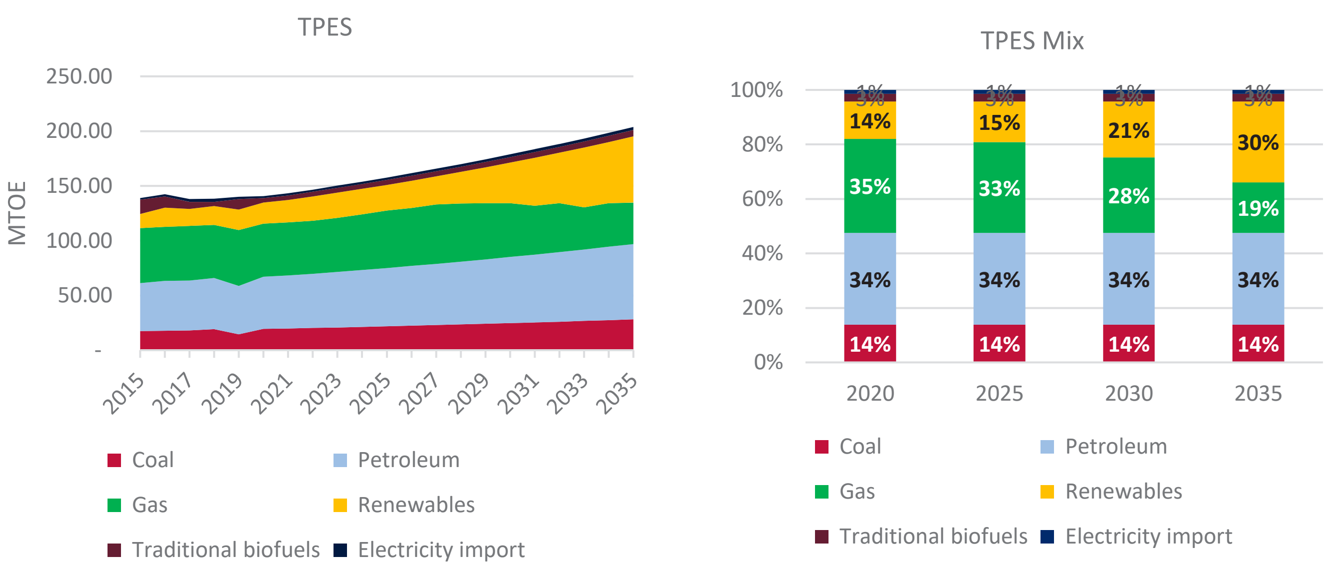
Figure 212: Thailand – Total Final Energy Consumption, 2035



Biomass refers to the use of traditional fuels such as firewood

TPES was derived through a regression relation with TFEC. Base on the same, TPES is expected to increase from 140 MTOE in 2019 to 204 MTOE in 2035, growing at a compound annual rate of 2.37%. An increase in share of renewable, to 30% is anticipated.

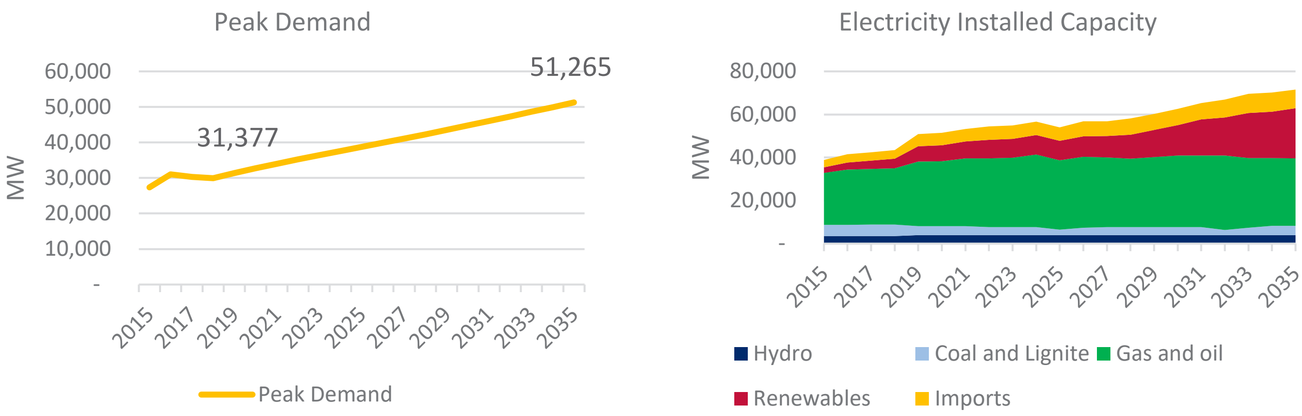
Figure 213: Thailand – Total Primary Energy Supply, 2035



7.8.2 Electricity Outlook

The electricity outlook for Thailand is primarily dependent on the Power Development Plan of 2018, prepared by the Ministry of Energy. [273] Based on the same, the peak demand is expected to increase from 29.97 GW in 2019 to 51.26 GW in 2035. The increase in demand is met through an increase in capacity of imports, oil and gas power plants, and renewable energy power plants, with the installed capacity increasing from 50.93 GW in 2019, to 71.54 GW in 2035.

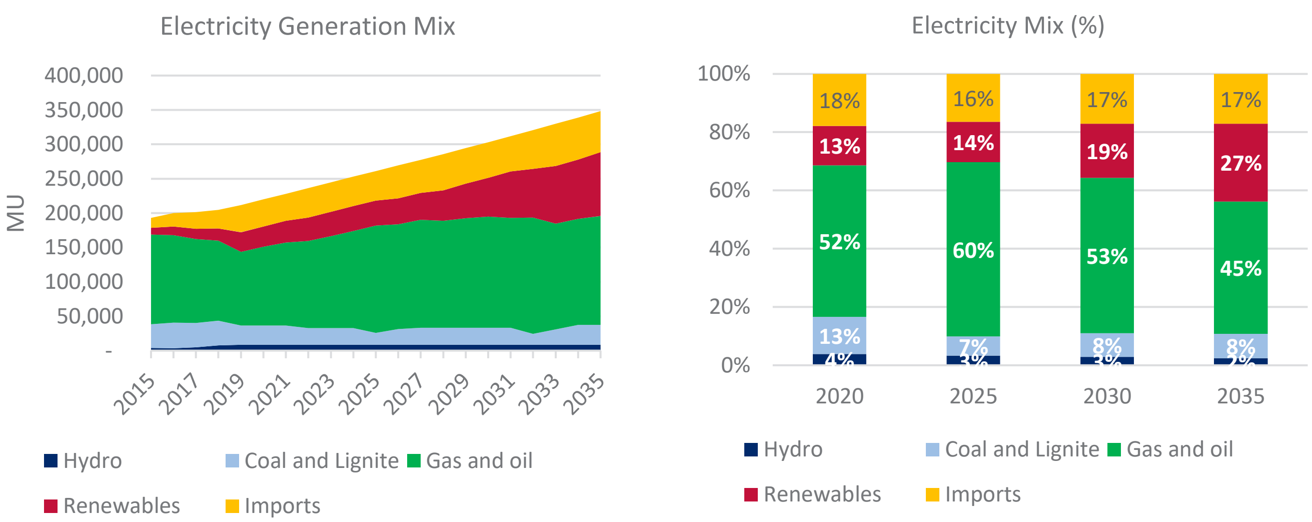
Figure 214: Thailand - Electricity demand and capacity 2035



Source: Ministry of Energy

The electricity generation mix is expected to reduce its reliance on coal, lignite, gas and oil sources, and shift towards increased renewables and imports to compensate for such reduction in reliance on thermal sources.

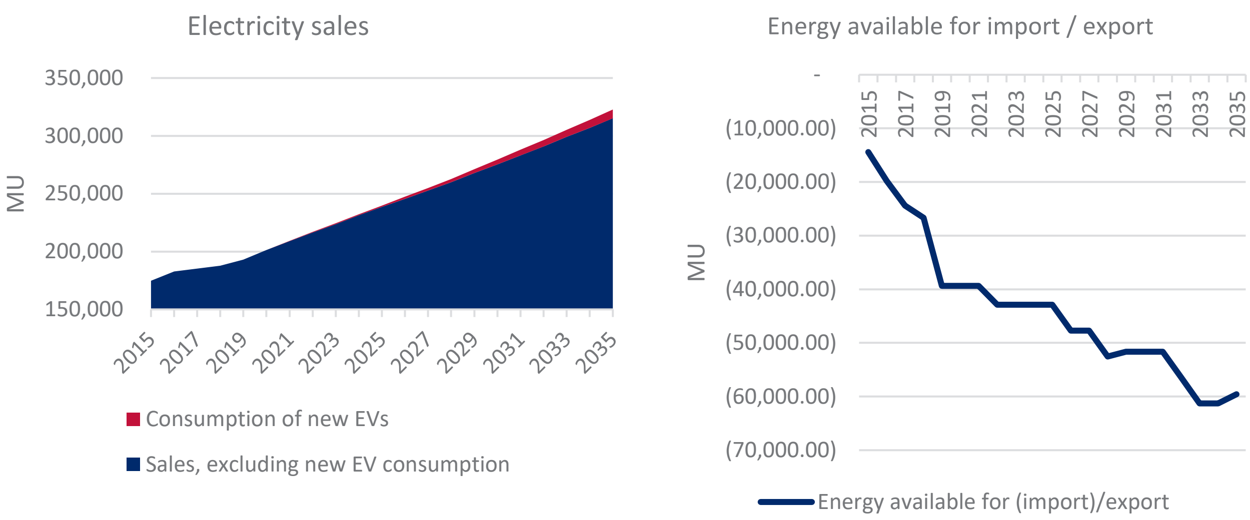
Figure 215: Thailand - Electricity generation mix 2035



The estimated electricity sales is inclusive of impact of electric vehicles, considering 15% of all new vehicles registered in 2030 to be electric vehicles. Considering the trajectory for the same, the share of EV consumption in total electricity sales is expected to reach 2.3% by 2035.

The country's reliance on electricity imports is expected to continue, with imports increasing from 39 BU in 2019 to 60 BU in 2035. This corresponds to import of 17% of annual energy requirement in 2035.

Figure 216: Thailand - Electricity sales and energy for cross border import/export 2035

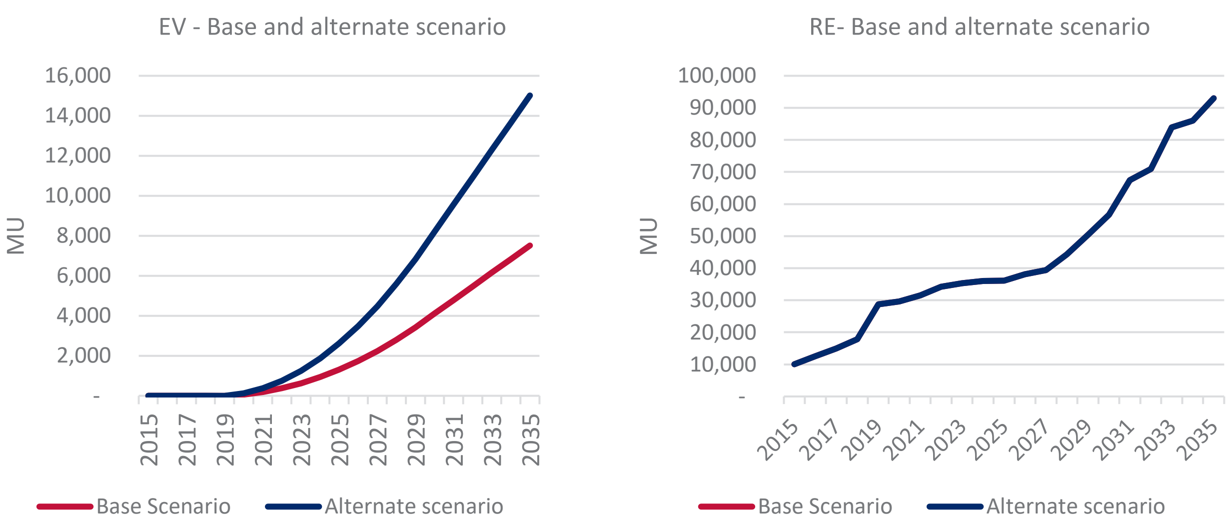


As per PDP 2018, the import is expected to be from Laos and Malaysia. The document does not envisage any import of power from Myanmar.

7.8.3 Alternate scenario

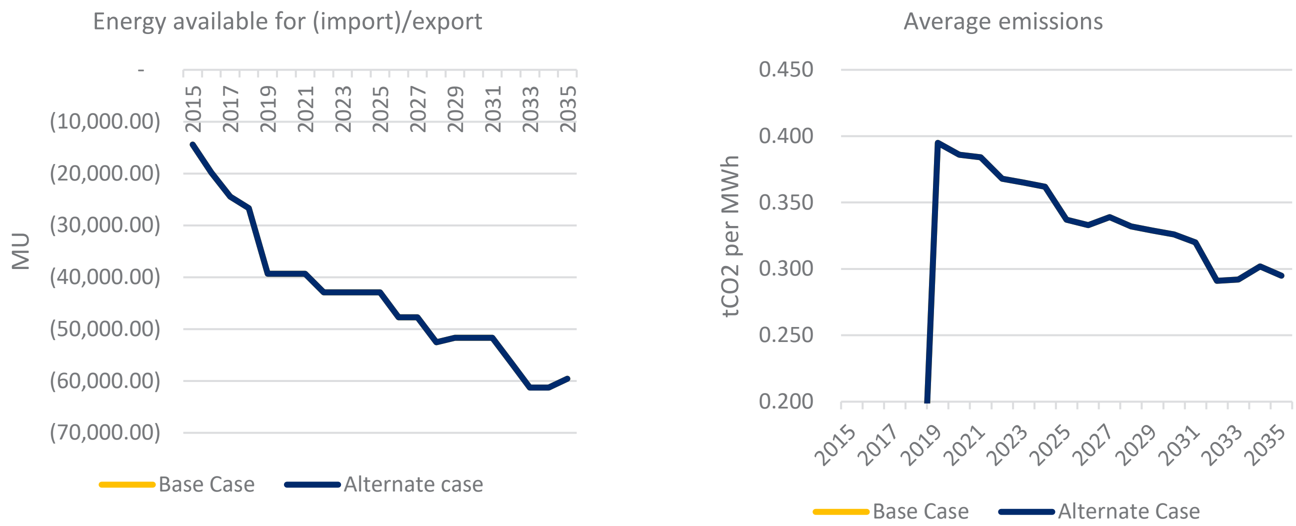
The alternate scenario considers EV sales as 30% of new vehicle sales at 2030. In the specific context of Thailand, since the PDP 2018 already considers a substantial amount of RE, no separate high RE scenario is incorporated in the alternate scenario for Thailand.

Figure 217: Thailand - Alternate scenario inputs



Based on the above, the change in available energy for cross border trade, and estimated average emissions are as shown below. As the renewable energy does not change, and imported energy is also fixed, there is no perceptible changes in estimated energy available for import, and average emissions between the two scenarios in the case of Thailand.

Figure 218: Thailand - Alternate scenario 2035

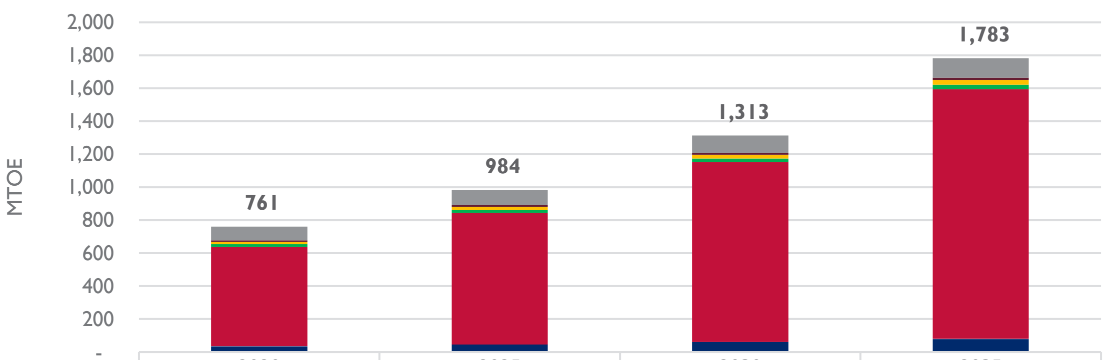


7.9 BIMSTEC Region

7.9.1 Energy Outlook

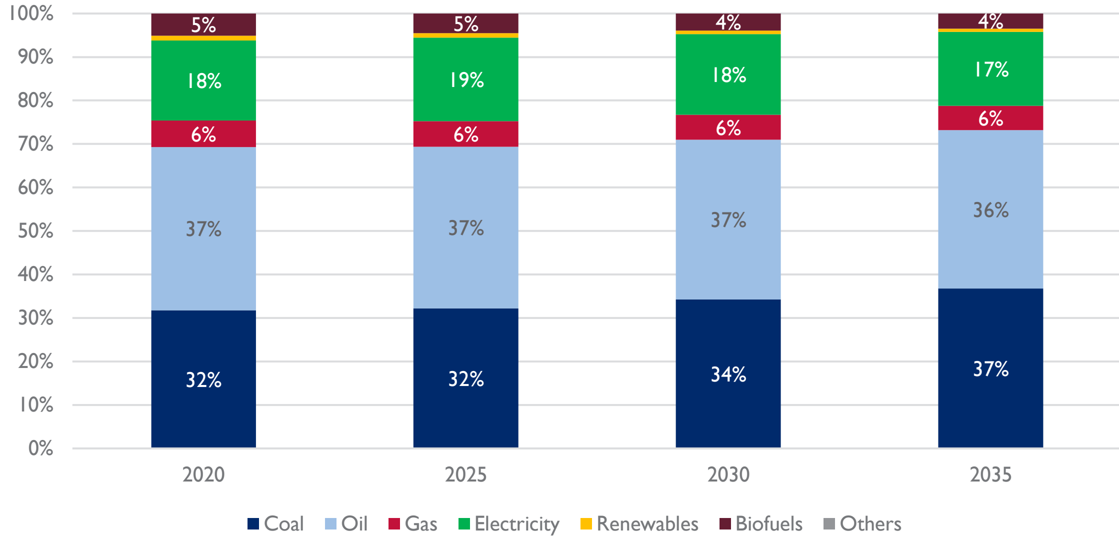
The aggregate of country outlooks of TFEC is illustrated below, which depicts TFEC increasing at a compound annual growth rate of 5.8%. The share of coal is expected to increase, whereas that of traditional biofuels are expected to decrease.

Figure 219: BIMSTEC - Total Final Energy Consumption, 2035



	2020	2025	2030	2035
Total	761	984	1,313	1,783
Thailand	82	92	105	119
Sri Lanka	10	11	12	14
Nepal	14	18	23	29
Myanmar	16	18	22	26
india	602	797	1,090	1,514
Bhutan	1	1	1	1
Bangladesh	35	45	60	79

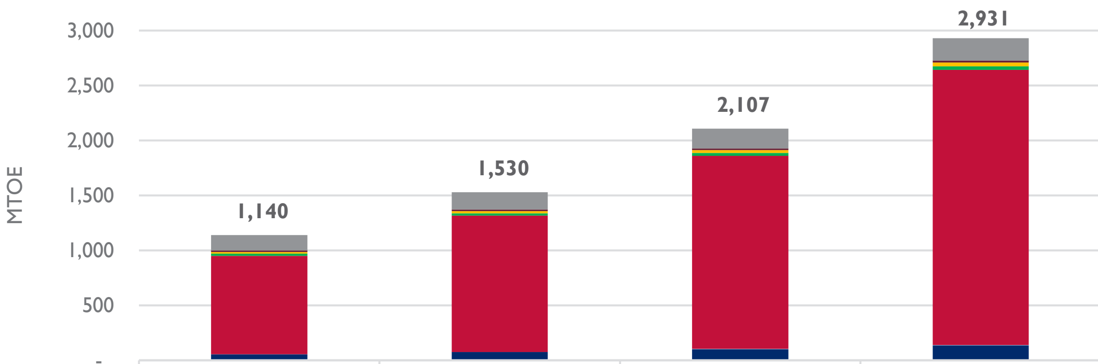
Bangladesh Bhutan india Myanmar Nepal Sri Lanka Thailand Total



India is the dominant country in terms of energy, followed by Thailand.

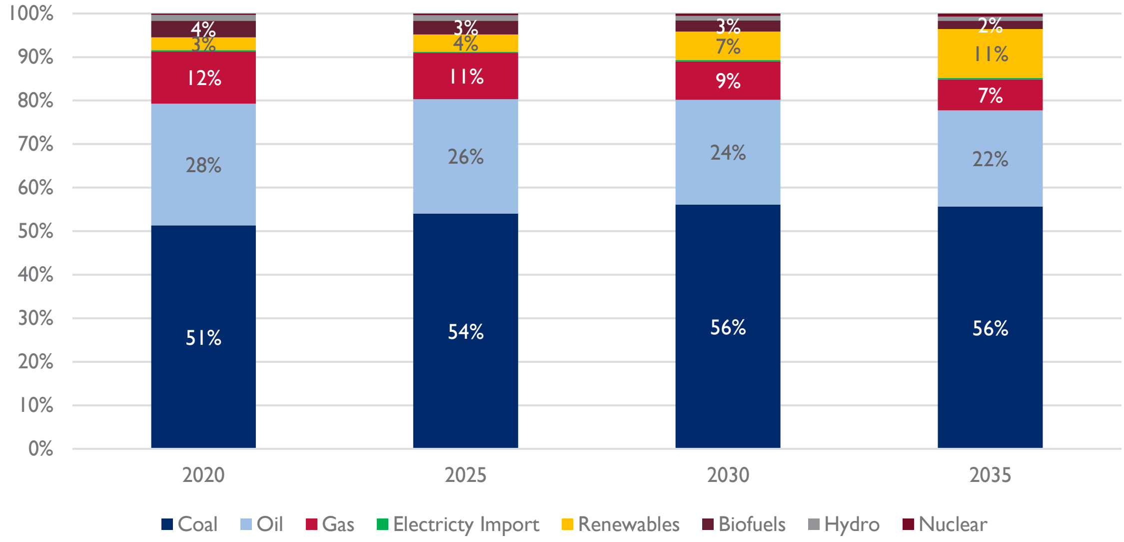
The TPES is expected to grow at 6.5%, from 1140 MTOE in 2020 to 2931 MTOE in 2035. An increase in share of renewables, and decrease in share of gas is anticipated by 2035. However, the overall dominance of fossil fuels in the total energy supply is not expected to reduce significantly; coal, oil and gas in total is still expected to contribute to 85% of primary energy supply in 2035.

Figure 220: BIMSTEC – Total Primary Energy Supply, 2035



	2020	2025	2030	2035
Total	1,140	1,530	2,107	2,931
Thailand	141	158	179	204
Sri Lanka	13	14	16	18
Nepal	17	21	27	34
Myanmar	19	21	26	33
india	894	1,240	1,756	2,504
Bhutan	1	1	1	2
Bangladesh	55	75	103	138

Bangladesh Bhutan india Myanmar Nepal Sri Lanka Thailand Total

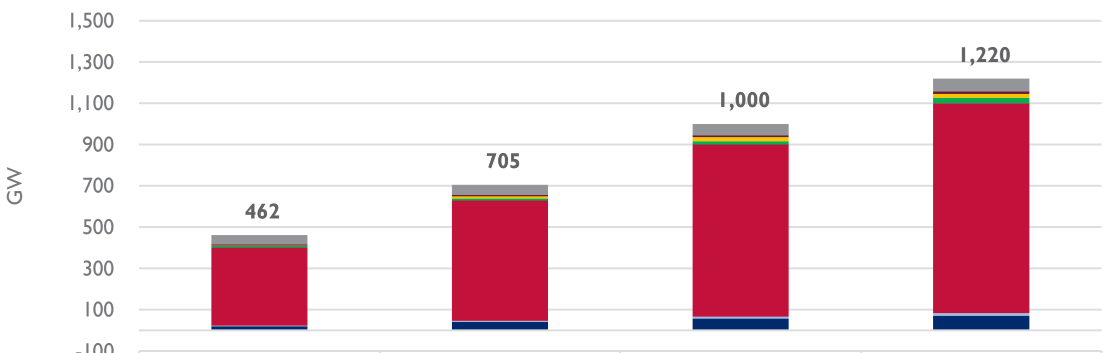


7.9.2 Electricity Outlook

The aggregate of country outlooks of energy generation is illustrated below, which depicts the installed capacity of electricity increasing at a compound annual growth rate of 6.7%, reaching 1220 TW by 2035. Similar to energy scenario, India has the highest capacity.

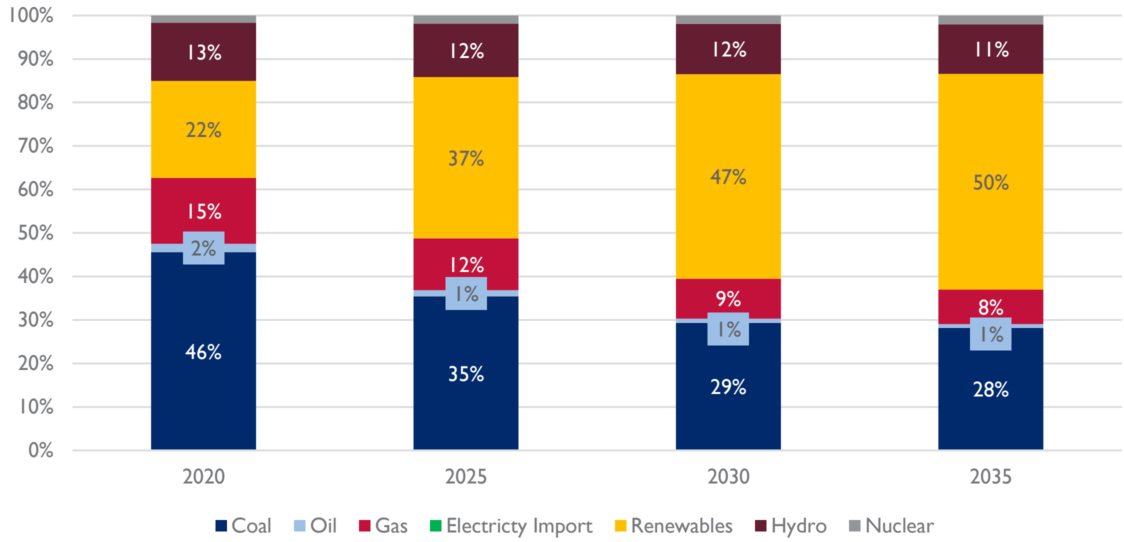
The energy transition is clearly evident here, with renewables increasing the share to 50% in 2035, from 22% of 2020.

Figure 221: BIMSTEC - Electricity installed capacity - 2035



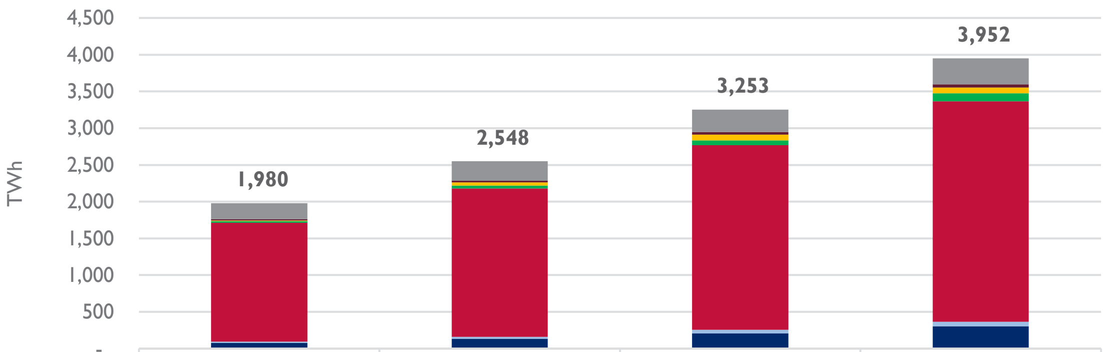
	2020	2025	2030	2035
Total	461,789	705,395	1,000,390	1,220,340
Thailand	45,671	47,791	55,044	62,882
Sri Lanka	6,045	8,328	9,568	11,342
Nepal	1,275	10,100	18,925	19,390
Myanmar	7,488	10,687	15,727	26,223
india	378,624	581,941	834,639	1,016,458
Bhutan	3,481	5,286	9,400	13,560
Bangladesh	19,205	41,262	57,087	70,485

Bangladesh Bhutan india Myanmar Nepal Sri Lanka Thailand Total



The electricity generation is expected to grow at a CAGR of 4.7%, reaching 3952 TWh in 2035.

Figure 222: BIMSTEC - Electricity generation outlook 2035



	2020	2025	2030	2035
Total	1,979,828	2,548,347	3,253,039	3,952,081
Thailand	220,014	262,518	307,576	356,397
Sri Lanka	18,542	24,779	32,061	40,621
Nepal	5,103	42,618	80,134	80,708
Myanmar	22,932	38,661	64,701	107,560
india	1,618,408	2,019,864	2,513,862	3,000,054
Bhutan	16,445	24,990	44,503	64,234
Bangladesh	78,385	134,916	210,202	302,506

Bangladesh Bhutan india Myanmar Nepal Sri Lanka Thailand Total

7.9.3 Investment Requirements and Business Opportunities

The planned electricity generation augmentation, and corresponding investment requirement is considered as below:

1. **Bangladesh** – The annual investment requirement is provided in the Revisiting PSMP 2016 report, which has been adopted. The report envisages 104,300 Million USD of investment between 2021 and 2035, for a total generation capacity augmentation of 57,276 MW.

2. **Bhutan** – The generation expansion plan for 2021-2035 considered in the outlook consists of 10 GW of large hydro and 5 MW of solar power. Based on IRENA estimates, a capital cost of 1.3 Million USD/MW was considered for large hydro.[274] For solar, based on industry practices, a capital cost of

0.7 Million USD/MW was adopted. Based on this, an investment requirement of 13,049 Million USD between 2021 and 2035 was arrived for Bhutan.

3. **India –** The generation expansion plan for 2021-2035 considered in the outlook consists of 100,744 MW of thermal power, 43,157 of hydropower, 480,209 of renewable energy and 13,724 MW of nuclear power. For thermal power, a cost of 1 Million USD/MW was adopted as capital cost, in line with industry practices. Based on IRENA estimates, a capital cost of 1.01 Million USD/MW was considered for renewables (average of solar, wind and small hydro).[275] For nuclear, a cost of 6.04 Million USD/MW was considered.[276]

4. **Myanmar –** In Myanmar, the generation expansion for 2021 – 2035 considered include hydropower of 6,708 MW, gas of 4,129 MW, coal of 7,849 MW and solar of 300 MW. The corresponding capital costs considered include 1.3 Million USD/MW for hydro, 1.08 Million USD/MW (US EIA) for gas, 1 Million USD/MW for coal and 0.7 Million USD/MW for solar.

5. **Nepal** - In Nepal the generation expansion for 2021 – 2035 considers 16,720 MW of hydro and 1,395 MW of RE power, at costs of 1.3 Million USD/MW and 0.7 Million USD/MW respectively.

6. **Sri Lanka** – In Sri Lanka, the generation expansion for 2021-2035 considers 190 MW of large hydro, 957 MW of oil, 1800 MW of coal and 2350 MW of renewable energy. The investment requirement as per CEB's Long Term Generation Expansion Plan (LTGEP) is 8512 Million USD.

7. **Thailand –** In Thailand, the generation expansion plan for 2021-2035, taken in line with PDP estimates, include 3140 MW of coal/lignite, 7145 MW of gas and 15,828 MW of renewables. The corresponding capital cost assumption include 1 Million USD/MW for coal, 1.07 Million USD/MW (US EIA) for gas and 0.78 Million USD/MW of solar/wind power plants.

In total, the investment requirement for the sector for 2021-2035 is estimated at 958,428 Million USD.

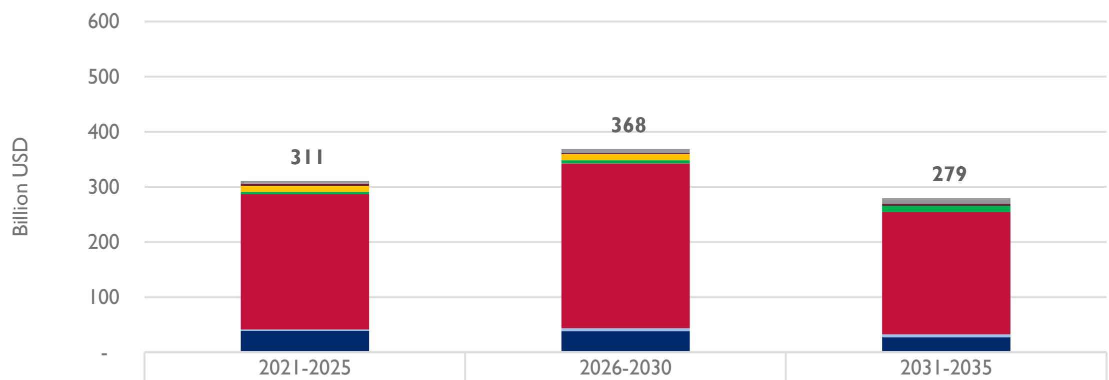
Table 33: Summary of generation investment requirement

Parameter	Unit	Bangladesh	Bhutan	India	Myanmar	Nepal	Sri Lanka	Thailand	Total
Generation capacity expansion									
Coal	MW	23,504		100,003	7,849		1,800	3,140	
Gas	MW	21,300		740	4,129			7,145	
Oil	MW	400					957		
Solar	MW		5		300	1,395	2,350		
Solar+Wind	MW							15,828	
Solar+Wind+SHP	MW	2,628		480,209					
Nuclear	MW	3,348		13,724					
Large Hydro	MW		10,074	43,157	6,708	16,720	190		
Capital cost									
Coal	USD Million/MW			1.00	1.00			1.00	
Gas	USD Million/MW			1.08	1.08			1.08	
Oil	USD Million/MW			1.08					
Solar	USD Million/MW		0.70		0.70	0.70			
Solar+Wind	USD Million/MW							0.78	
Solar+Wind+SHP	USD Million/MW			1.10					
Nuclear	USD Million/MW			6.04					

Parameter	Unit	Bangladesh	Bhutan	India	Myanmar	Nepal	Sri Lanka	Thailand	Total
Large Hydro	USD Million/MW		1.30	1.30	1.30	1.30			
Total cost									
Coal	USD Million		-	100,003	7,849	-		3,140	
Gas	USD Million		-	802	4,476	-		7,745	
Oil	USD Million		-	-	-	-		-	
Solar	USD Million		4	-	210	977		-	
Solar+Wind	USD Million		-	-	-	-		12,330	
Solar+Wind+ SHP	USD Million		-	525,901	-	-		-	
Nuclear	USD Million		-	82,907	-	-		-	
Large Hydro	USD Million		13,046	55,888	8,687	21,652		-	
Total cost	**USD Million**	**104,300**	**13,049**	**765,501**	**21,222**	**22,629**	**8,512**	**23,215**	**958,428**

The above investment, split into five year intervals for each of the countries is illustrated below.

Figure 223: BIMSTEC - Electricity generation investment requirements 2035



	2021-2025	2026-2030	2031-2035
Total	311	368	279
Thailand	5	7	11
Sri Lanka	4	2	3
Nepal	11	11	0
Myanmar	4	6	11
india	245	299	221
Bhutan	2	5	5
Bangladesh	39	38	27

Between 2021 and 2035, the cumulative investment in electricity generation is estimated to be 958.4 billion USD. India and Thailand account for nearly 80% of the investment requirements.

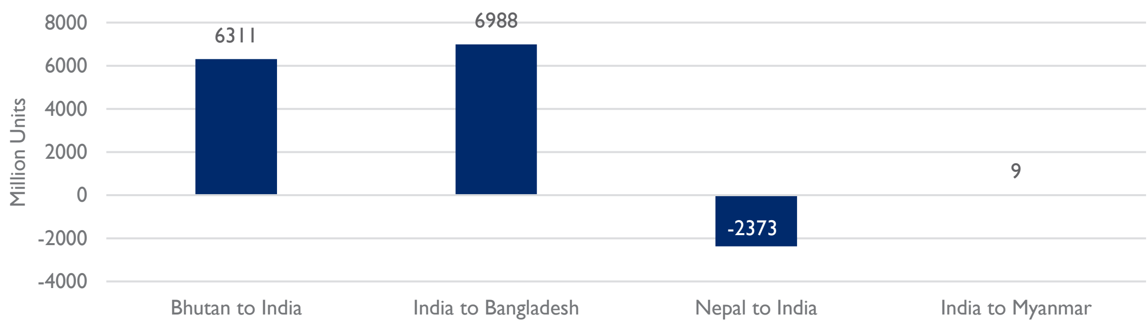
In addition, there will be need for transmission investments, which will be a combination of expansion of transmission network within the country and for cross border infrastructure. Due to variation in geography, length to nearest grid network etc., it is not practical to estimate transmission investment requirement on an aggregate basis. However, rough estimates based on average can be attempted. For example, in Nepal, the transmission investment cost is assessed at 6038 Million USD for 38 GW of installed capacity, i.e. 0.159 Million USD/MW. If we extend the same benchmark to installed capacity addition of 767,603 MW, the total transmission investment requirement will be 122 billion USD. However, as discussed, such estimate is only indicative as the transmission investment requirement can vary considerably between countries and even projects.

8 Outlook for future Cross Border Electricity Trade

8.1 Existing and planned CBET in BIMSTEC

Currently, CBET happens within BIMSTEC between Bhutan-India. India-Bangladesh, India-Nepal, and India-Myanmar. The overall trade is nearly 15,681 MU, which if converted to round-the-clock MW terms, will be 1790 MW. The actual MW transfer will be higher, as the actual CBET need not necessarily be constant across day and seasons.

Figure 224: CBET within BIMSTEC, 2020



Source: POSOCO, Government of Myanmar, EPPO[277]

In addition to the above, there is CBET between BIMSTEC and non-BIMSTEC countries, such as Myanmar-China, and import of power by Thailand from Laos, Cambodia and Malaysia.

The respective governments / utilities in BIMSTEC have identified a few key project / set of projects, for future CBET. This includes the following:

- Under an intergovernmental agreement, Government of India has agreed to assist Royal Government of Bhutan in developing a minimum of 10,000 MW of hydropower and import the surplus electricity from this to India.[278]
- Bhutan has identified 1125 MW Dorjilung HPP as one of the potential power plants for supply to Bangladesh.[279]
- It is also assumed that Bhutan may export power from 404 MW Nyera Amari HPP to Bangladesh, though a decision on the same seems to have not been taken yet.
- India already exports close to 1200 MW of power to Bangladesh.
- India has agreed to import power from the 900 MW Arun-III hydropower project in Nepal.
- Bangladesh has agreed to import 500 MW of power from the 900 MW Upper Karnali hydropower project in Nepal. Considering the involvement of Indian developer, rest of the power may be considered to be off taken in India. Bangladesh's PSMP envisages new import of 1496 MW in 2022, and additional 4500 MW of import between 2023 and 2035, and another 4500 MW of import between 2036 and 2041.

8.2 Energy available for CBET

As part of the country specific energy modelling, the anticipated generation from the planned power plants were compared against the domestic requirements, to identify if there is any excess power that can be exported, or if there is any deficit that needs to be met through imports. The analysis suggested the following country-wide energy available for import or export for 2035.

Table 34: Energy available for import/export in 2035

Country	Energy available for export MU	Energy required to be met through imports MU
Bangladesh	-	51,439
Bhutan	57,799	-
India	278,891	-
Nepal	28,913	-
Thailand	-	59,569

Before considering the potential ways for these countries to undertake CBET, existing commitments for CBET can also be considered. Considering the committed CBET projects described in 8.1, the following committed energy transactions are assumed to happen, irrespective of cost dynamics:

Table 35: Committed CBET transactions

Countries	Committed CBET transaction	Estimated energy [MU]
Bhutan - India	10,000 MW as per MoU	47,427
Bhutan - Bangladesh	1533 MW (Nyera Amari and Dorjeeling)	7,271
Nepal - India	900 MW Arun III, 400 MW Upper Karnali	5,744
Nepal - Bangladesh	500 MW Upper Karnali	2,209
India - Bangladesh	Existing 1200 MW	8,935

** Average CUFs in respective countries for the relevant fuel source have been considered to convert MW to energy.*

Considering the above, the available energy for export, after accounting for already committed cross border trade can be considered as below:

Table 36: Energy available for export in 2035 after committed CBET

Country	Energy available for export MU	Committed to India MU	Committed to Bangladesh MU	Remaining Energy MU
Bhutan	57799	47,427	7,271	3,102
Nepal	28913	5,744	2,209	20,960
India	278,891		8,935	269,956

The above also results in reduction of available energy for import, in the case of Bangladesh. In addition, to check viability of CBET, the following avenues can also be considered:

3. In Myanmar, the additional energy to be procured through new power plants in 2030-2035 is estimated as 15,641 MU. It can be considered instead as a potential option for import from other countries.
4. In Sri Lanka, considering the ongoing discussions on transmission interconnection of up to 1000 MW with India, corresponding energy can also be assessed as a potential option, instead of generating the same domestically.

Considering the above, the energy to be met through imports, after committed cross border transactions will be as below.

Table 37: Energy for import in 2035 after committed CBET

Country	Quantum Required [MU]
Bangladesh	33,024
Myanmar	15641
Sri Lanka	7008
Thailand	59,569

8.3 Comparative cost of power

CBET will be commercially attractive, only if the landed cost of power is cheaper than the domestic power. With the same in mind, a comparison of cost of generation in potential export countries, and cost of power purchase in potential import countries is undertaken using the current cost data.

Table 38: Comparison of cost of power

Country	Cost of Power from new projects [USD/kWh]	Average power generation / purchase cost [USD/kWh]	Comments
Bhutan	0.0587		Manghdechu HEP Year 1 rate at border
India	0.0634		Solar cost of 2.99 INR/kWh based on recent bids, with fixed cost for balancing power at 1.2 INR/kWh, adjusted with losses and charges from Rajasthan to border
Nepal	0.0558		Upper Tamakoshi PPA rate, adjusted with losses and charges to the border
Bangladesh		0.0714	BPDB cost of power generation
Myanmar		0.1275	Estimated cost of natural gas plants at 170 Kyatt per kWh
Sri Lanka		0.1032	CEB cost of power generation
Thailand		0.0481	EGAT cost of power generation

In addition to the cost of power from projects, there will be additional charges and losses towards the cross border transmission lines, and the transit through network of one country, in case of third country trade.

However the cost comparison is undertaken only for the quantum remaining for potential CBET, after including the committed CBET transactions. The committed energy transfer is assumed to happen irrespective of cost economics.

8.4 Overall CBET outlook for 2035

The inputs discussed in previous subsections have been used, along with assumptions on charges and losses of cross border links were used to do an analysis with a combination of excel and GAMS to arrive at the overall CBET. For the same, the following additional assumptions were taken:

1. Transmission interconnectivity to Myanmar from South Asia is assumed to be through Bangladesh.
2. For import of power by Myanmar, transit costs for use of India and Bangladesh transmission networks were taken.
3. For import of power by Thailand, additional transit charges and losses for Myanmar grid were considered, by taking the average of similar charges and losses for India and Bangladesh.
4. Transmission charges and losses for each specific cross border interconnections were assumed as 0.001 USD/kWh and 0.02%, in the absence of any additional information regarding the same in public domain.

5. The GAMS optimization algorithm considers only the cost of imported power, and minimization of the same.
6. The committed CBET transactions are already included in the analysis, and they are assumed to happen irrespective of any cost economics.

Considering the above assumptions and information, the total potential combinations of CBET are listed below.

Table 39: Potential CBET options

From	Quantum Available [MU]	Tariff at border (source) [USD/kWh]	To	Tariff at border (destination) [USD/kWh]	Existing avg. cost of PP [USD/kWh]	Total Requirement [MU]
Bhutan	3,102	0.06	Bangladesh	0.0678	0.07	33,024
Bhutan	3,102	0.06	Myanmar	0.0744	0.13	15,641
Bhutan	3,102	0.06	Sri Lanka	0.0678	0.10	7,008
Bhutan	3,102	0.06	Thailand	0.0822	0.05	59,569
India	269,956	0.06	Bangladesh	0.0644	0.07	33,024
India	269,956	0.06	Myanmar	0.0708	0.13	15,641
India	269,956	0.06	Sri Lanka	0.0644	0.10	7,008
India	269,956	0.06	Thailand	0.0785	0.05	59,569
Nepal	20,960	0.06	Bangladesh	0.0649	0.07	33,024
Nepal	20,960	0.06	Myanmar	0.0713	0.13	15,641
Nepal	20,960	0.06	Sri Lanka	0.0649	0.10	7,008
Nepal	20,960	0.06	Thailand	0.0791	0.05	59,569

The above results are further analysed from a cost optimization perspective through GAMS.

Considering all the previously discussed assumptions, the cross border outlook for 2035, inclusive of committed transactions and cost-optimized additional trade, is illustrated below:

Table 40: Anticipated cross border trade in 2035, MU

To -> From	Bangladesh	Sri Lanka	Myanmar	India	Thailand	Total
Bhutan	7,271			47,427		54,697
India	41,959	7,008	15,641			64,608
Nepal	2,209			5,744		7,953[#]
Total	51,439	7,008	15,641	53,171	-	**127,259**

** Values in Million Units*

 # The quantum could be higher if there are more projects developed based on intergovernmental discussions, or at a different cost economics.

In case of Thailand, the available cost of power from sources in South Asia does not seem to be competitive when compared with its existing power procurement rates. Therefore, ongoing arrangements, such as import of power from HPPs in Lao PDR may continue in the case Thailand. For example, the tariff for Nam Theun 2 HPP in Laos, for 2020 is 0.024 USD/kWh. Cost of generation from HPPs in Bhutan and Nepal are substantially higher than this. EGAT's own cost of power generation is also lower than the cost of generation from HPPs in South Asia.

The above estimated CBET, when converted to MW in round-the-clock (RTC) terms is provided below, to give a sense of total transmission capacity. The actual MW transfer will be higher, as the actual CBET need not necessarily be constant across day and seasons. The corresponding transmission capacity will also be higher as there are considerations of seasonality, and safety margins.

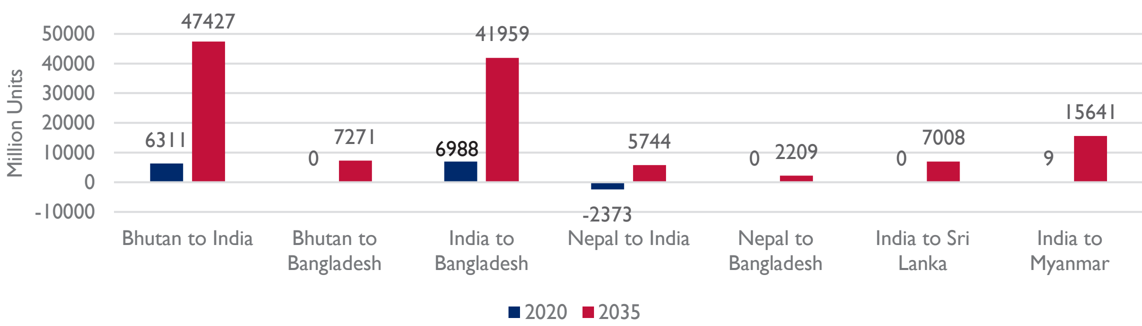
Table 41: Estimated CBET in MW, assuming RTC power, in MW

To -> From	Bangladesh	Sri Lanka	Myanmar	India	Thailand	Total
Bhutan	830*	-	-	5,414	-	6,244
India	4,790	800	1,786	-	-	7,375
Nepal	252*	-	-	656	-	908
Total	5,872	800	1,786	6,070	-	**14,527**

** Through India*

Based on this analysis, it is estimated that CBET in BIMSTEC region has the potential to increase up to 7 times, from 15,618 MU in 2020, to 127,259 MU. This will be equivalent to trade of 14.5 GW on Round-the-Clock basis in 2035.

Figure 225: CBET in BIMSTEC, in 2020 and estimate for 2035



It may be noted that the above analysis is considerably sensitive to cost parameters, and therefore any variation in assumed costs could change the results of the analysis substantially. A reduction in generation costs could open up more trade such as increased export of power from Nepal, or CBET between Thailand and South Asia. More importantly, the intended message is the potential for BIMSTEC Member States to cooperate on energy sector, in a mutually beneficial manner.

8.5 Benefits on CBET for BIMSTEC

A BIMSTEC regional power grid, extending from India to Thailand offers multiple benefits to the BIMSTEC Member States. While some of these are applicable to any regional grid, there are also a few benefits that are specific to the region due to the complementarity in demand patterns and generation resources.

A summary of benefits of regional energy cooperation for BIMSTEC is provided below.

Table 42: Benefits of regional energy cooperation

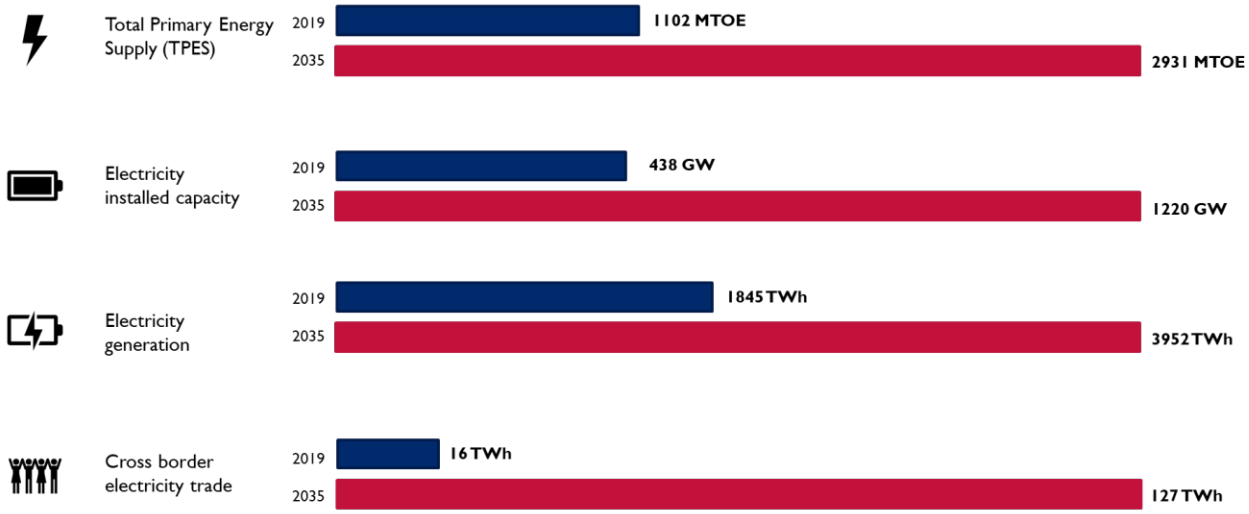
Access to wider range of generation resources All countries	**Access to cheaper power sources** Nepal, Bangladesh, Sri Lanka	**Potential for large-scale hydropower plants** Bhutan, Nepal
Seasonality of generation in hydropower dependent countries Bhutan, Nepal	**Foreign exchange revenue** Bhutan, Nepal, Myanmar	**Sharing of variable generation source for RE balancing** India
Difference in time zones All countries	**Utilization of surplus generation of one country in another** India	**Regional energy market development** All countries
Optimum alignment of transmission lines India, Myanmar	**Economic extension of grid** Myanmar	**Mobilization of investments at regional level** All countries

A detailed overview of the benefits is provided in section 5.8.

9 Way forward

The energy sector within BIMSTEC is expected to grow considerably from the present state, by 2035. A comparison of some of the key energy statistics for 2019 and 2035 is provided below. Parameters such as primary energy supply, installed capacity of electricity, and electricity generation is expected to increase by more than 100%, by 2035. While TPES and electricity generation is expected to become slightly more than double, the electricity installed capacity is expected to increase by two times from the 2019 level, and the cross border trade is expected to increase by more than 7 times, from the 2019 level.

Figure 226: BIMSTEC – Energy parameters - 2019 and 2035



The anticipated energy scenario raises various questions and challenges, such as the following.

1. The investment requirement in electricity generation itself, if spread equally across of 2021-2035 will be 64 billion USD per year. While some portion of this may as well be private investment, the Governments will still have to be ready to invest at least in a portion in this. In addition, there will be costs for transmission evacuation, system balancing etc.
2. The commercial potential of a South Asia – South East Asia interconnection, between Myanmar and India/Bangladesh is there, if competitive power can be made available. Will BIMSTEC Member States be able to develop cheaper projects, in comparison to other countries in the region, such as Laos?
3. Cross border interconnections in oil and gas are prominent in Thailand and Myanmar, though not widely adopted in rest of BIMSTEC. The possibilities in wider energy cooperation can be explored.
4. There is a wide variation in renewable energy potential, most of which is located in India. Out of the 1359 GW of renewable energy potential in the region, 1242 GW is in India. In comparison, the anticipated installed capacity of renewable energy in India for 2035 is only 574 GW. Thus, there is a possibility of developing untapped RE potential in countries such as India, for use in smaller countries or countries with limited available land in the region.
5. As discussed in section 5.8 and 8.3, there are cost arbitrage opportunities, in terms of displacing costly domestic power with cheaper imported power. However, it is the policy maker's prerogative to arrive at the desired trade-off between economics, energy security and flexibility.
6. In addition to the anticipated CBET of 127 TWh in 2035, there is an additional available power of over 230 TWh. This opens the possibility of either restricting the generation expansion plans to slightly lesser levels, or to also explore CBET opportunities even beyond BIMSTEC.

7. Some of the cross border trade considered in section 8 was analysed in spite of any solid proposals for cross border transmission line, such as in the case of potential CBET between India and Myanmar. The overall assumption was that once the parties decide on undertaking CBET, the transmission arrangements can be quickly put in place. However, there is another viewpoint on whether the visibility of interconnection plans in the near future can accelerate the efforts for regional energy integration.
8. The installed capacity of renewable energy in the region is expected to reach 50% by 2035. Such a large share of RE requires flexible generation sources, which may not necessarily be available in the countries where such generation is located. This opens up a potential possibility of planning for regional RE balancing resources, or power plants offering flexible power through CBET.

While the potential opportunities and key questions are considered by the policy makers, the institutional aspects will also require attention. BIMSTEC as a regional grouping can play an important role in channelling the country level initiatives to provide a platform for securing affordable, sustainable and reliable supply of energy/electricity by integrating the energy resources vis-à-vis socio-economic development of the region.

The existing success stories in CBET, energy efficiency measures and renewable capacity additions need to be replicated across the region. To materialise these investment a conducive and cooperative political, economic and investment friendly environment is required in the BIMSTEC region. There are certain initiatives which can be taken up for enhanced energy cooperation in BIMSTEC region, such as:

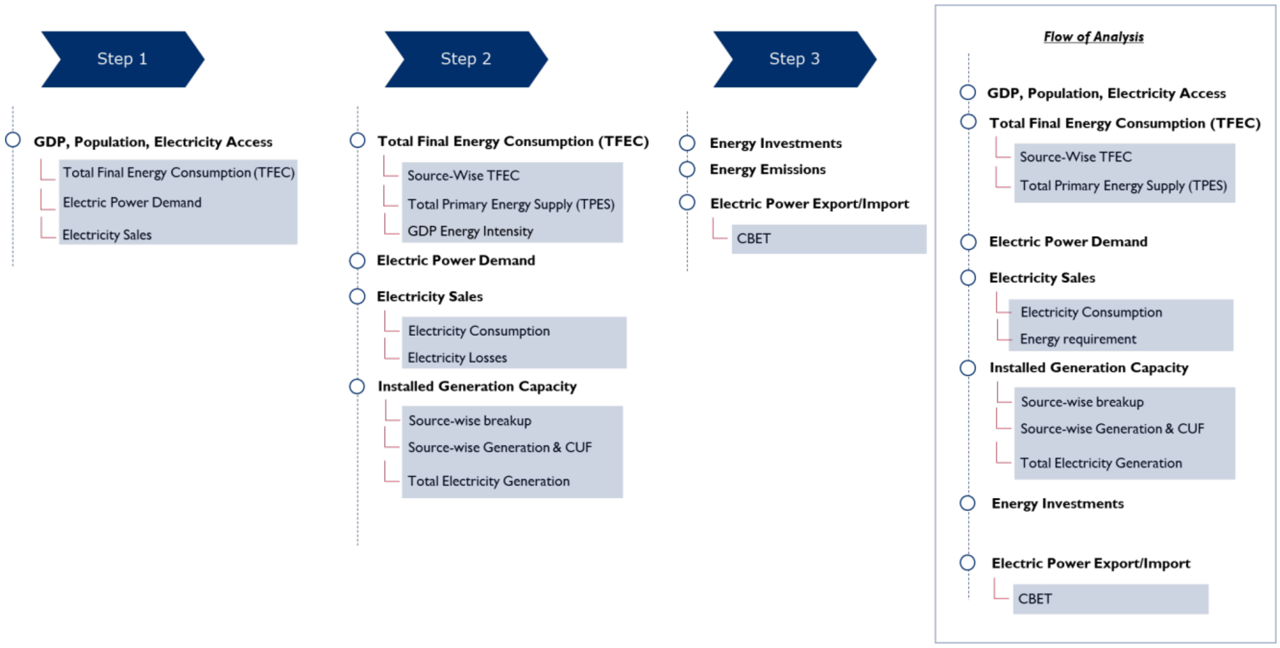
4. Strengthening of existing MoUs on energy cooperation through a separate BIMSTEC-Comprehensive Plan for Energy Cooperation (BIMSTEC-CPEC);
5. Development of detailed master plans for energy cooperation, identifying the regional level projects and implementation modalities; and
6. Commence the operations of regional coordination institutions such as BIMSTEC Grid Interconnection Coordination Committee (BGICC) and BIMSTEC Energy Center (BEC).

Once these basic aspects are implemented, the next phase of regional coordination, including the development of a seamless energy market will be easier to get adopted and implemented, as supporting policy, institutional and physical framework will already be available. In parallel to the efforts for BIMSTEC energy grids and energy markets, the BIMSTEC Member States can also cooperate among each other on sharing of leading practices and successful strategies for implementation of energy efficiency measures, distributed generation, smart grid initiatives, fuel cell, clean coal technologies, energy storage, electric mobility and renewable energy integration.

10 Annexure 1: Methodology for modelling of 2035 outlook

The BIMSTEC Energy Outlook 2035 provides the long-term forecast i.e. 2020-2035, for overall energy usage in the BIMSTEC region along with energy transition patterns at the individual country level. Key energy parameters considered include final energy consumption, electric power demand, electricity sales, electricity mix, and cross border electricity trade (CBET). The energy parameters considered are standard in nature with each having their own sub-components.

Figure 227: Energy parameters analysed at different stages



The schematic showcases various stages at which each energy parameter is derived in the model and provides the overall flow of the analysis.

In Step 1, the macro-economic indicators such as GDP, Population, and Electricity access are used as main drivers to forecast basic energy parameters using an econometric method. Basic energy parameters include primary energy, power demand, and electricity sales as shown under Step 1 in the schematic above.

In Step 2, sub-components of these energy parameters are derived which include energy mix, electricity consumption, and source-wise installed generation capacity etc. In Step 3, parameters such as energy investment, and CBET are derived based on inputs from Step 1 & 2.

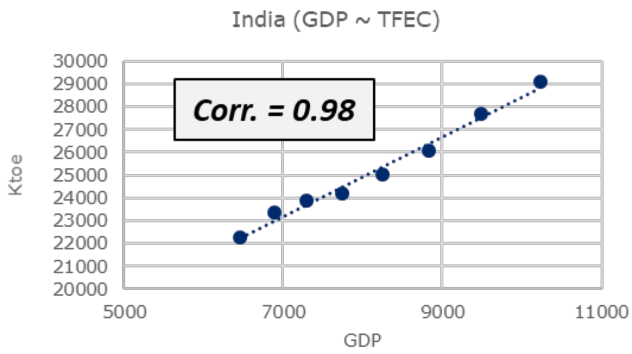
A detailed description of approach and methodology is provided in section 4.2.

10.1 Econometric Analysis

While each country is modelled separately considering its unique government level policies and targets, certain basic assumptions are common across all country models. First, high emphasis is put on using forecast values for energy parameters which are publicly available from official sources of a country. In case official forecasts are not available, macro-economic indicators are used as independent variables to forecast dependent variables such as energy use. A key macro-economic indicator used is Gross Domestic Product (GDP) along with others such as population and electricity access. Dependent variables include Primary Energy Consumption (MTOE), Electricity Power Demand (MW), and Electricity Consumption (MU).

An econometric method is used to build a statistical relation between GDP and energy using a linear regression. The linear regression estimates the relation between one or more independent variables and a dependent variable using an Ordinary Least Squares (OLS) approach. In doing so, a degree of correlation is first established between GDP and energy based on historical data. This helps in understanding how closely linked are these two values for any given country. Widely used in energy forecast studies, this approach helps in analysing how much energy use shall change along with future increase in GDP based on their relation historically. The figure showcases the regression output of India's GDP and TFEC. It can be observed that the correlation between India's GDP and its TFEC is close to 0.98[5] which means they are highly correlated. Hence, future forecast of GDP is used for forecasting TFEC for India based on their relation historically. An illustration of forecast equation produced from the regression analysis is as follows:

Figure 228: GDP and TFEC correlation– illustration



Forecast equation: $Y_t = a + b \times X1_t + C \times X2_t + \ldots$

Where 'Y' is energy use, 'a' is the intercept, 'b' and 'c' are the coefficient for 'X' terms, and 'X1' and 'X2' are GDP, and Population/Electricity Access etc, and 't' is times for years between 2020-2035.

The statistical accuracy of forecast thus derived depends on how well 'Y' and 'X' are correlated amongst other factors. Same methodology is applied for forecasting Power Demand and Electricity Consumption. This is done for each individual country. Accounting for impact of future changes in multiple independent variables on a dependent variable can provide more accurate forecasts in specific cases. So, a combination of independent variables such as GDP and Population and GDP and Electricity Access have also been used where necessary.

Validation of results is done at each stage to ensure that the values are statistically accurate, follow a plausible trajectory, and more importantly incorporate country specific policies and targets to their best possible extent.

10.2 Detailed Approach and Methodology

This section provides a detailed approach followed analyse energy use in each of the BIMSTEC region countries. It provides key assumptions used for the analysis and provides a mapping of how various parameters are interconnected in the model. As shown in the figure below, the model used a range of independent variables and other information to come up with the dependent variables ranging from overall energy, electricity, and CBET and energy investments etc.

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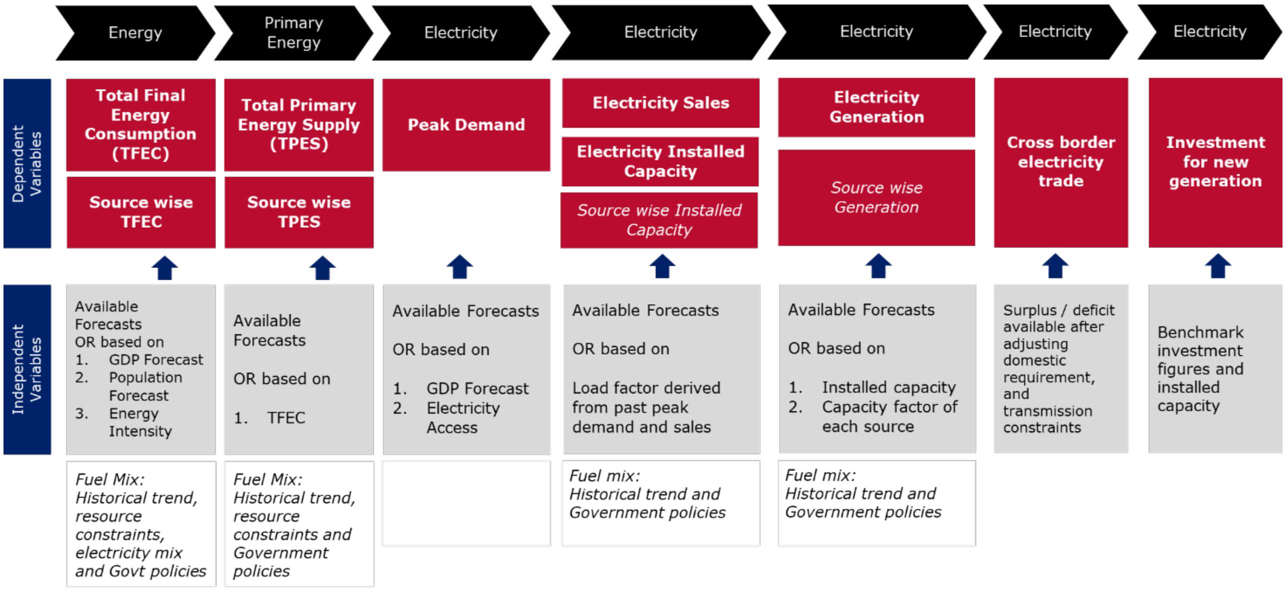
[5] Correlation values are measures on a scale of 0-1 with 1 being perfectly correlated and o being no correlation.

Figure 229: Methodology for outlook projection



Each of the key parameters constitutes sub-components and are expressed using their standard units. Key definitions of the specific energy parameters as used in the model are as follows:

1. **Primary Energy** is the total energy supply and consumption in a country. It is expressed in terms of Million/Kilo Tons of Oil Equivalent (MTOE/KTOE). The sub-components of total primary energy include sources such as coal, oil, gas, biomass, and electricity etc. Both supply and consumption of total as well as source-wise primary energy has been analysed.
2. **Electric Power Demand** is the peak electricity demand in the country and is expressed in Mega-Watt (MW) and Giga-Watt (GW) terms.
3. **Electricity Sales** is the total sale of electric power in the country and is expressed in Million Units (MU). Electricity sales includes imports of electric power to meet a country's requirement.
4. **Electricity Generation** is the total generation required to meet the electricity requirement in the country. It is expressed in Million Units (MU). Total electricity generated is the sum of source-wise electricity generation.
5. **Electric Power Generation Capacity** is the sum of the total installed power generation capacity in the country expressed in MW and GW terms. Different sources of energy generation include coal, gas, hydro, diesel, nuclear, large hydro, small hydro, solar, wind, and biomass etc.
6. **Cross Border Electricity Trade (CBET)** is the electric power traded between BIMSTEC region countries and is expressed in MUs.

10.2.1 Energy Consumption and Supply

Final Energy Consumption

The schematic provides a step-wise approach followed for calculating primary energy and its various components. Total Final Energy Consumption (TFEC) forecast 2020-2035 for each BIMSTEC country is derived using econometric analysis using regression.

GDP and Population are mainly used as independent variables in the regression. GDP itself is forecasted using a growth rate as per Asian Development Bank forecast or government forecasts based on availability. Similarly, government estimates of population was used wherever available, and in its absence, trend based estimate was adopted.

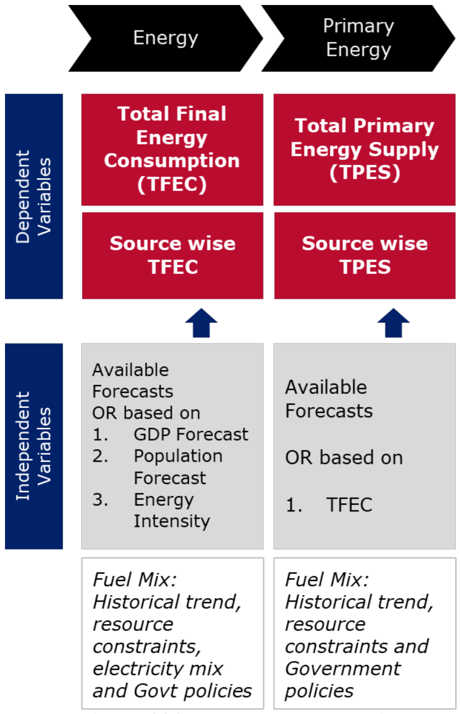


Figure 230: Methodology – Primary Energy Analysis

Energy Consumption Mix

Source-wise energy mix is then derived from TFEC based on historical share of different sources in a country's primary energy mix, resource constraints, and government policies.

Total Primary Energy Supply

Total Primary Energy Supply (TPES) forecast is derived using a regression between TPES and TFEC. Similar to TFEC, source-wise fuel mix of TPES is estimated based on historical share of different energy sources in supply, resource constraints, and government policies.

10.2.2 Electricity: Peak Demand, Sales, and Installed Capacity

The schematic provides details of steps followed to analyse Peak Demand, Electricity Sales, and Installed Capacity.

Peak Power Demand

For several countries, peak power demand was already available in utility / Government forecasts, and the same has been used. For several other countries where forecast of peak demand is not available, a regression method is applied using independent variables such as GDP to forecast peak power demand for 2020-2035.

Electricity sales

In the absence of sales estimates, based on peak demand, future sales of electricity is derived using Average Load Factor (ALF) for peak demand. ALF is calculated based on total electricity sales and peak demand for any given year:

$$\text{ALF (\%)} = \frac{Total\ Electricity\ Sales}{Peak\ Demand\ x\ 8760\ hours}$$

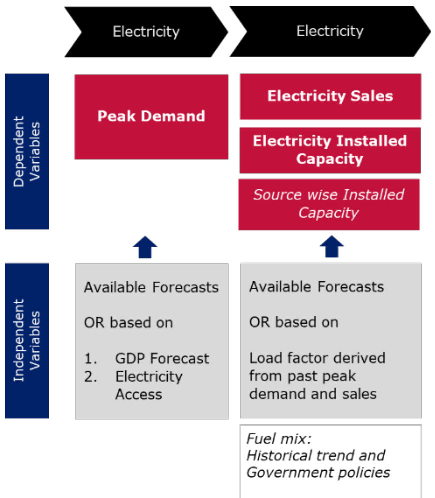


Figure 231: Methodology – Peak Demand, Sales. Installed Capacity

Total electricity requirement was derived using electricity sales and T&D losses. Historical T&D losses for each country has been derived from official government sources. Future T&D losses i.e. 2020-35 is derived using government targets for efficiency improvement. Where such targets were not available, a plausible rate of reduction in T&D losses has been assumed.

Incorporating the impact of electricity vehicles on electricity requirement

Additional sales of electricity on account of Electric Vehicles (EV) charging is derived from EV penetration levels in a country's transport sector. The EV penetration targets are derived from government policy and roadmap available for specific countries. Several countries have targets for EV penetration in annual vehicle sales and the same has been used to calculate the total number of EVs that a country shall have on road in the future. EV vehicle sales trajectory is thus a key input in calculating electricity requirement on account of EV charging, For estimation of EV sales, global benchmark for EV penetration levels have been utilized e.g. 15% EV penetration level by 2030 as per IEA Global EV outlook 2030.

For calculation of additional electricity sales, a benchmark of rate of 0.2 kWh/KM and 20 KM per day has been used. This provides an annual consumption of 1460 kWh per EV which is near to India's estimate of 1333 kWh considered in National Mobility Plan. Similarly, values for EV sales and energy consumption for each country has been utilized to calculate electricity requirement from EVs. Value thus derived is added to the total electricity requirement for a specific country.

10.2.3 Electricity: Generation capacity and Generation

Electricity Generation Capacity

Official country capacity addition targets have been used to project capacity addition in the future to meet electricity requirement for a country. It was found that all BIMSTEC countries have source-wise capacity addition targets for the future. Based on these values, source-wise and total electricity generation capacity installation in the future for 2020-2035 has been calculated.

Electricity Generation

Historical data on source-wise installed capacity and energy generation for each specific country has been used to calculate the Capacity Utilization Factor (CUF) for specific energy technologies. Based on forecasted installed capacity and CUF for different energy technology sources, source-wise and total electricity generation is thus derived for 2020-2035. Changes in CUF based on government plans have also been assumed while calculating electricity generation in the future. Total electricity generation and requirement is then used to analyse export and import requirements for a given country in the BIMSTEC region.

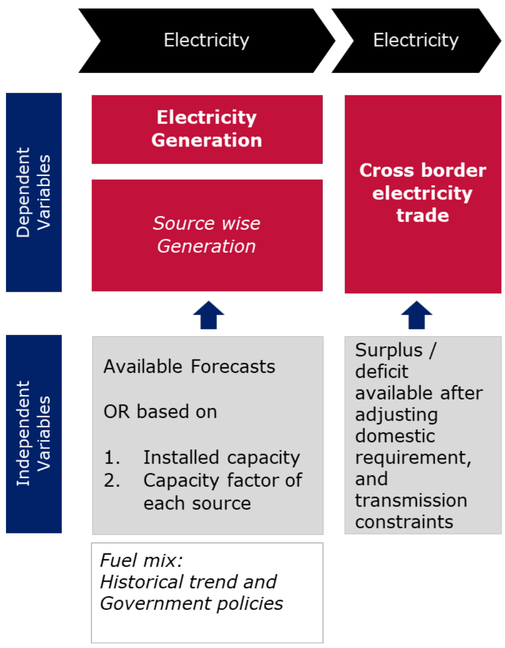


Figure 232: Methodology – Generation and CBET

10.2.4 Cross Border Electricity Trade (CBET)

Surplus and deficit of electricity for each country is derived based on electricity requirement and generation, and is treated as energy available for export/import. Historical electricity trade between BIMSTEC region countries is analysed and used as input.

10.2.5 Summary of general assumptions

A summary of general assumptions used across the model is shown below to help better understand the overall approach and methodology:

1. In the absence of separate publicly available (from utility/government) forecasts on Total Final Energy Consumption (TFEC), TFEC can be estimated based on a regression relationship with GDP and Population, subject to statistical significance of these variables derived based on past trends.

2. In the absence of separate publicly available (from utility/government) forecasts on Total Primary Energy Supply (TPES), TPES can be estimated based on a regression relationship with TPEC.
3. In the absence of separate publicly available (from utility/government) forecasts on GDP, future GDP can be estimated based on past growth rate. However available credible forecasts such as that of ADB will also be used.
4. In the absence of separate publicly available (from utility/government) forecasts on Population, future Population can be estimated based on past growth rate.
5. As long as available, peak demand will be as per publicly available (from utility/government) estimates of respective countries. In the absence of separate publicly available (from utility/government) forecasts on peak demand, peak demand can be estimated based on a regression relationship with GDP, population and (in case of countries with low electricity access) electricity access.
6. Publicly available (from utility/government) peak demand projections of the countries are assumed to have already considered the impact of energy conservation and demand side management (DSM) measures.
7. In the absence of utility/government estimates on future electricity sales, the same will be estimated from peak demand under the assumption that average load factor of the country, will continue to be the same as that of average of past years.
8. Capacity utilization factor / plant load factor of each generation source can be estimated based on past trends.
9. Investment for new electricity generation is estimated based on global benchmark figures.
10. Impact of Covid-19 is assumed to be temporary, and therefore not considered.
11. Electricity consumption on account of new electric vehicles is assumed to be in addition to the sales estimated by the utility for the future. For estimation of electricity consumption per electric vehicle, a consumption of 0.20 kWh/km, and daily average distance of 20 KM is assumed. For calculating equivalent reduction in petroleum consumption, a mileage of 5.49 litre per 100 KM is assumed.

10.3 Model Scenarios

10.3.1 Base Case

The energy outlook is analysed under two main scenario i.e. Base Case and Alternate Scenario. The Base Case takes into consideration the policies and targets currently in place in BIMSTEC region countries. Each country is modelled separately considering its unique energy transition plan and historical energy use pattern. Energy projections in the Base Case scenario have thus been observed from the lens of individual country's current and future government policies.

The energy outlook forecast timeline is 2020-2035 with an annual resolution. The historical data used in the analysis range from 2010-2019 as per availability in official government documents of BIMSTEC countries.

The base case scenario provides forecast for key energy parameters with following insights:

- Change in primary energy consumption as well as energy mix change during 2020-2035.
- Increase in power demand and electricity consumption.
- Changes in power generation mix.
- Export/import requirement and cross-border electricity trade.

10.3.2 Alternate Scenario

While the outlook is developed under a base case, an alternate case is also estimated, considering a high EV and RE scenario. The alternate scenario focuses on difference in energy for import / export in the backdrop of increased energy requirement due to higher consumption for electric vehicles, and the difference in emission profile of electricity generation due to increased mix of renewable energy.

The methodology is further detailed in annexure.

10.3.3 Constraints

1. The outlook projections primarily rely on forecasts prepared by the utilities / Government. As most of these forecasts were prepared in previous years, it may not necessarily depict the latest scenario.
2. Impact of EVs are considered only in consumption, and not in peak demand, as the coincidence of peak demand timings and EV demand is not known.
3. As the data source varies from country to country, there could be variations in terminologies / groupings which cannot be made uniform. For example, Bangladesh and Thailand considers import MW in their installed capacity, whereas India does not.
4. The focus was on arriving at the outlook for 2035. For some of the variables, the target for 2035 is reconciled with the projections of utilities / Governments. It is possible that the trajectory followed by the variable between 2020 and 2035, which is considered in this report varies from the trajectory considered / assumed in the source report.
5. The assessment of cross border import / export of electricity is based on deficit/surplus from annual figures. In actual scenario, differences in daily and seasonal patterns, transmission constraints and commercial constraints could cause a difference between the import / export estimated, and actual import / export.

11 Annexure 2: Inputs used for CBET optimization analysis

GAMS objective function

Objective function:

$$Minimize\ production\ and\ transmission\ cost\ and\ Maximize\ Total\ Trade \qquad [1]$$

Where,

$$Total\ Trade = \sum CBET(j,i) \qquad [2]$$

Subject to,

$$Total\ Cost = \sum CBET(j,i) * [prodcost(j) + \ transcost(j,i)] \qquad [3]$$

Where Total Trade is sum of trade in the BIMSTEC region between countries in 2035, CBET is the annual Cross-Border Electricity Trade between countries, j is the country of electricity sale, i is the country of electricity purchase, Total Cost is the sum of production and transmission cost of trade in BIMSTEC region, prodcost is the production cost of power in country j, and transcost is the transmission cost of power transfer from country j to i.

Potential energy flows, after considering committed CBET transactions

From	Quantum Available [MU]	Tariff at border [USD/kWh]	To	Transit Charges [USD/kWh]	Transit Losses [%]	CB Link charges [USD/kWh]	CB Link losses [USD/kWh]	Total Charges [USD/kWh]	Existing avg. cost of PP [USD/kWh]	Total Requirement [MU]
Bhutan	3,102	0.06	Bangladesh	0.01	1.83%	0.002	0.04%	0.0678	0.07	40,295
Bhutan	3,102	0.06	Myanmar	0.01	0.05	0.003	0.06%	0.0744	0.13	15,641
Bhutan	3,102	0.06	Sri Lanka	0.01	0.02	0.002	0.04%	0.0678	0.10	7,008
Bhutan	3,102	0.06	Thailand	0.01	0.07	0.004	0.08%	0.0822	0.05	59,569
India	269,956	0.06	Bangladesh	0.00	0.00	0.001	0.02%	0.0644	0.07	40,295
India	269,956	0.06	Myanmar	0.00	0.03	0.002	0.04%	0.0708	0.13	15,641
India	269,956	0.06	Sri Lanka	0.00	0.00	0.001	0.02%	0.0644	0.10	7,008
India	269,956	0.06	Thailand	0.01	0.06	0.003	0.06%	0.0785	0.05	59,569
Nepal	20,960	0.06	Bangladesh	0.01	0.02	0.002	0.04%	0.0649	0.07	40,295
Nepal	20,960	0.06	Myanmar	0.01	0.05	0.003	0.06%	0.0713	0.13	15,641
Nepal	20,960	0.06	Sri Lanka	0.01	0.02	0.002	0.04%	0.0649	0.10	7,008
Nepal	20,960	0.06	Thailand	0.01	0.07	0.004	0.08%	0.0791	0.05	59,569

12 Annexure 3: Conversion Factors

12.1 IEA's conversion factors (Chapter 3)

The conversion factors are adopted by International Energy Agency using the below:

Coal

For electricity/heat generation, coal inputs to each type of plant are converted to energy units using average factors calculated from the Annual Electricity Questionnaire. All other flows are converted using an average net calorific value.

Crude Oil

Country-specific net calorific values (NCV) for production, imports and exports by country are used to calculate the balances. The average value is used to convert all the other flows to heat values.

Natural Gas

Gas data provided in joules should be converted as follows:

Data in TJ divided by 41868 = Data in Mtoe.

To calculate the net heat content of a gas from its gross heat content, multiply the gross heat content by a factor of NCV to GCV.

Electricity

Data in TWh x 0.086 = Data in Mtoe

General conversion factors for energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
terajoule (TJ)	1	2.388×10^{2}	2.388×10^{-5}	9.478×10^{2}	2.778×10^{-1}
gigacalorie (Gcal)	4.187×10^{-3}	1	1.000×10^{-7}	3.968	1.163×10^{-3}
million tonnes of oil equivalent (Mtoe)	4.187×10^{4}	1.000×10^{7}	1	3.968×10^{7}	1.163×10^{4}
million British thermal units (MBtu)	1.055×10^{-3}	2.520×10^{-1}	2.520×10^{-8}	1	2.931×10^{-4}
gigawatt hour (GWh)	3.600	8.598×10^{2}	8.598×10^{-5}	3.412×10^{3}	1

Source: International Energy Agency[280]

12.2 Conversion factor considered by India's Ministry of Statistics and Program Implementation

- 1 kilogram = 2.2046 pounds
- 1 Pound = 454 gm.
- 1 Cubic metres = 35.3 cubic feet (gas)
- 1 Metric ton = 1 Tonne =1000 kilogram
- 1 Joule = 0.23884 calories
- 1 Mega Joule = 10^6 joules = 238.84 x 10^3 calories
- 1 Giga Joule = 10^9 joules = 238.84 x 10^6 calories
- 1 Tera Joule = 10^12 joules = 238.84 x 10^9 calories
- 1 Peta Joule = 10^15 joules = 238.84 x 10^12 calories
- One million tonnes of coal = 15.13 petajoules of energy
- One million tonnes of oil equivalent (MTOE) = 15.13 petajoules of energy
- One billion cubic meter of natural gas = 38.52 petajoules of energy

- One million cubic meter of natural gas = 0.03852 petajoules of energy
- One billion kilowatt hour of electricity = 3.60 petajoules of energy

Source: Ministry of Statistics and Program Implementation[281]

12.3 Conversion factors considered by Sri Lanka Sustainable Energy Authority

Primary Energy	toe/t	kJ/t
Bagasse	0.40	16,747,200
Charcoal	0.65	27,214,200
Coal	0.70	29,307,600
Crude Oil	1.03	43,124,040
Fuel wood	0.38	15,909,840
Hydro electricity (thermal equivalent) (toe/GWh)	240.00	10,048,320,000

Products	toe/t	kJ/t
Aviation Gasoline	1.06	44,380,080
Aviation Turbine Fuel	1.05	43,961,400
Ethane	1.18	49,404,240
Fuel Oil	0.98	41,030,640
Gas Oil /Diesel Oil	1.05	43,961,400
Kerosene	1.05	43,961,400
LPG	1.06	44,380,080
Motor Gasoline (Petrol)	1.09	45,636,120
Naphtha	1.09	45,636,120
Refinery gas	1.15	48,148,200
Residual Oil	0.98	41,030,640
Solvent	0.89	37,262,520

Electricity	kJ/kWh
Electricity	3,600

Source: Sri Lanka Sustainable Energy Authority [282]

13 References

Due acknowledgment is provided to all the below sources and their authors, for providing enabling inputs for this study.

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About SARI/EI

The US Agency for International Development (USAID) initiated the South Asia Regional Initiative for Energy (SARI/E) program in the year 2000 to promote Energy Security in the South Asia region, working on three focus areas: Cross Border Energy Trade (CBET); Energy Market Formation; and Regional Clean Energy development. The program covers the eight countries in South Asia, viz. Afghanistan, Bangladesh, Bhutan, India, The Maldives, Nepal, Pakistan and Sri Lanka. The fourth and current phase of the program, called South Asia Regional Initiative for Energy Integration (SARI/EI), is aimed at advancing regional grid integration through cross border power trade. This phase is being implemented by Integrated Research and Action for Development (IRADe), leading South Asian Think Tank. SARI/EI is a key program under USAID's Asia EDGE (Enhancing Growth and Development through Energy) Initiative. SARI/EI focuses on moving the region from bilateral to trilateral and multilateral power trade, and establishing the South Asia Regional Energy Market (SAREM)

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IRADe, located in Delhi, is a non-pro t and fully autonomous institute for advance research. IRADe's multidisciplinary research and policy analysis aid action programs. It is a hub for a network of diverse stakeholders. Established in 2002, the institute is recognized as an R&D organization by the Department of Scienti c and Industrial Research and Ministry of Science and Technology of the Government of India. The Ministry of Urban Development has accorded IRADe the status of Centre of Excellence for Urban Development and Climate Change. Through the SARI/EI program, IRADe is pushing the envelope for sustainable energy access through experts and members from South Asia.

For more information, please visit the SARI/EI project website:

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