ASEAN Green Future Project Phase 2.1 Report

December 2023

Thailand Power Sector Modelling

Bundit Limmeechokchai
Rathana Lorm
Kannika Thampanishvong

Authors

Bundit Limmeechokchai
Rathana Lorm

Kannika Thampanishvong

About ASEAN Green Future

ASEAN Green Future is a multi-year regional research project that involves the UN Sustainable Development Solutions Network (SDSN), Climateworks Centre and nine country teams from leading universities and think tanks across Southeast Asia (Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam). The researchers undertake quantitative and qualitative climate policy analysis and develop net zero pathways to inform policy recommendations and support the strategic foresight of policy makers.

The Phase 1 country reports present priorities and actions to date, and key technology and policy opportunities to further advance domestic climate action. The Phase 1 regional report positions Southeast Asia's low carbon transition pathways within a global context using the country reports and other studies. This series of reports, produced through a synthesis of existing research and knowledge, builds the case for advancing the region's climate agenda. Phase 2 of the ASEAN Green Future project uses modelling to quantitatively assess the different decarbonisation pathways for Southeast Asia.

Acknowledgements

The authors are deeply grateful to Dimas Fauzi, Uttam Ghimire, Charlie Heaps, Pimolporn Jintarith, Kuntum Melati and Silvia Ulloa, from the Stockholm Environment Institute (SEI) for their wholehearted support in training and mentoring the ASEAN Green Future (AGF) researchers on the implementation of the Low Emission Analysis Platform[1] (LEAP) for energy planning and climate change mitigation assessment since March 2023. LEAP gave the AGF researchers across Southeast Asia a common language, shared tools, and a transparent platform for communication and collaboration. The initial model that SEI prepared for AGF initiated the regional modelling process, allowing the AGF researchers to continue building the power model on a solid foundation and independently conduct their own analysis. By reducing dependence on external expertise, this fosters long-term sustainability in regional energy planning and empowers stakeholders to participate in the energy transition process and contribute to well-informed decision-making. The authors also extend their gratitude for the supports from Thammasat University & Research Unit in Sustainable Energy and Built Environment, and Thailand Development Research Institute, Thailand.

The authors acknowledge the valuable and generous contributions of input and feedback to this report by our expert reviewers - Muhammad Rizki, Climateworks Centre and Ho Jen Sim, Malaysian Institute of Road Safety Research.

Disclaimer

This ASEAN Green Future report was written by a group of independent experts acting in their personal capacities. Any views expressed in this report do not necessarily reflect the views of any government or organisation, agency, or programme of the United Nations.

Corresponding Author

Bundit Limmeechokchai (bundit.lim@gmail.com)

[1] Heaps, C.G., 2022. LEAP: The Low Emissions Analysis Platform. [Software version: 2020.1.107] Stockholm Environment Institute. Somerville, MA, USA. https://leap.sei.org

CONTENTS

List of Figures

List of Tables

1. INTRODUCTION TO THAILAND

Thailand is located in the center of the Southeast Asian mainland, bordered by Cambodia, Lao PDR, Malaysia, and Myanmar. The total population in the country increased at an average growth rate of 0.81%, rising from 59.42 million in 1995 to 71.12 million in 2018. As of 2018, 49.94% of the total population lived in urban areas (World Bank, 2023). Thailand is the second-largest economy among the ASEAN countries, and the gross domestic product (GDP) growth rate has increased by 3.00% annually between 1995 and 2018. In 2018, the total GDP in Thailand amounted to 1,172.34 billion $PPP, while the per capita income standing at 16.50 thousand $PPP (World Bank, 2023).

It is clear that the energy sector, especially electricity, plays a key role in boosting the country's economy and urbanization. Therefore, the growth of electricity demand is proportional to the growth of GDP and the population of the country. The increase in energy prices and the limited availability of fossil fuel resources over the years have emerged as significant challenges for every nation. On the other hand, dependency on fossil fuels leads to the production of a massive amount of GHG emissions, posing a significant threat to global warming and having severe effects on every country, particularly those most vulnerable to climate change, like Thailand and other ASEAN nations. Therefore, projecting future electricity demand and generation is necessary to maintain proportional demand and supply growth, minimize environmental impacts, and ensure energy security aligns with sustainable development goals.

2. HISTORICAL TRENDS OF POWER AND GREEENHOUSE GAS EMISSIONS

2.1 Historical Trends of Energy Consumption

Energy plays a vital role in developing the nation. From 1995 to 2018, the total final energy consumption (TFEC) increased from 42.1 Mtoe to 83.95 Mtoe, with an average annual growth rate of 3.08% (DEDE, 2020b). In 2018, the transport sector alone consumed 39.41% of the TFEC, followed by the industrial sector (36.26%), residential sector (13.10%), commercial sector (7.8%), and other sectors (3.43%) (see Figure 1).

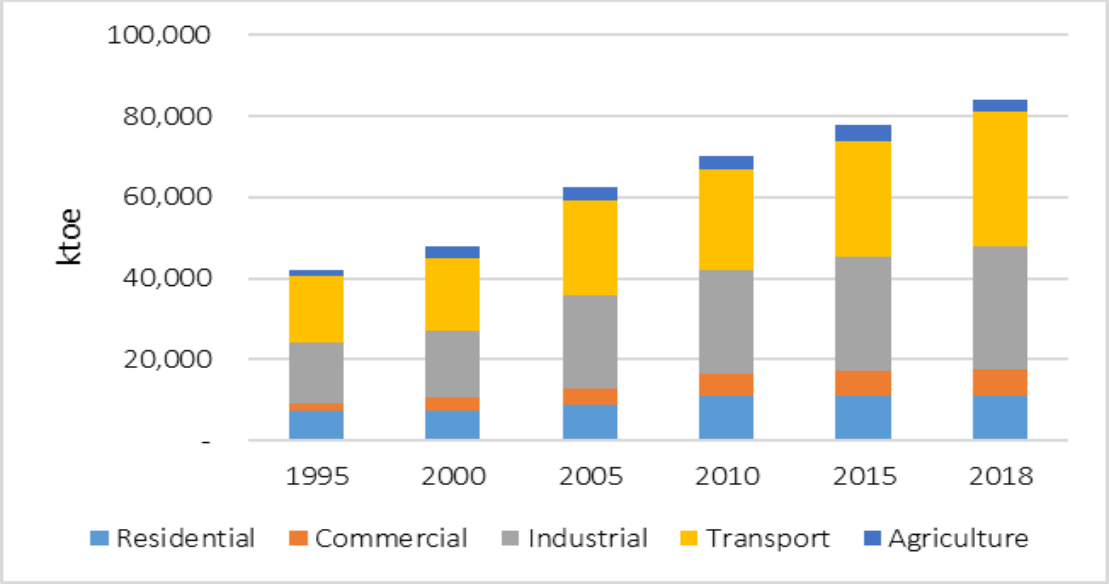

Figure 1: Historical energy consumption by sector (1995-2018)

According to the report on the energy balance of Thailand 2020 (DEDE, 2020b), the TFEC mainly comes from fossil fuels (oil products, natural gas, and coal), followed by electricity and biomass. As seen in Figure 2, in 2018, the final energy consumption from oil products was approximately 41.38 Mtoe, followed by electricity (16.81 Mtoe), biomass (13.13 Mtoe), coal products (6.87 Mtoe), and natural gas (5.77 Mtoe), respectively.

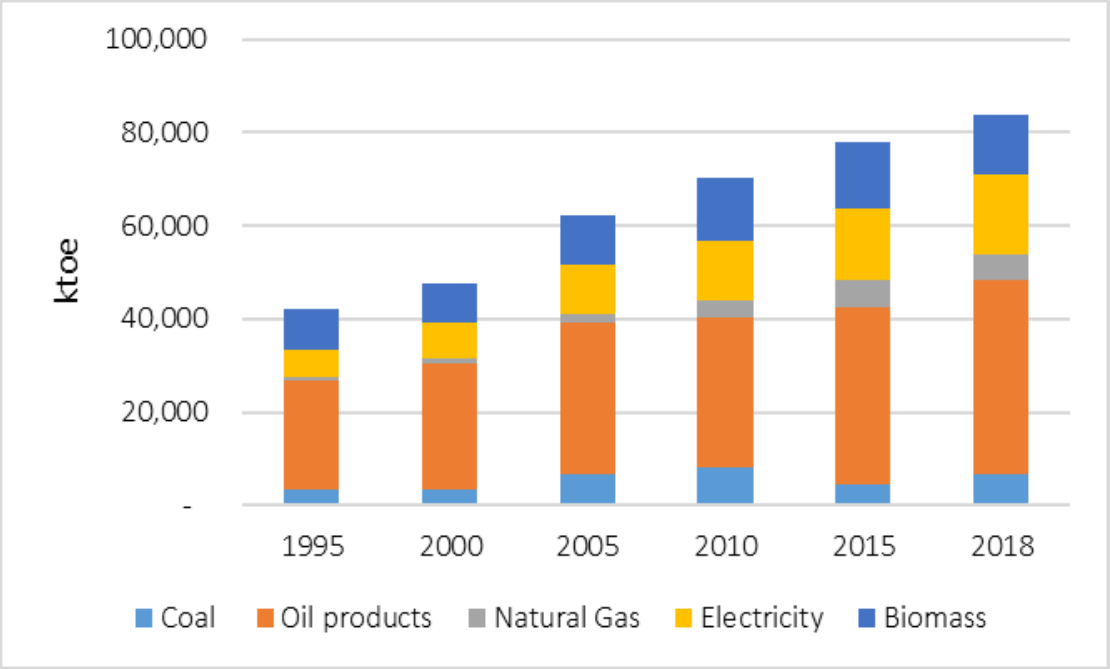

Figure 2: Historical energy consumption by fuel type (1995-2018)

2.2 Historical Trends of Electricity Demand

The total electricity demand in Thailand has tremendously increased between 2000 and 2018, with an average growth rate of 4.63% per annum, from 87.20 TWh to 195.44 TWh (DEDE, 2020b). In 2018, the share of electricity consumption by sector showed that the industrial sector consumed around 41.39% of the country's total electricity consumption. The building sector, including the residential and commercial sectors, utilized 23.01% and 35.31%, respectively, of the total generation. On the other hand, electricity demand from the transport sector in Thailand is relatively too small compared to other sectors, which accounted for 0.11% due to the limited use of electric vehicles. Other sectors, such as public lighting, agriculture, and public buildings, contribute to the rest of electricity consumption. Figure 3 illustrates the trend of sectoral electricity demand.

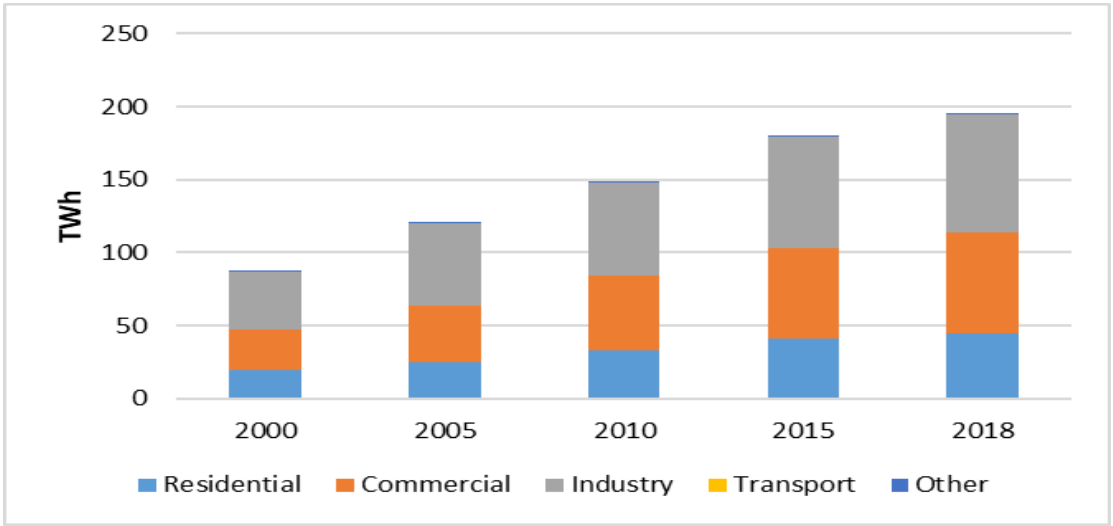

Figure 3: Historical electricity demand by sector (2000-2018)

2.3 Power Generation and Installed Capacity

The electricity generation in Thailand has tremendously grown from 80.44 TWh in 1995 to 204.43 TWh in 2018, according to the electricity statistics for 2023 of the Energy Policy and Planning Office (EPPO), Ministry of Energy (EPPO, 2023a). Power generation in Thailand mainly relies on natural gas, coal, and hydropower. In 2018, natural gas accounted for 56.87% of the electricity generation mix, followed by coal at 17.51%, hydropower at 3.72%, other renewable energy at 8.77%, imported electricity at 13.04%, and other oil products at 0.09% (see Figure 4).

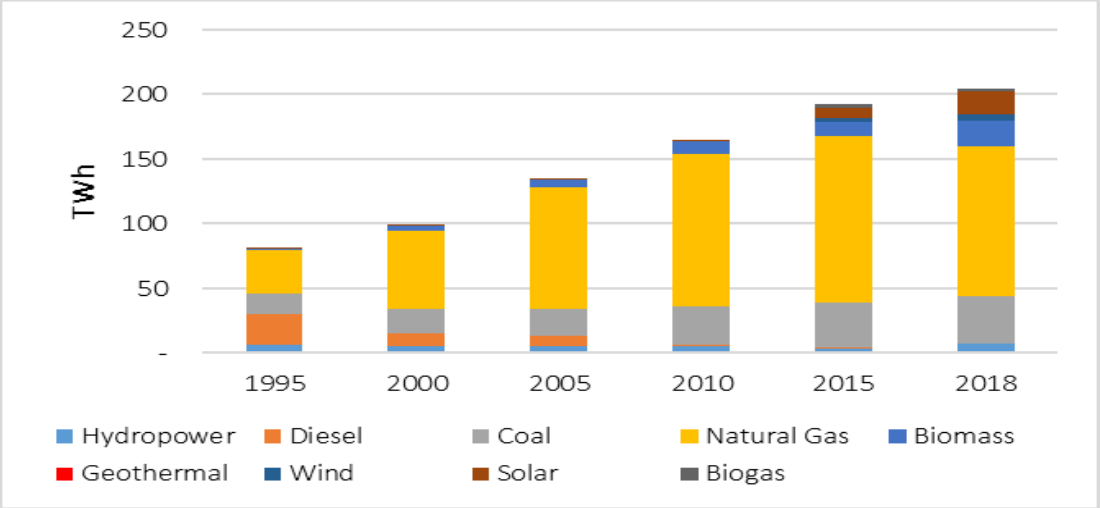

Figure 4: Historical power generation by fuel type (1995-2018)

The total installed capacity of power plants in Thailand shows a remarkable increase due to the growth of electricity demand in the country. The total capacity of power generation increased by approximately 201% between 1995 (14,441 MW) and 2018 (43,374 MW) (EPPO, 2023a). In 2018, the installed capacity of natural gas power plants was 24,837 MW, followed by coal power plants with 4,637 MW. However, the total capacity of RE was 8,586 MW, consisting of hydropower (3,282 MW), solar (2,967 MW), biomass (2,257 MW), wind (1,081 MW), and biogas (80 MW). The remaining 3,878 MW and 355 MW of installed capacity originated from neighboring countries and diesel/oil power plants, respectively (see Figure 5).

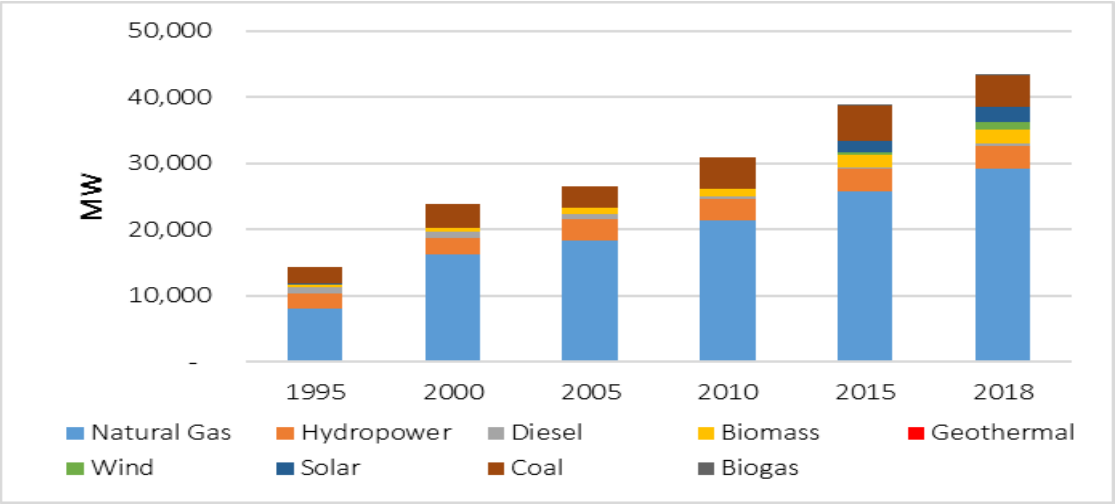

Figure 5: Historical installed capacity by fuel type (1995-2018)

2.4 Historical GHG Emissions from the Energy Sector and Power Generation

The 4th Biennial Update Report of Thailand indicates the trend of GHG emissions in the energy sector has increased from 165 MtCO2eq in 2000 to 257 MtCO2eq in 2018 (MoNRE, 2023). Of the amount of emissions in 2018, the transport and power sectors contributed the highest emissions, ejecting 95 MtCO2eq and 100 MtCO2eq, respectively. The industrial sector, the third highest emissions contributor, emitted 46 MtCO2eq in the country, followed by the others (8 MtCO2eq), residential sector (6 MtCO2eq), and commercial sector (2 MtCO2eq) (see Figure 6).

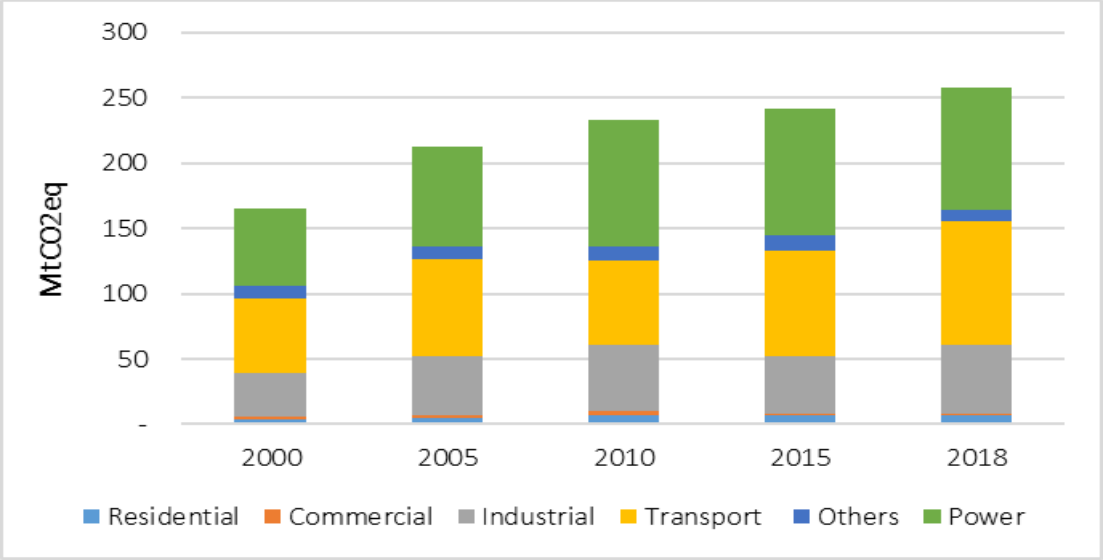

Figure 6: Historical GHG emissions from the energy sector (2000-2018)

In the power sector, the main sources of emissions are coal, natural gas, and diesel power plants. Figure 7 demonstrates that the power sector in Thailand has produced a heavy amount of GHG emissions, from 62 MtCO2eq in 2000 to 100 MtCO2eq in 2018 (EPPO, 2023b). In 2018, coal and natural gas power plants accounted for 50% and 49% to the total emissions, respectively, while the remaining 1% was emitted by diesel power plants.

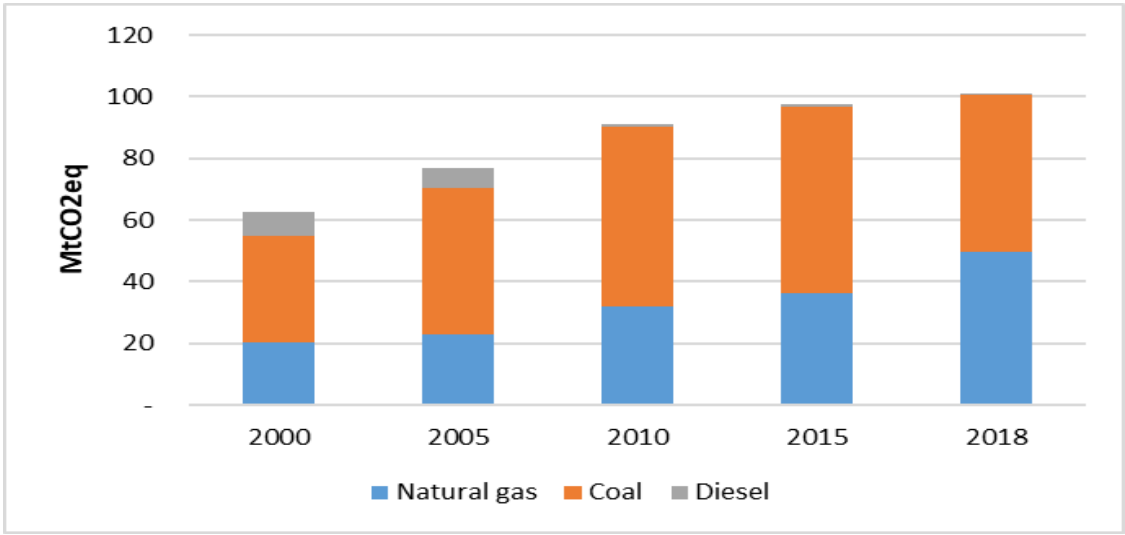

Figure 7: Historical GHG emissions from electricity generation (2000-2018)

3. METHODOLOGY

3.1 LEAP Model

The Stockholm Environment Institute developed LEAP software to evaluate energy policy and climate change management (Heaps, 2022). LEAP is structured as a hierarchical tree, allowing the input historical data and future data to analyze the Demand, Transformation, Resource, and Environmental. The LEAP model can be classified as a flexible tool for tracking energy consumption and supply of all economic sectors and GHG emissions from both energy and non-energy sectors. It is suitable for designing energy policies.

3.2 Scope

- The study focuses on the power sector, including both the supply side (electricity generation) and the demand side (electricity consumption in the residential, commercial, industrial, and transportation sectors).
- Thailand's historical data ranges from 2000 to 2018, and the first scenario year begins in 2019. The end year of the study is in 2060.
- The data is gathered from reliable sources such as official reports and documents from the government and reports and online databases from official organizations (World Bank, World Health Organization, Global Data Lab, etc.).

3.3 Key Drivers for the Energy Demand Projections

There are some main drivers for the energy demand projections, including GDP, population, household electrification, appliance ownership, energy intensity, and sectoral value-added.

- **GDP:** In this study, the 2nd Shared Socioeconomic Pathway scenario (SSP2) is selected to be the key driver for the energy demand projections. The total GDP of Thailand is estimated to increase by 3.00% per annum between 2018 and 2060. The total GDP in Thailand would be 4,096.8 billion $PPP in 2060 (see Figure 8).

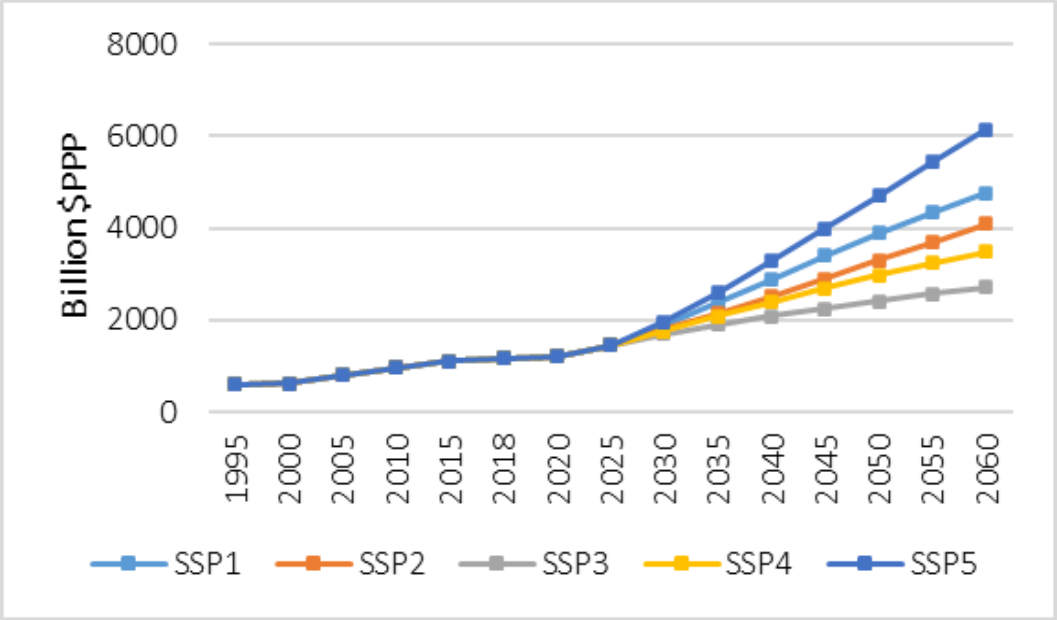

Figure 8: GDP projections

- **Population:** The medium scenario of world population prospects 2022, forecasted by the United Nations, illustrates that the average annual growth rate of population in Thailand between 2018 and 2060 will be -0.26% (United Nations, 2022). The total population of Thailand is estimated to be around 63.61 million people by 2060 (see Figure 9).

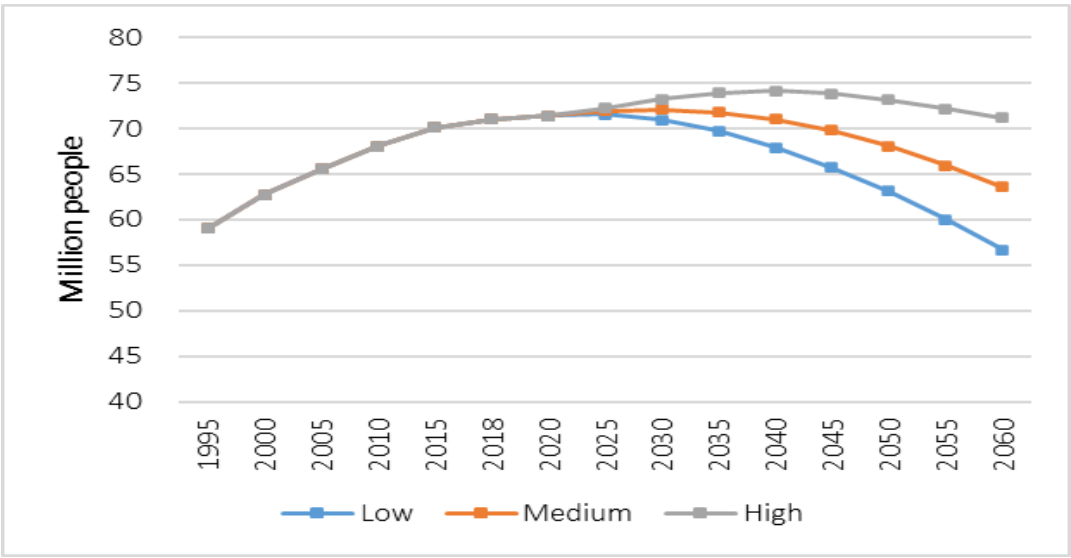

Figure 9: Population projections

- **Household numbers and Urbanization Growth**: the future number of households in Thailand is forecasted proportionally to the number of populations in the country divided by the number of people per household. The assumption of people per household is derived from the historical trend from the National Statistics Office report (NSO, 2023a). Besides this, the urbanization growth is gathered from the World Urbanization Prospects 2018 forecasted by the United Nations (United Nations, 2018). Therefore, the total number of households in Thailand in 2060 would be 23.13 million, an increase of 1 million from 2018, while urbanization in the country would increase from 49.94% in 2018 to approximately 74.35% in 2060 (see Figure 10).

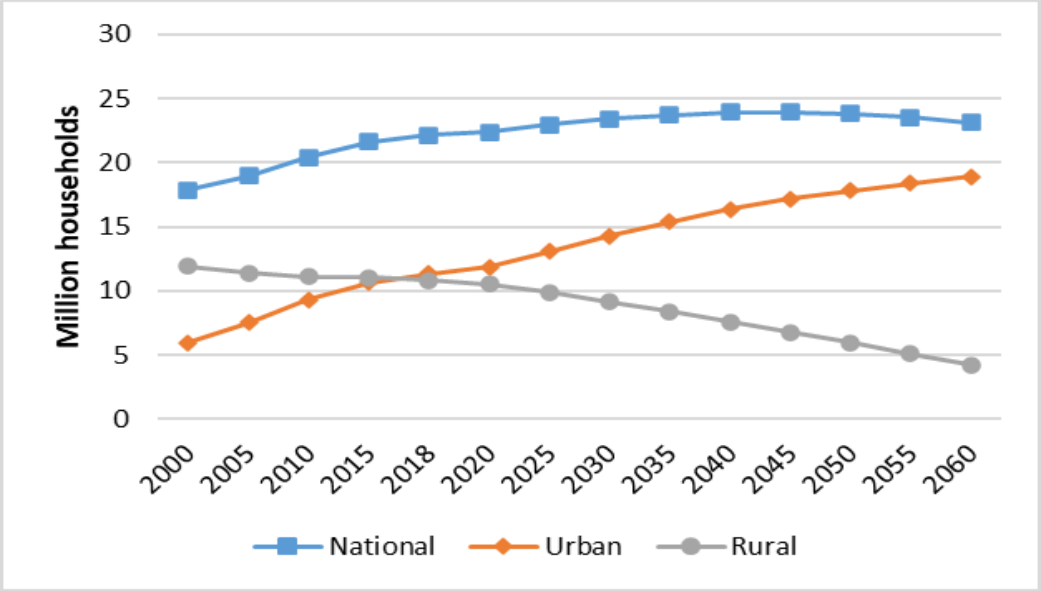

Figure 10: Household numbers and urbanization projections

- **Household electrification**: from the data in the world development indicator of the World Bank (World Bank, 2023) and the Thailand Annual Statistics Report (NSO, 2023b), the residential sector of Thailand achieved 100% electrification in 2020.

- **Appliance ownership:** the ownership of appliances in the residential sector can be found in the Household Socio-Economic Survey (NSO, 2023a).

- **Energy intensity**: refers to the energy consumption per unit of economic output (GDP). In the commercial sector, industrial sector, and other sectors, historical energy intensity is used to forecast the future of energy demand in the respective sectors.

- **Sectoral value-added:** refers to the GDP contribution to the country from different economic sectors, such as the commercial, industrial, and agricultural sectors. The sectoral value-added can be found in the World Development Indicators (World Bank, 2023) and in the Thailand Annual Statistics Report (NSO, 2023b). The projection of the share of sectoral value added to GDP is made based on the historical trend taken from these sources. As shown in Figure 11, the share of GDP from the commercial sector is steadily increasing from 55.71% to 66.49% between 2018 and 2060, whereas the share of the industrial sector in the GPD contribution drops from 35.27% to 30.10%. The remaining share of sectoral value added to the country's GDP is coming from the agricultural sector.

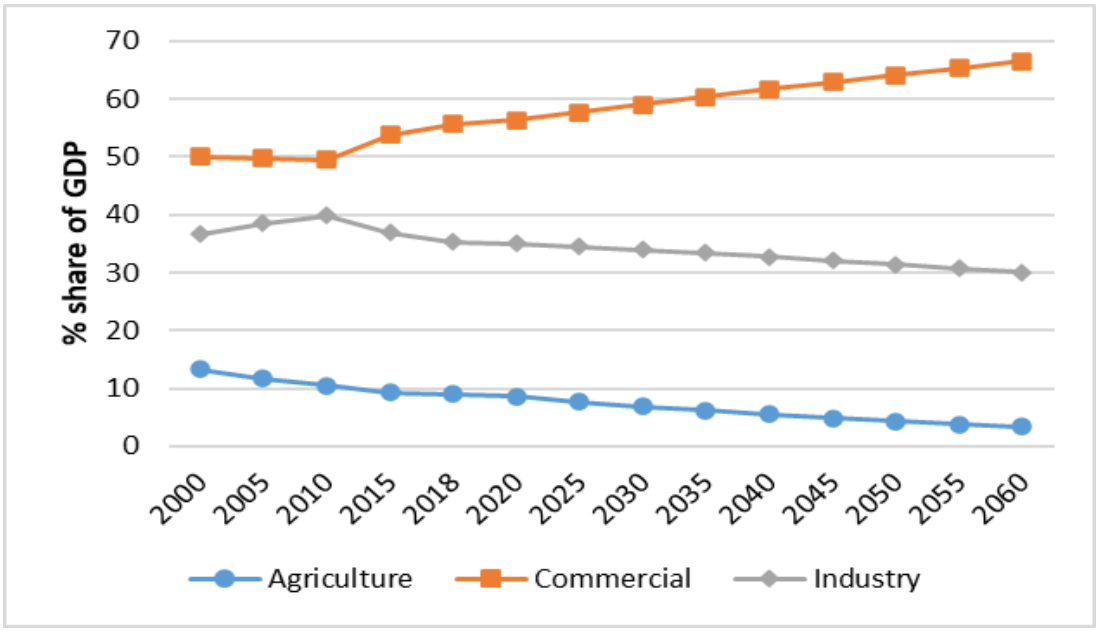

Figure 11: Projections of the share of sectoral value-added to the GDP

- **Number of vehicles:** the projection number of vehicles in Thailand is estimated by multiplying the vehicle ownership per capita by the number of populations, where the vehicle per capita is calculated by using the linear regression model between the historical number of vehicles as a dependent variable and income per capita as an independent variable. Furthermore, the share of types of vehicles in the future is also projected based on historical trends. The historical number of vehicles and share of vehicles are extracted from the statistics report of the Transport Statistics Group 2023 of the Department of Land Transport (DLT, 2023). By 2060, the total number of vehicles is estimated to be around 50 million, which is a 26% increase compared to 2018. The estimations suggest that cars, motorcycles, buses, and trucks will account for approximately 41.71%, 53.35%, 0.41%, and 4.51% of the total number of vehicles in 2060, respectively.

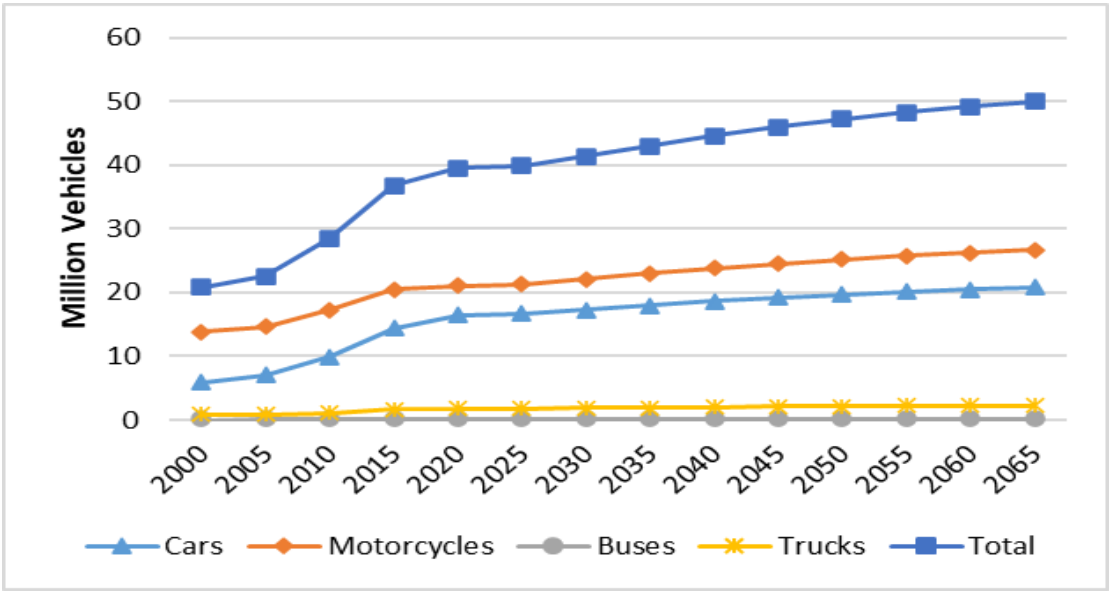

Figure 12: Projections of number of vehicles

4. EXISTING POLICY SCENARIO

4.1 Description of the Existing Policy Scenario

a) Residential Sector

Forecasting energy demand in the residential sector involves multiplying the energy consumption of each device with the activity data (number of households). In the residential sector, under the Existing Policy Scenario, the Energy Efficiency Plan 2018–2037 (EEP2018) (DEDE, 2020c) is integrated into the demand projection. There are three main measures to be implemented, comprising LED lighting, energy labeling, and EERS. The total energy savings from the implementation of the EEP2018 in 2037 will be 3,300 Ktoe. The assumptions of energy efficiency measures in the residential sector are illustrated below:

- Deployment of LED lighting: the LED lamps will replace conventional lamps. It is assumed that in 2018, no households have LED lamps. In 2037, it is expected that 70% of households will switch from conventional lamps to LED light bulbs.
- Implementation of energy labelling: it is expected that the share of efficient air-conditioning and refrigerators will increase from zero percent in 2018 to 30% in 2037.
- Implementation of energy efficiency resource standards (EERS): it is expected that the conventional appliances in other services will be fully replaced by the efficient ones in 2037.

b) Commercial Sector

In the commercial sector, the projection of energy demand is estimated to be proportional to the growth of GDP and share value-added from this sector. Additionally, in this scenario, there will be an integration of the government's energy development plan, namely the Alternative Energy Development Plan 2018–2037 (AEDP2018) (DEDE, 2020a). The key measure in the commercial sector is the utilization of solar in cooling and heating systems. There are five measures in the EEP2018 (DEDE, 2020c), including LED lighting, energy labeling, EERS, designated buildings, and building energy codes.

- Implementation of renewable energy: the application of solar in cooling and heating services is expected to increase from 0.15% in 2018 to 2% in 2037.
- Energy efficiency improvements are projected to save 6,418 Ktoe of final energy consumption in the commercial sector.

c) Industrial Sector

The implication of GDP share from the industrial sector is utilized to estimate future energy consumption in this sector, which is similar to the commercial sector. Furthermore, under this scenario, there would be integration with the AEDP2018 and EEP2018 plans from the government. The AEDP2018 plan aims to increase the share of renewable energy to replace the utilization of coal and oil products in the industrial sector (DEDE, 2020a). The EEP2018 plan consists of four

measures, including LED deployment, energy labelling, EERS, and designated factories (DEDE, 2020c).

- Implementation of renewable energy: the share of biomass and solar in the industrial sector will increase from 26% in 2018 to 30% in 2037.

- Implementation of energy efficiency improvements will decrease the amount of energy consumption by 21,137 Ktoe in 2037.

d) Transport Sector

Energy demand in the transport sector is forecasted based on the number of vehicles and vehicle fleet (vehicles per kilometer). The projections of the number of vehicles are estimated as indicated in Figure 3.5. The distance driven by each type of vehicle is based on assumptions, such as assuming that in 2018, cars, motorcycles, buses, and trucks covered approximately 12,000 kilometers per vehicle per year (km/veh/yr), 5,000 km/veh/yr, 18,000 km/veh/yr, and 12,000 km/veh/yr, respectively. It is assumed that the travel distance of each type of vehicle will increase proportionately with the rise in income. Therefore, by 2060, the average distance driven by cars, motorcycles, buses, and trucks is expected to increase to 20,000 km/veh/yr, 10,000 km/veh/yr, 26,000 km/veh/yr, and 20,000 km/veh/yr, respectively.

In the projection of energy demand in this sector, the EEP2018 plan would be included. This strategy aims to decrease energy consumption in the transport sector through fuel economy and efficiency enhancement. With the increasing fuel economy efficiency of ICE vehicles, the total amount of energy will be conserved by 17,682 ktoe in 2037 (DEDE, 2020c).

Under the latest Long-Term Low Emissions Development Strategy (LT-LEDS), Thailand aims to achieve 30% of light-duty vehicle penetration into road passenger transport by 2030 (ONEP, 2022).

e) Power Sector

Based on the Renewable Energy Outlook of ASEAN 2020 (IRENA & ACE, 2022), Thailand has significant potential for RE, including solar PV, onshore and offshore wind, biomass, and hydropower. The total potential capacity of the RE in Thailand is around 3,604 GW, consisting of Solar PV (3,509 GW), Onshore wind (32.4 GW), Offshore wind (29.4 GW), Biomass (18 GW), and Hydro (15 GW).

The Ministry of Energy of Thailand has formulated the policies for electricity, namely the Power Development Plan 2018–2037 (PDP2018) (EPPO, 2020). The objective is to maintain the following aspects: (1) Energy Security, (2) Economy, and (3) Ecology.

The PDP2018 commits to increasing the share of RE installed capacity (including hydropower/import hydropower from Lao PDR) from 21% in 2018 to around 47% (37% domestically) in 2037. The assumed share of RE installed capacity in 2016 corresponds to the target in 2037. The total installed capacity in 2060 is assumed to increase based on the trend in PDP2018.

Table 1: Installed capacity in the Existing Policy scenario

Power plants	2018	2020	2025	2030	2037	2060
Import*	3,878	5,721	6,235	7,509	8,661	9,000
Natural gas	24,837	29,084	33,186	33,224	32,112	47,000
Coal	4,637	6,110	6,2080	6,307	6,505	7,000
Diesel	355	380	380	380	65	65
Hydro	3,282	4,073	4,105	4,105	4,105	4,105
Biomass	2,257	2,333	3,712	3,374	5,522	11,500
Solar	2,967	3,022	3,608	7,936	14,754	26,000
Wind	1,081	1,488	1,774	1,774	2,989	6,000
Biogas	80	666	1,165	1,165	1,565	2,600
Total	**43,374**	**52,577**	**60,374**	**65,775**	**76,279**	**113,270**

Unit: MW
Note: * the import of electricity from neighboring countries (Lao PDR, Myanmar, and Malaysia)

4.2 Results in the Existing Policy Scenario

a) Sectoral Electricity Demand

The results in the Existing Policy Pathway scenario for Thailand indicate that the total electricity consumption is projected to increase from 195 TWh in 2018 to approximately 562 TWh in 2060 (see Figure 13). The sectoral growth of electricity demand shows that the industrial sector would have the highest share of electricity, estimated to be 49% of total demand due to the increase in industry electrification. Besides this, the commercial sector has the second-largest consumption of electricity, which is estimated to account for 30% of total 2060 electricity demand. The high demand in the commercial sector indicates that this sector mainly uses electricity for almost all building equipment. The transport sector jumps up to be the third-highest demand for electricity owing to the plan for electric vehicle penetration. Calculations estimate that this sector consumes approximately 11% of the total electricity. Additionally, residential is projected to have the fourth largest consumption of electricity, with a share of around 10%. The electricity demand in this sector is comparatively slow compared to others due to the drop in the total number of households and the decreasing population in the future. The remaining electricity demand will be absorbed by other sectors.

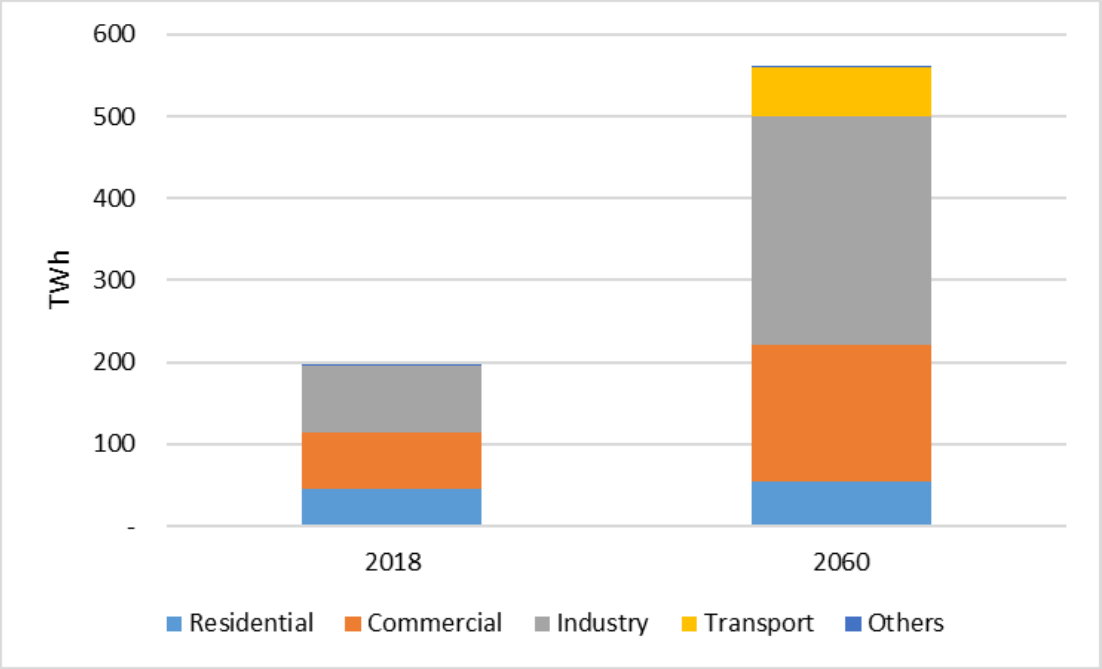

Figure 13: Electricity consumption by sector

b) Electricity Generation

Electricity generation will significantly expand from 204.43 TWh to 609.73 TWh between 2018 and 2060. During this study period, natural gas is expected to maintain the highest share of power production. In 2060, the share of natural gas in electricity production would be 51.69% of overall generation. With the deployment of the PDP2018 in Thailand, the share of domestic RE (including hydropower) would increase from 12.48% to 32.34% of total generation between 2018 and 2060. On the other hand, electricity generation from coal is gradually decreasing, from 17.51% in 2018 to around 7.23% in 2060. Imported electricity accounts for approximately 8.66% of the remaining electricity generation, while oil products contribute 0.07%.

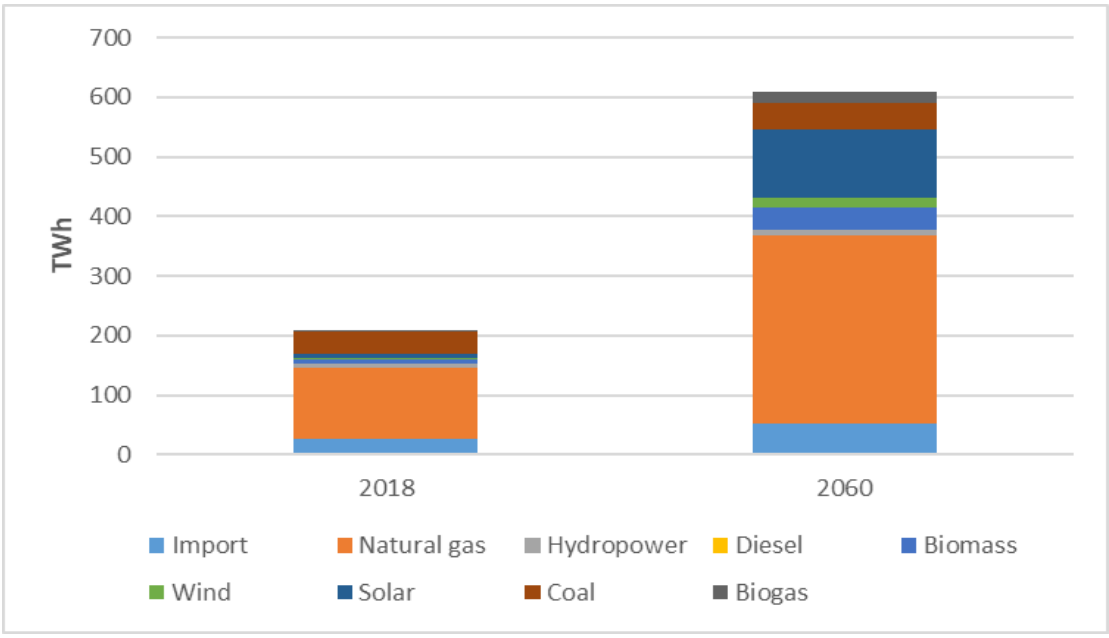

Figure 14: Electricity generation by fuel type

c) GHG Emissions from Electricity Generation

Under the Existing Policy scenario, GHG emissions would eminently increase due to the high dependency on fossil fuels to generate substantial amounts of electricity in order to meet the electricity requirements of each economic sector. The total amount of emissions from electricity production in Thailand was 100 MtCO2eq in 2018, and it is projected to increase by 77% to around 178.41 MtCO2eq by 2060. By 2060, the natural gas power plants are projected to become source of emissions, with 117.35 MtCO2eq (65.77% of total GHG emissions), as indicated in Figure 15. In addition, 33.69% of all GHG emissions would come from coal power generation. GHG emissions from bioenergy (biomass and biogas) are very low compared to the top two sources of emissions above. Bioenergy is estimated to emit around 0.40% of total emissions in 2060. The remaining emissions came from electricity generated by diesel and oil. Figure 15 illustrates the trend of Thailand's GHG emissions from the power sector between 2018 and 2060.

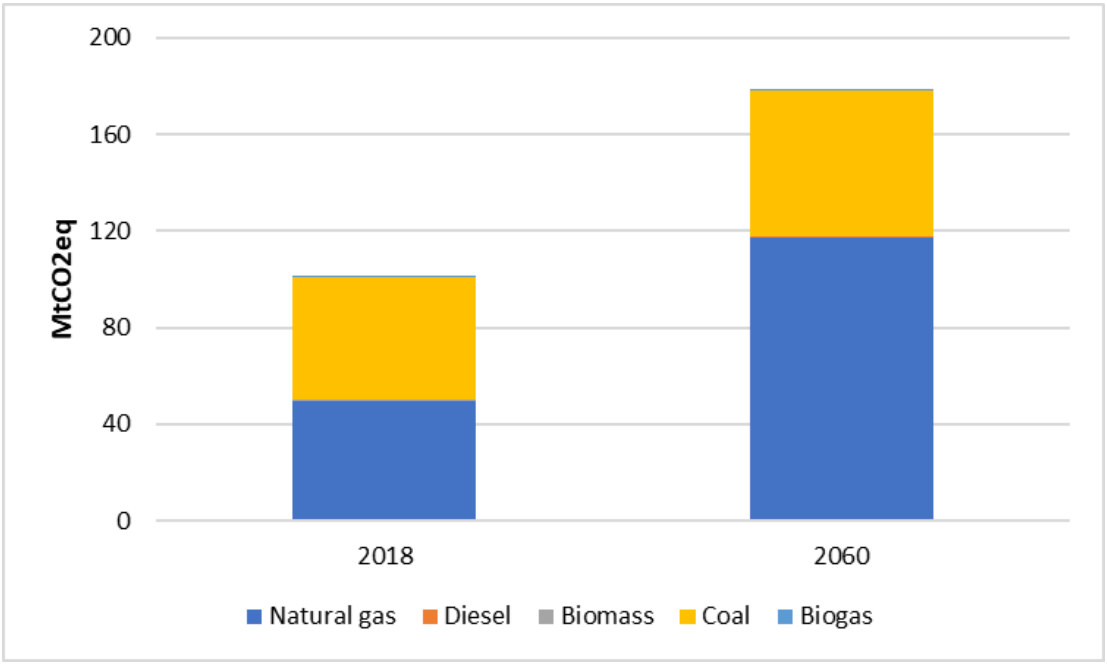

Figure 15: GHG emissions from electricity generation

5. MORE AMBITIOUS POLICY SCENARIO

5.1 Description of the More Ambitious Policy Scenario

The High Ambitious Policies Scenario is the extended scenario from 2037 to 2060 of the Existing Policies Scenario. In this case, the target of energy efficiency savings and the consumption of renewable energy in all sectors will continue to increase from 2037 to 2050.

a) Residential Sector

In the residential sector, there are two assumptions, including energy efficiency and the promotion of electric cooking measures:

- **Energy efficiency improvement measures**

  – In 2060, every household in Thailand will fully utilize LED lamps for lighting.

  – In 2060, 60% of households in Thailand will switch to using efficient air-conditioning and efficient refrigerators.

- **Promotion of electric cooking**

  – In the residential sector, the percentage of households using electric for cooking will linearly increase from 5% in 2018 to 25% in 2060.

The measures of the More Ambitious Policy Pathway in the residential sector are shown in Table 2.

Table 2: More Ambitious Policy pathway assumption in the residential sector

Target Year	2018	2037	2050	2060
EE improvement measures				
Lighting				
- Penetration of LED lamps	0%	70%	85%	100%
Cooling				
- Penetration of efficient AC	0%	30%	45%	60%
- Penetration of efficient Refrigerator				
Promotion of electric cooking				
Cooking services in households:				
• Biomass (Wood and Charcoal)	15%	10%	7%	5%
• LPG	80%	76%	72%	70%
• Electricity	5%	15%	20%	25%

b) Commercial Sector

There are two assumptions in the commercial sector, such as the enhancement of energy efficiency and the promotion of renewable energy:

- In the energy efficiency improvement measure, it is assumed that in 2050, the energy conservation in the commercial sector will double compared to the energy savings in 2037 under the Existing Policies Scenario, equivalent to 12,836 ktoe.

- In the promotion of renewable energy, the share of solar heating in 2060, is assumed to double compared to the share of solar heating in 2037 under the AEDP2018.

c) Industrial Sector

There are several assumptions in the More Ambitious Policy scenario in the industrial sector, including energy efficiency improvement and renewable energy promotion:

- In 2060, it is assumed that energy efficiency improvement in the industrial sector will increase 1% annually from 2018 to 2060.

- Regarding the RE promotion, in 2050, the share of RE (biomass and solar) in the final energy consumption in the industrial sector will increase by 5% over the RE target in 2037 under the AEDP2018. The promotion of RE in the industrial sector is illustrated in Table 3.

Table 3: RE promotion in the More Ambitious Policy pathway assumption in the industrial sector

Target Year	2018	2037	2050	2060
Fuel consumption in the industrial sector:				
• Oil products	16%	10%	8%	7%
• Electricity	23%	33%	34%	35%
• Biomass	26%	29%	31%	32%
• Solar	-	1%	2%	3%
• Natural Gas	13%	14%	15%	15%
• Coal products	22%	13%	10%	8%

d) Transport Sector

In the transport sector, the More Ambitious Policy scenario aims to increase the efficiency of internal combustion engine vehicles (ICE vehicles) and the efficiency of fuel economy, drastically utilize electric vehicles in road transportation modes, and increase the share of electric trains in passenger-kilometer and tonne-kilometer. The measures of the More Ambitious Policy Pathway in the transport sector are shown in Table 4.

Table 4: More Ambitious Policy pathway assumption in the transport sector

Target Year EE improvement measures	2018	2030	2050	2050
Improving efficiency of fuel economy in ICE vehicles compared to fuel economy in 2018.	0%	25%	30%	40%
EV promotion measures				
Road Transportation Mode				
• The share of electric vehicles	0%	30%	45%	60%
Rail transportation				
• Electric train for passenger-transport (pass-km)	31.91%	40%	45%	50%
• Electric train for freight-transport (tonne-km)	0%	10%	20%	25%

e) Power Sector

Under the More Ambitious Policy scenario, for the power sector, two key assumptions are being made, including the reduction of transmission and distribution losses and the increase of the share of RE towards 2060 by extending from the existing plan (PDP2018). The share of domestic RE installed capacity in 2037 from the PDP2018 plan is 37% of the total capacity. Therefore, in 2060, in this scenario, the share of RE installed capacity will increase by around 28% compared to the existing policies. Hence, the share of domestic RE installed capacity is expected to be around 65% in 2060. The measures of the High Ambition Policies Pathway in the power sector are shown in Table 5.

Table 5: More Ambition Policies Pathway assumption in the power sector

Target Year EE improvement measures	2018	2037	2060
Transmission and distribution losses			
• T&D losses reduction	6.42%	5%	5%
RE promotion measures			
Power generation installed capacity			
• Import	3,878	8,661	11,000
• Coal-based power plant	4,637	6,505	2,000
• Natural gas-based power plant	24,837	32,112	31,000
• Diesel/Fuel oil-based power plant	355	65	65
• Hydropower	3,282	4,105	4,105
• Biomass-based power plant	2,257	5,522	14,900
• Biogas-based power plant	80	1,565	3,000
• Solar	2,967	14,754	45,000
• Wind	1081	2,989	15,000

Unit: MW

5.2 Results in the More Ambitious Policy Scenario

a) Sectoral Electricity Demand

The results in the More Ambitious Policy scenario show that, despite having more efficient technologies integrated into the energy system, total electricity consumption will still slightly increase by 5.55% in 2060 compared to the Existing Policy scenario. Electric vehicles in road transport and electric trains in rail transport mainly contribute to the increase in electricity demand. The results illustrate a 120% surge in electricity demand in the transport sector compared to the 2060 Existing Policy scenario. In the More Ambitious Policy scenario, it clearly shows that the electricity demand in the commercial sector and industrial sector has decreased by 24.84% and 11.48%, respectively, compared to the amount of electricity demand in the Existing Policy scenario due to the high integration of efficient technologies. On the other hand, the consumption of electricity in the residential sector has grown by 2.5 TWh owing to the increase in electric cooking (see Figure 16).

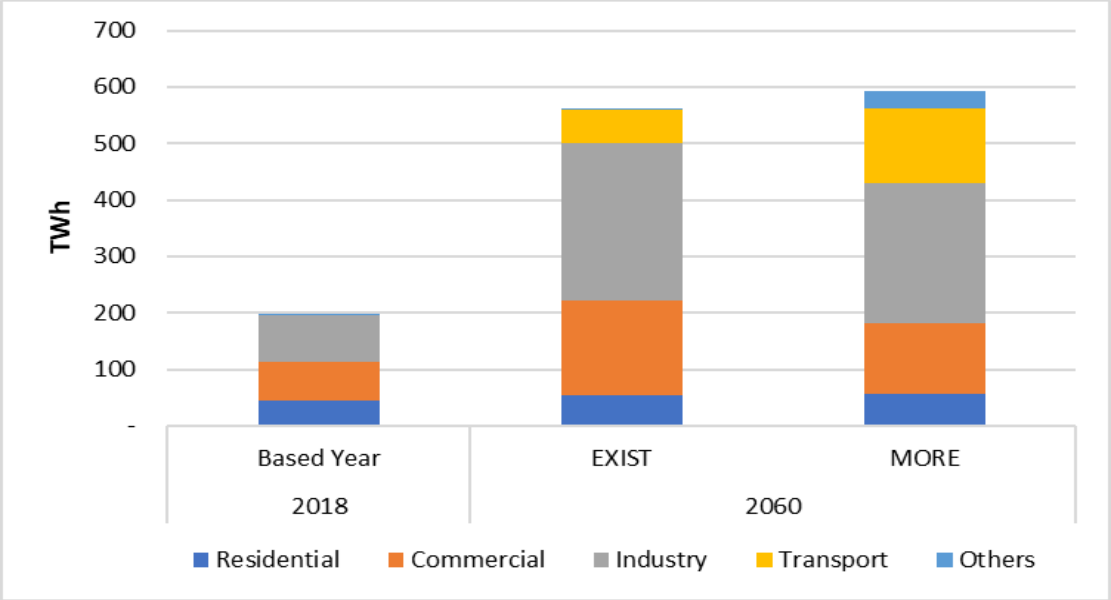

Figure 16: Electricity consumption by sector

b) Electricity Generation

The electricity generation in the More Ambitious Policy scenario is estimated to be 1.3% higher than in the Existing Policy scenario in 2016, amounting to 617.67 TWh.

Looking into the share of fuel types in power generation, the total electricity generation from RE (including hydropower) would tremendously increase to around 52.24%, which is around 20% higher than the share of electricity generation from RE in the Existing Policy scenario. Besides this, the generation from coal power plants would drastically decrease to 2.04% of total generation. In addition, natural gas electricity generation is projected to decrease from 56.87% in 2018 to 35.19% in 2060. The share of electricity imports from neighboring countries would slightly increase to 10.45%, while the remaining generation would come from oil power plants (see Figure 17).

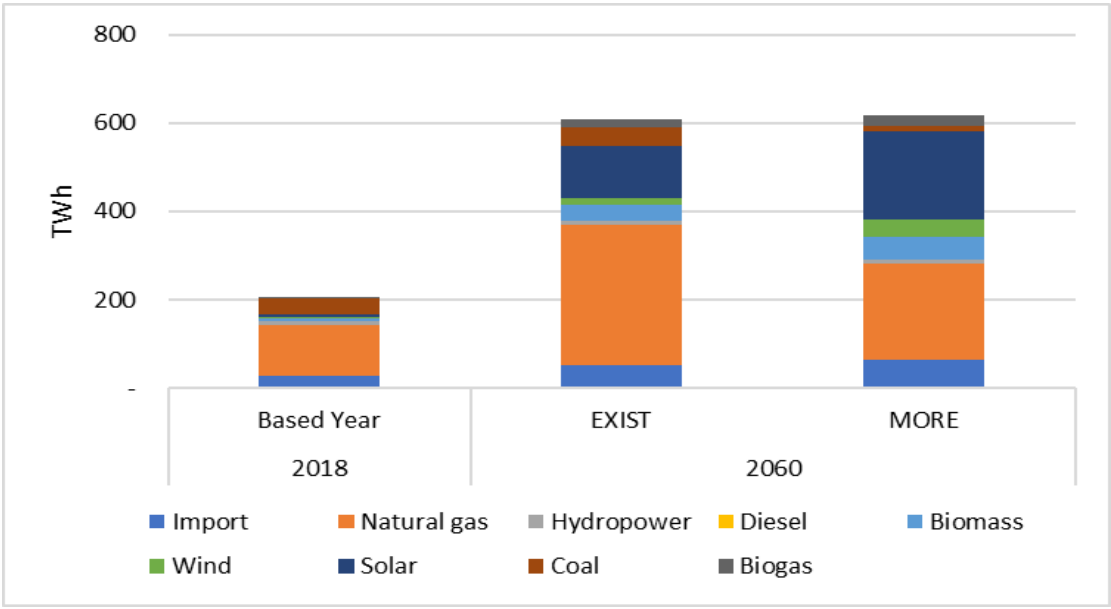

Figure 17: Electricity generation by fuel type

c) GHG Emissions from Electricity Generation

In the More Ambitious Policy Pathway scenario, GHG emissions in Thailand's power generation would be massively reduced. Compared to the Existing Policy Pathway scenario, the total GHG emissions in 2060 would drop by 44.14%, or equivalent to 78.75 MtCO2eq of reduction. The approximate GHG emissions from electricity production in Thailand would be 99.66 MtCO2eq in 2060. The results of great reduction in emissions is primarily attributed to the integration from the integration of renewable energy (solar, wind, biomass, and biogas) into electricity generation, coupled with the massive reduction in power generation from coal and natural gas power plants. The amount of GHG emissions from natural gas power generation notably decreased from 117.35 MtCO2eq in the Existing Policy scenario to 81.34 MtCO2eq (30.69%) in the More Ambitious Policy scenario. Meanwhile, coal generation experiences a significant reduction in GHG emissions, dropping from 60.10 MtCO2eq to 17.15 MtCO2eq. Figure 18 identifies the reduction of GHG emissions from electricity generation in Thailand between the More Ambitious Policy scenario and the Existing Policy Scenario.

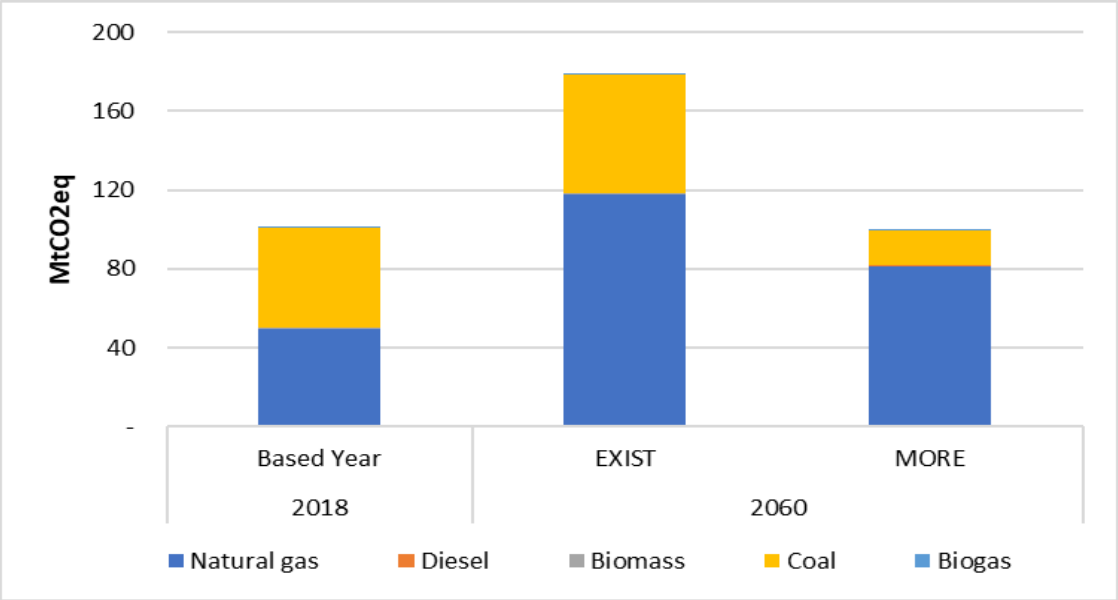

Figure 18: GHG emissions from electricity generation

6. RECOMMENDATIONS

Following the results in both scenarios, Thailand will not be able to achieve the target of net zero GHG emissions by the middle of this century. Therefore, there are some crucial mitigation measure recommendations for Thailand to consider, as indicated in the table below.

Table 6: Recommendations for mitigation measures to reach net zero emissions by 2050

Sector	Recommendations
Residential	• Increase in electric cooking devices • Increase the utilization of the efficient technologies
Commercial	• Increase in solar heating and cooling services • Increase the utilization of the efficient technologies
Industrial	• Increase the share of RE (biomass and solar) • Phase out of coal • Using bio-energy-based and natural gas-based technologies equipped with the carbon capture and storage (CCS)
Transport	• Increase the share of electric vehicle • Promote public transportation mode (electric train, electric bus, etc.)
Power	• Smart grid technology development could reduce the T&D losses in the power system • Increase the share of RE (solar, wind, biomass, and hydro) in power generation • Phase out of coal-fired power plants • Using bio-energy-based and natural gas-based technologies equipped with the CCS technology

REFERENCES

DEDE. (2020a). *Alternative Energy Development Plan 2018-2037 (AEDP2018)*. Department of Alternative Energy Development and Efficiency, Ministry of Energy.

DEDE. (2020b). *Energy Balance of Thailand 2020*. Department of Alternative Energy Development and Efficiency, Ministry of Energy.

DEDE. (2020c). *Energy Efficiency Plan 2018-2037 (EEP2018)*. Department of Alternative Energy Development and Efficiency, Ministry of Energy.

DLT. (2023). *Transport Statistics Group, Vehicle Registration Information*. Department of Land Transport. https://web.dlt.go.th/statistics/index.php

EPPO. (2020). *Power Development Plan 2018-2037 (PDP2018)*. Energy Policy and Planning Office, Ministry of Energy.

EPPO. (2023a). *Electricity Statistic 2023*. Energy Policy and Planning Office, Ministry of Energy. https://www.eppo.go.th/index.php/en/en-energystatistics/electricity-statistic

EPPO. (2023b). *GHG Emissions in Power Generation by Energy Type*. Energy Policy and Planning Office, Ministry of Energy. http://www.epa.gov/otaq/climate/420f07049.pdf

Heaps, C. . (2022). *LEAP: The Low Emissions Analysis Platform. [Software version 2020.1.99]*. Stockholm Environment Institute; Stockholm Environment Institute. https://leap.sei.org

IRENA & ACE. (2022). Renewable energy outlook for ASEAN towards a regional energy transition. In *International Renewable, Energy Agency, Abu Dhabi; and ASEAN Centre for Energy, Jakarta*. www.irena.org

MoNRE. (2023). *Thailand's Fourth Biennial Update Report*. Ministry of Natural Resources and Environment. https://unfccc.int/documents/624750

NSO. (2023a). *Household Socio-Economic Survey*. National Statistics Office. http://www.nso.go.th/sites/2014en/Pages/survey/Social/Household/The-2017-Household-Socio-Economic-Survey.aspx

NSO. (2023b). *Thailand Annual Statistics Report*. National Statistics Office. http://www.nso.go.th/sites/2014/Pages/e-Book/รายงานสถิติรายปี.aspx

ONEP. (2022). *Long-Term Low Greenhouse Gas Emission Development Strategy (Revised Version)*. *November*. www.onep.go.th

United Nations. (2018). *World Urbanization Prospect 2018*. Department of Economic and Social Affairs, Population Dynamics. https://population.un.org/wup/

United Nations. (2022). *World Population Prospects 2022*. Department of Economic and Social Affairs, Population Division. https://population.un.org/wpp/

World Bank. (2023). *World Development Indicators*. https://databank.worldbank.org/source/world-development-indicators

For further enquiries about the ASEAN Green Future project, please contact:

UN SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK (SDSN)

SDSN Asia Headquarters
Sunway University
No. 5, Jalan Universiti
Sunway City
47500 Selangor Darul Ehsan
Malaysia
Tel: +6 (03) 7491 8622
Email: sdsn-in-asia@unsdsn.org

CLIMATEWORKS CENTRE

Level 27, 35 Collins Street
Melbourne, Victoria 3000
Wurundjeri Country
Australia
Tel: +61 3 9902 0741
Email: info@climateworkscentre.org

Supported by

Jeffrey Cheah Foundation
Nurturing the Seeds of Wisdom

Hosted by

SUNWAY UNIVERSITY
A CLASS ABOVE