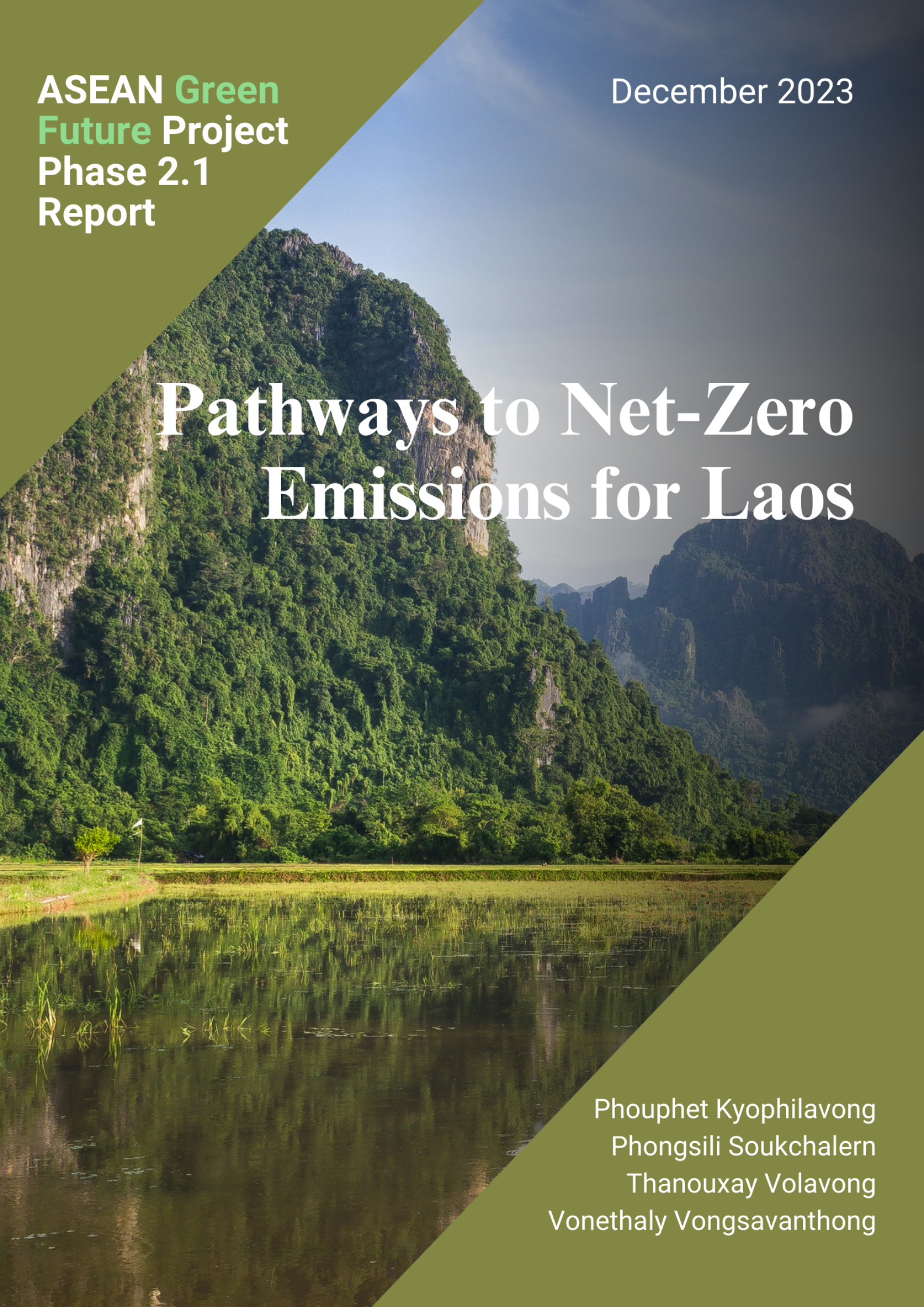
ASEAN Green Future Project Phase 2.1 Report

December 2023

Pathways to Net-Zero Emissions for Laos



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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 Faculty of Economics and Business Management, National University of Laos, Ministry of Energy and Mines, and Ministry of Natural Resources and Environment. The authors acknowledge the valuable and generous contributions of input and feedback to this report by our expert reviewers - Muhammad Rizki, Climateworks Centre and Kensuke Yamaguchi, University of Tokyo.

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.

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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

1. INTRODUCTION TO LAO PDR

Lao PDR, commonly known as Laos, is a landlocked country situated in Southeast Asia. It shares borders with several countries, including Cambodia, Thailand, Vietnam, China, and Myanmar. The population of Laos has experienced moderate growth, with an average annual growth rate about 1.62% between 1995 to 2018.

Laos has been working towards economic development, and its GDP growth rate showed an upward trend, increasing by an average of 6.79% annually between 1995 and 2018. In 2018, the total GDP and per capita income in Laos were recorded at 51.18 billion $PPP and 2.42 thousand $PPP, respectively (World Bank, 2021).

While Laos is considered one of the smaller economies in the ASEAN region, it plays a crucial role in the broader Southeast Asian context. The country has been striving for sustainable development, and its economic progress is reflected in the positive trends in GDP growth and per capita income over the years.

The Lao People's Democratic Republic (Lao PDR) possesses abundant renewable energy resources, particularly hydropower, which have been extensively developed since 1990 to meet domestic and regional electricity needs. Revenue from power exports significantly contributes to the country's socioeconomic development and energy security, while the power sector is a key player in the economy[2]. With an electrification ratio of 88.94% in 2015, the government aims to increase it to 95% by 2020, aligning with poverty eradication priorities and addressing the rising electricity demand through ongoing optimization efforts in the power sector.

There are several studies related to energy and electricity in Laos (Sousa et al.,2023; Kyophilavong et al., 2023; Kyophilavong et al., 2017; Lamphayphan et al., 2015). Additionally, some studies focus on the impact of climate change and decarbonization in Laos (Kyophilavong, 2021; Kyophilavong & Takamatsu, 2011; Kyophilavong, 2011). However, a study on Laos's long-term energy strategy scenarios and decarbonization needs to be conducted. This paper aims to use the LEAP model to simulate long-term energy strategy scenarios and decarbonization in Laos.

[2] There are a few studies related to electricity and power sector (Sasaki et al., 2013; Kyophilavong & Lamphayphan, 2014; Martin & Susanto, 2014)

2. HISTORICAL TREND OF LAOS' ENERGY PROFILE

2.1 Historical Trends of Energy Consumption

The historical energy consumption of Laos reveals a notable upward trend across various sectors from 1995 to 2018 (see Figure 2-1). Over this period, the total energy consumption more than doubled, increasing from 1,511.19 Ktoe in 1995 to 3,091.22 Ktoe in 2018 with an average growth rate of approximately 4.36% per year. Among the sectors, the transport experiencing a rise from 258.84 Ktoe in 1995 to 1,018.72 Ktoe in 2018. The industry sectors also exhibit substantial growth from 82.89 Ktoe in 1995 to 417.13 Ktoe in 2018.

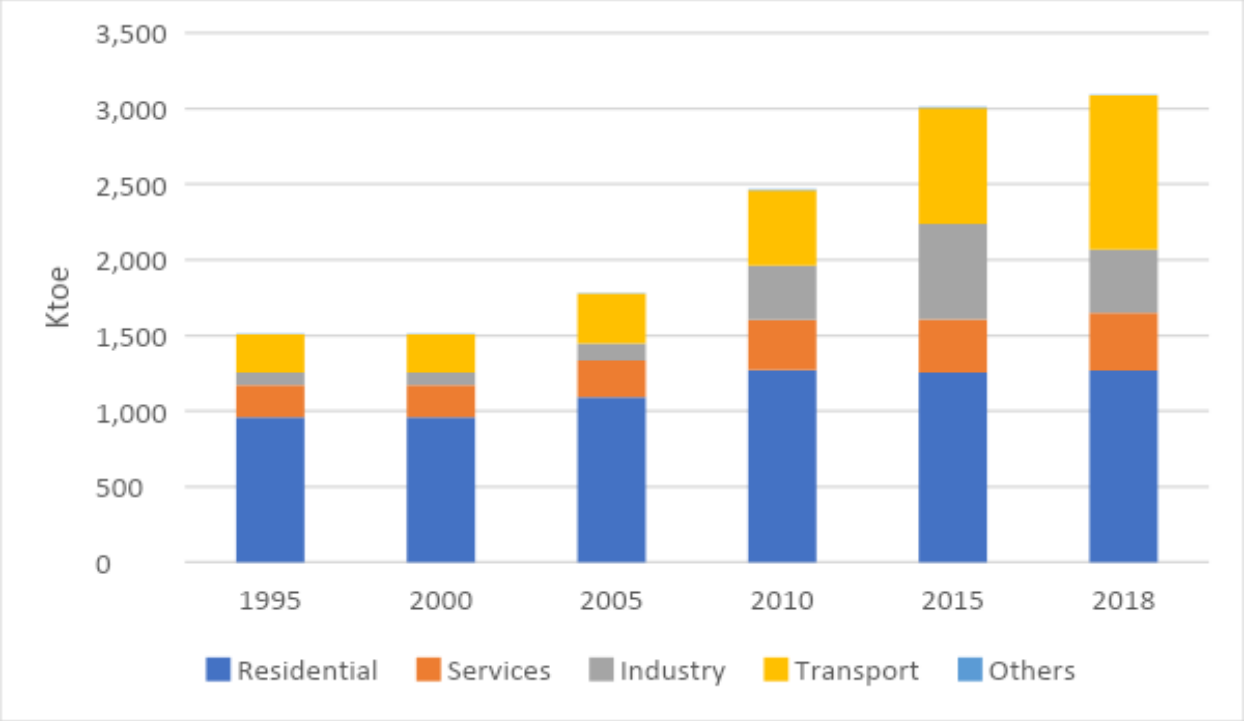

Figure 2-1: Historical Energy Consumption by Sector (1995-2018)
Source: MoEM (2018)

Figure 2-2 represents the distribution of final energy consumption among different fuel types across various years. Electricity consistently stands out as a significant contributor, experiencing substantial growth from 55.03 Ktoe in 1995 to 462.26 Ktoe in 2018. Gasoline and diesel also show a general upward trend, while wood consumption initially rises but later declines. In terms of absolute values, wood stands out as the highest consumed fuel type in 2018, with 1,284.78 Ktoe, followed by diesel at 867.19 Ktoe. The fuel consumption underscores a dynamic energy landscape, with shifts in fuel preferences and a notable increase in the reliance on electricity over the years.

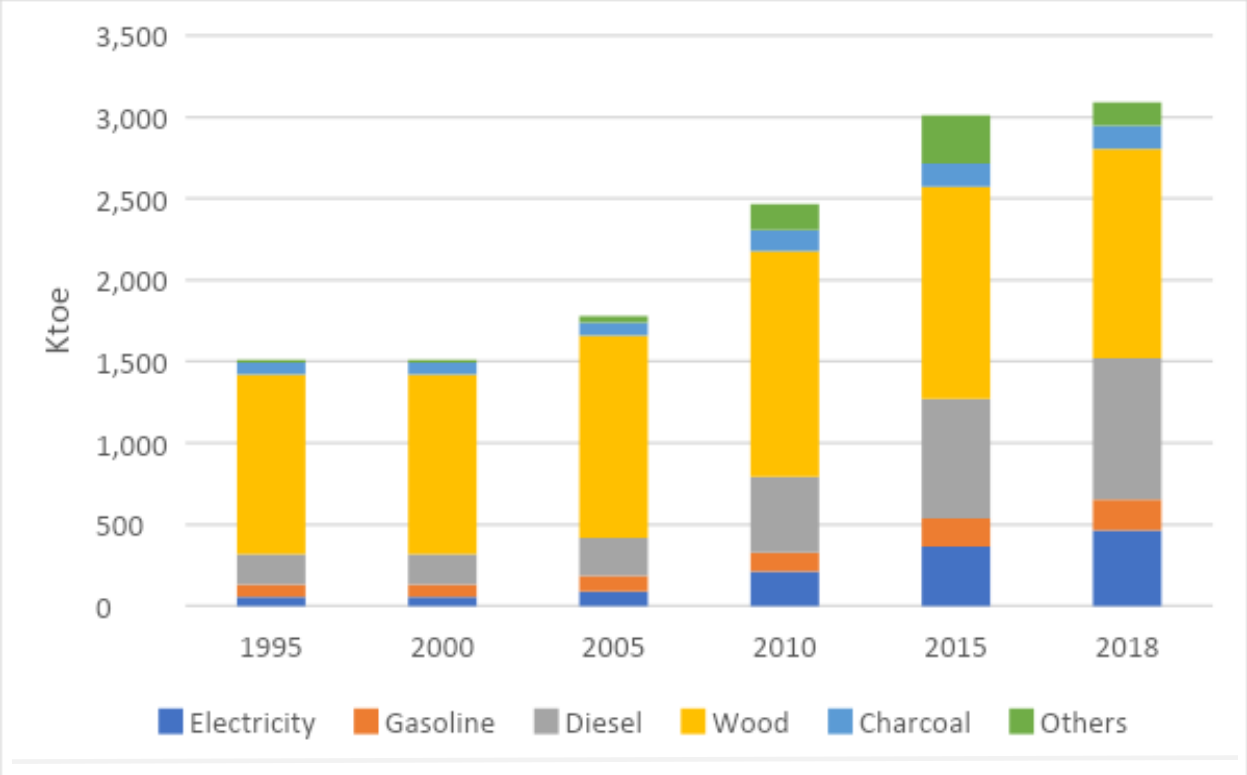

Figure 2-2: Historical Energy Consumption by Fuel Type (1995-2018)
Source: MoEM (2018)

2.2 Historical Trends of Power Generation and Installed Capacity

Figure 2-3 illustrates the evolution of power generation in terawatt-hours (TWh) across different sources from 1995 to 2018. The power generation has increased from 1.04 TWh in 1995 to 26.13 TWh in 2018. Notably, hydropower consistently contributed a significant portion, increasing from 1.04 TWh in 1995 to 22.33 TWh in 2018, marking substantial growth. Coal, biomass and solar energy began to play a role in 2015. By 2018, Coal contributions increased marginally, reaching 3.74 TWh, and accounting 14.03% of total power generation (Lao PDR Energy Outlook, 2020).

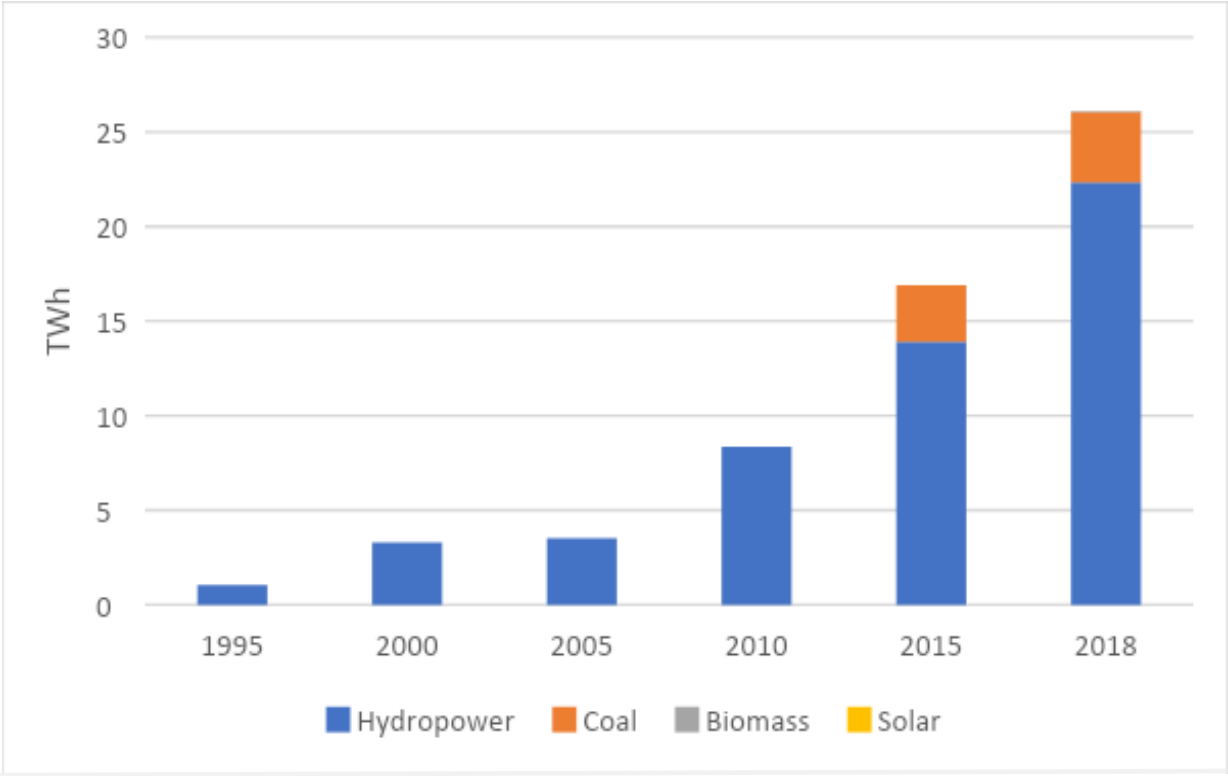

Figure 2-3: Historical Power Generation by Fuel (1995-2018)
Source: MoEM (2018)

Figure 2-4 denotes the installed capacity of different power generation sources measured in megawatts (MW) from 1995 to 2018. The total installed capacity rises notably from 241.26 MW in 1995 to 6,980.52 MW in 2018, reflecting an overall expansion in the power generation infrastructure. Hydropower emerges as a consistent major contributor, steadily increasing from 205 MW in 1995 to 5,056 MW in 2018. Coal reaches a capacity of 1,878 MW in 2018. The figure underscores a shift towards renewable energy sources, particularly evident in the substantial increase in hydropower and solar capacity, aligning with global efforts to transition to cleaner and more sustainable energy options.

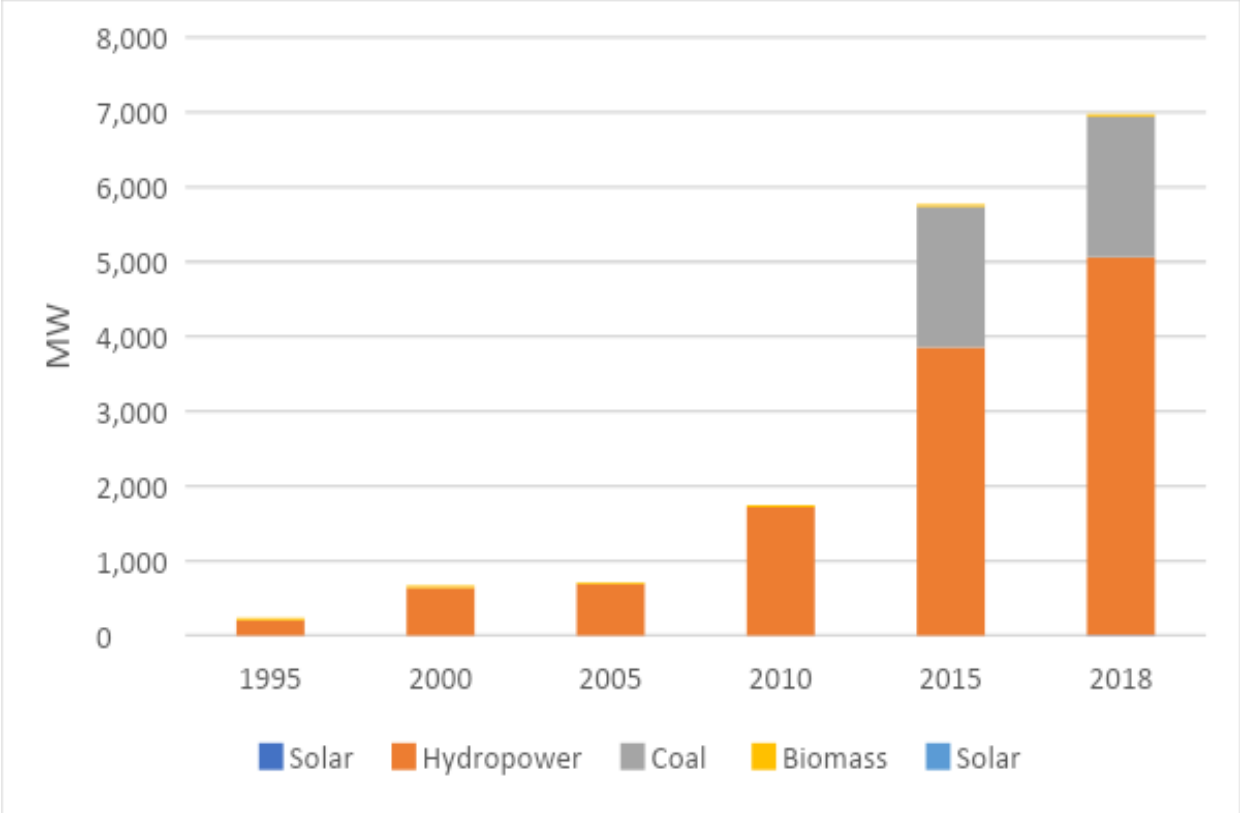

Figure 2-4: Historical Installed Capacity by Fuel (1995-2018)
Source: MoEM (2018)

2.3 Historical Trends of GHG Emissions

The total GHG emissions surged from 1,260.64 tCO2eq in 1995 to 4,295.05 tCO2eq in 2018, reflecting an annual growth rate of approximately 6.75% (see Figure 2-5). Notably, the transport sector emerged as a prominent contributor, experiencing a substantial increase from 789.66 tCO2eq in 1995 to 3,179.77 tCO2eq in 2018. The industry sector also demonstrated significant emissions, notably in 2015, reaching 1,584.76 tCO2eq. While the residential and services sectors contributed relatively lower emission levels.

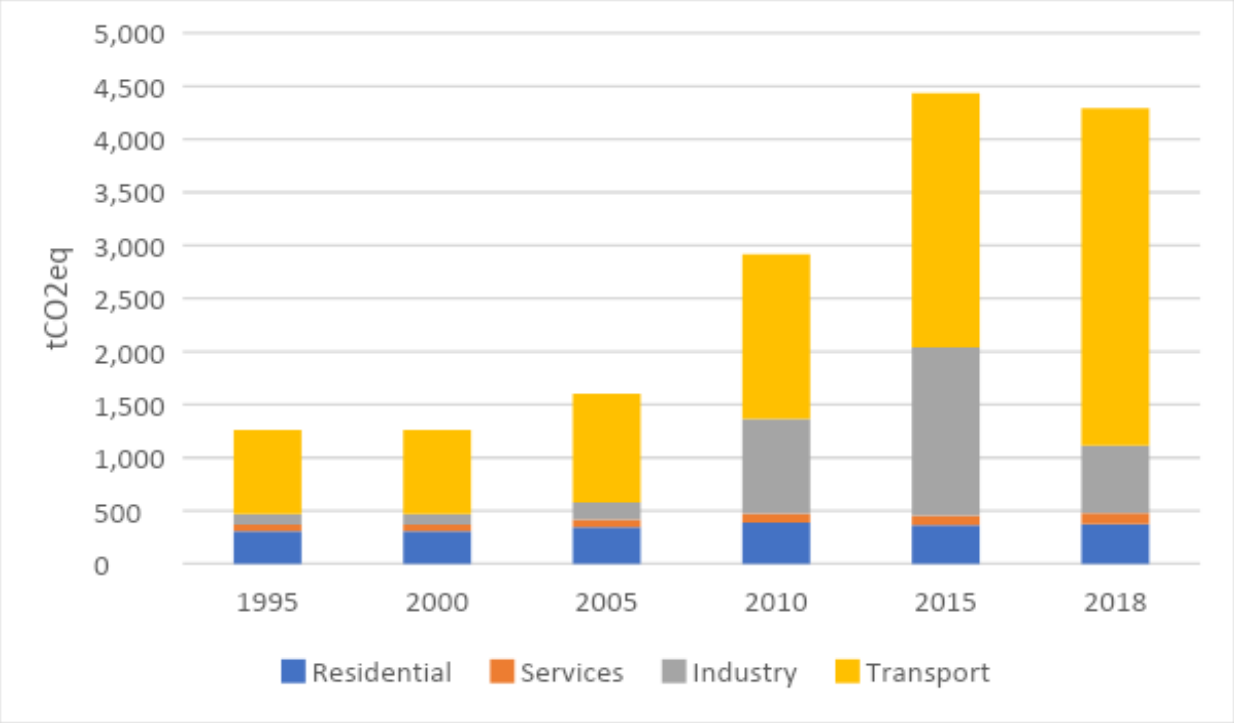

Figure 2-5: Historical GHG Emissions by Sector (1995-2018)
Source: MoEM (2018)

3. METHODOLOGY

3.1 LEAP Model

The Low Emission Analysis Pathways (LEAP) model is a software tool designed to assist countries and regions in developing integrated greenhouse gas (GHG) emissions inventory and mitigation assessment, developed by the Stockholm Environment Institute (SEI) (Heaps, 2022). LEAP is often used in the context of sustainable development and climate action planning. LEAP builds a comprehensive and detailed picture of energy use, emissions, and the impact of various policies and measures on those emissions. It can model a wide range of sectors, including energy, industry, agriculture, waste, and more. The model enables the analysis of different scenarios, and analysts assess the potential outcomes of different strategies for reducing GHG emissions[3].

3.2 Scope

The research is centered on the energy sector, encompassing both the supply side (particularly the power sector) and the demand side, which includes the residential, commercial, industrial, and transportation sectors.

The temporal scope of Laos' historical data extends from the year 2000 to 2018, with the initial scenario year commencing in 2019. The study concludes in the year 2060.

Data for this study is sourced from official reports and documents from the government of Laos. Additionally, it is also extracted from reports and online databases provided by international organizations, including the World Bank, International Energy Agency, World Health Organization, etc.

[3] The studies using LEAP model (Emodi et al., 2017; Nieves et al., 2019; Shin et al., 2005; Hong et al., 2016; Huang et al., 2011; Amoo-Aidoo et al., 2022; McPherson & Karney, 2014; Cai et al., 2023)

3.3 Key Drivers for the Energy Demand Projections

In the future scenarios, gross domestic product (GDP), population, electricity access, appliance ownership, energy intensity, and sectoral value-added are the key drivers for electricity demand projection.

- **GDP:** The 2nd Shared Socioeconomic Pathway scenario (SSP2) is a key driver for energy demand. In SSP2, the GPD is projected to increase from 51.18 billion $PPP in 2018 to 288.40 billion $PPP in 2060, with an annual growth rate of approximately 4.22% (World Bank, 2021).

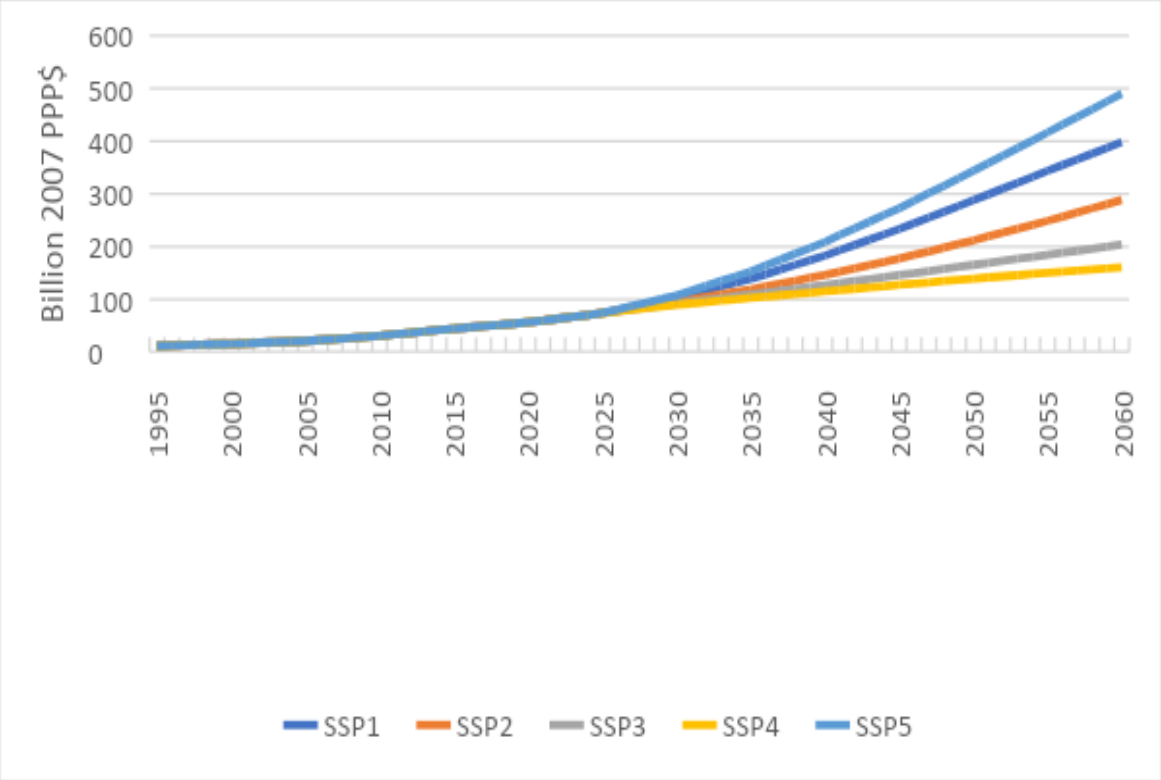

Figure 2-6: GDP Projections

- **Population:** The Medium scenario of projected population is selected to be a key driver for energy demand. In the Medium, the population is estimated to increase from 7.05 million people in 2018 to 10.60 million people in 2060, with an annual growth rate of approximately 0.89% (United Nation, 2019).

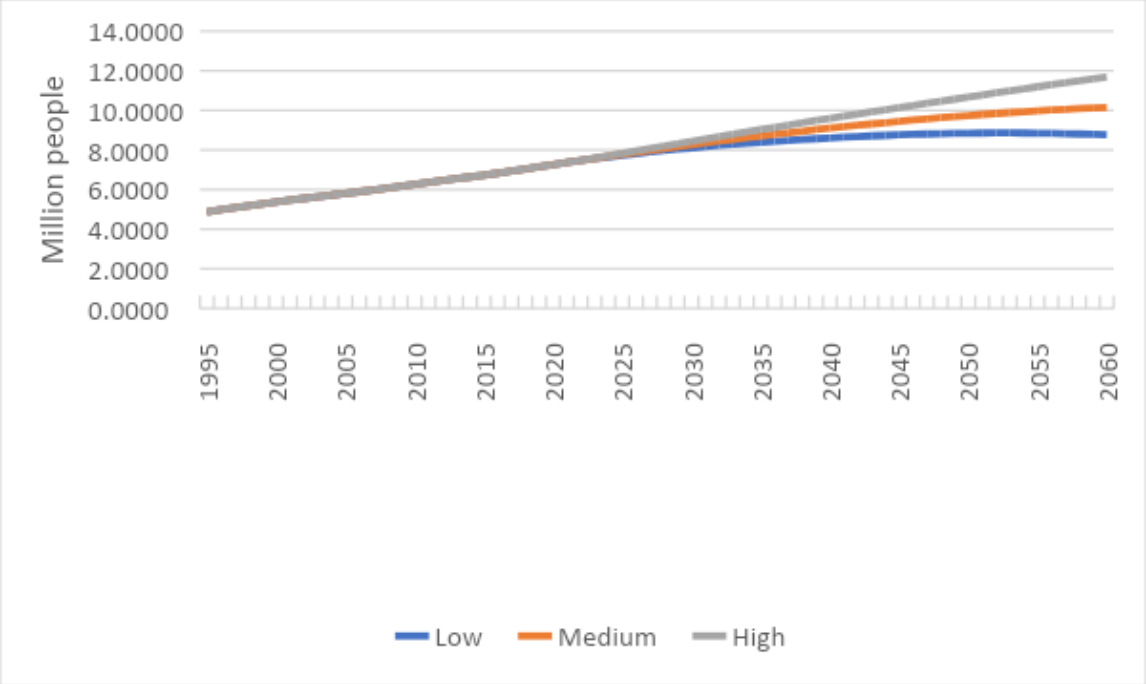

Figure 2-7: Population Projections

- **Household electrification:** according to the World Bank (2023), the residential sector of Lao PDR achieved 95% electrification in 2020.

- **Appliance ownership:** refers to the ownership of appliances in the residential sector and the number of vehicle registrations.

- **Energy intensity:** refers to the energy consumption per unit of economic output (GDP). In the energy demand sectors, historical energy intensity is used to forecast.

- **Sectoral value-added:** refers to the GDP contribution to the country from different economic sectors. This information is accessible through the world development indicator (World Bank, 2021).

3.4 Key Assumption for the Future Scenario Projections

This study separates the future scenario into two scenarios, namely the existing policy scenario and the more ambitious policy scenario. The existing policy scenario includes the current policies or plans that the government has set as targets to be achieved. Meanwhile, the more ambitious policy scenario is the developed version of the existing policy scenario, aiming for higher targets. The key assumptions of both scenarios are summarized below:

Table 3-2: Key Assumptions in the Existing Policy and More Ambitious Policy scenarios

Sector	Existing Policy	More Ambitious Policy
Power generation	• Power generation from coal is targeted to increase 7.6%. • Power generation from coal is targeted to increase 5.4%.	• Electricity generation from solar energy is targeted to replace 50% of electricity generation from coal.
Resident	• Urban and rural households follow the historical trend. • For urban household: ➢ All urban households are targeted to use refrigerators in 2030. ➢ 70% of air condition in 2060. ➢ 70% of electricity is used for cooking in 2060. • For rural household: ➢ All rural households are targeted to use refrigerators in 2060. ➢ 30% of air condition in 2060. ➢ 35% of electricity is used for cooking in 2060.	• For Urban household: ➢ 95% of air condition in 2060. ➢ 88% of electricity will be used for cooking in 2060. • For rural household: ➢ 60% of air condition in 2060. ➢ 57% of electricity is used for cooking in 2060.
Transport	• 20% of electric cars in 2030, and 50% in 2060. • 20% of electric motorbike in 2030, and 50% in 2060. • 100% of electric rail for passenger in 2030. • 30% and 70% of electric rail for freight in 2030 and 2060, respectively.	• 20% of electric carsvin 2030, and 70% in 2060. • 30% of electric motorbike in 2030, and 70% in 2060. • 100% of electric rail for passenger in 2030. • 30% and 95% of electric rail for freight in 2030 and 2060, respectively.

Source: GoL (2021) and authors

4. RESULTS OF EXISTING POLICY SCENARIO

4.1 Final Energy Consumption

The results of the Existing Policy scenario for Lao PDR, as depicted in Figure 4-1, show that between 2018 and 2060, there are notable changes in energy consumption across sectors, with a focus on the total final energy consumption.

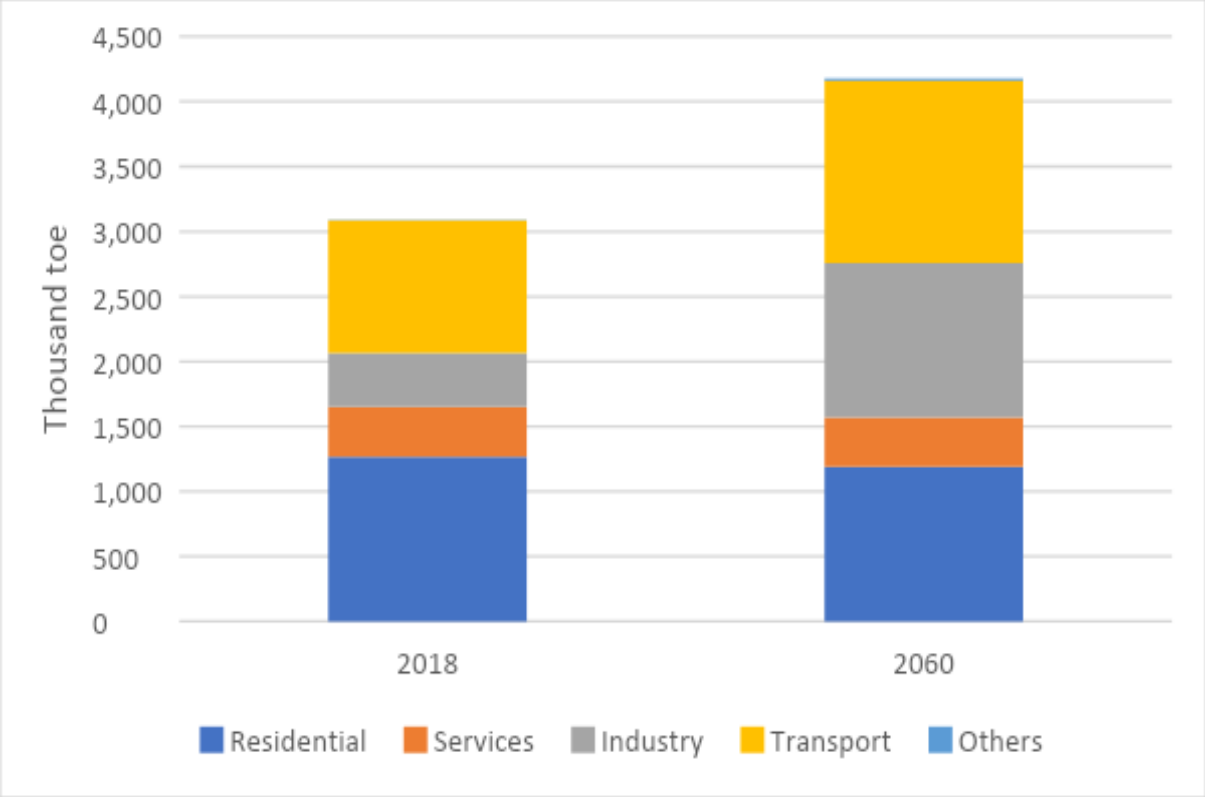

Figure 4-1: Final Energy Consumption by Sector

In 2018, the total final energy consumption was 3,091 thousand toe. The residential sector consumed the highest amount at 1,269 thousand toe, accounting 41.05% of the total. By 2060, the total final energy consumption increased to 4,177 thousand toe. Residential sector decreased to 1,191 thousand toe, comprising 28.54% of the total, indicative of potential improvements in residential energy efficiency. The services sector also experienced a decline from 381 thousand toe (12.33%) in 2018 to 378 thousand toe (9.05%) in 2060, reflecting advancements in energy efficiency within service-related activities. In contrast, the industrial sector's energy consumption surged from 417 thousand toe (13.50%) in 2018 to 1,188 thousand toe (28.44%) in 2060, signaling substantial growth in energy demand for industrial processes and manufacturing. The transport sector remained crucial, with energy consumption increasing slightly from 1,019 thousand toe (32.99%) in 2018 to 1,404 thousand toe (33.67%) in 2060. This comparison underscores a dynamic shift in energy consumption, emphasizing potential efficiency gains in residential and services sectors, a considerable increase in industrial energy demand, and an overall growth in total final energy consumption by 2060.

In 2018, the energy consumption by fuel type varied, with dominant contributors being wood (1,285 thousand toe), constituting 41.60% of the total, and diesel (867 thousand toe), contributing 28.03%. Electricity consumption was 462 thousand toe, accounting for 14.95% of the total. By 2060, a significant shift occurred. Electricity consumption increased substantially to 1,639 thousand toe, constituting 38.66% of the total. Diesel usage declines to 957 thousand toe (22.67%). While gasoline and wood consumption decline, anthracite, charcoal and other sources show a slight increase. This shift reflects a move towards more diverse and cleaner energy sources, with electricity playing a prominent role, possibly indicating advancements in renewable energy technologies and a move away from traditional fossil fuels (see Figure 4-2).

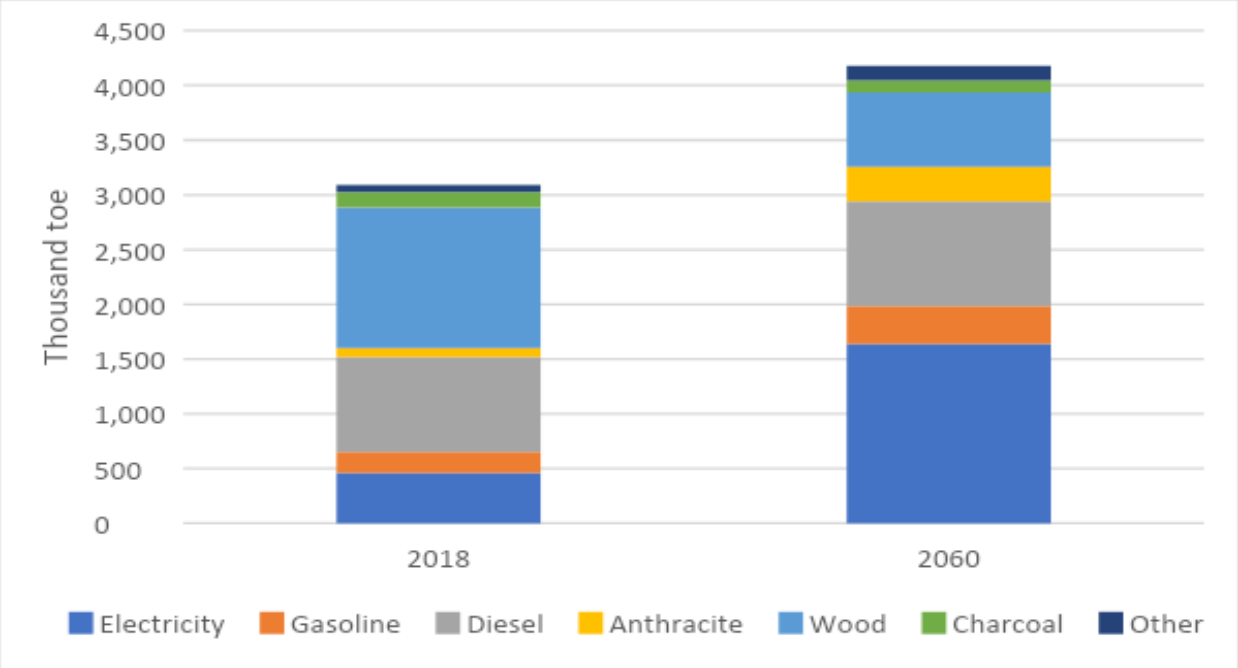

Figure 4-2: Final Energy Consumption by Fuel

4.2 Electricity Generation

The electricity generation landscape in Laos undergoes a substantial transformation from 2018 to the projected values in 2060 (see Figure 4-3). The total electricity generation is anticipated to surge from 26.13 TWh in 2018 to 251.90 TWh in 2060. Hydropower, the leading contributor, experiences remarkable growth, surging from 22.33 TWh in 2018 to 170.52 TWh in 2060. Coal emerges prominently, witnessing a substantial rise from 3.74 TWh to 81.04 TWh, while biomass and solar power make a modest contribution. This transformation underscores a shift towards coal and hydropower dominance, with coal standing out as a prominent and rapidly expanding sector in Laos' evolving energy mix. This shift necessitates a nuanced consideration of environmental and sustainability implications.

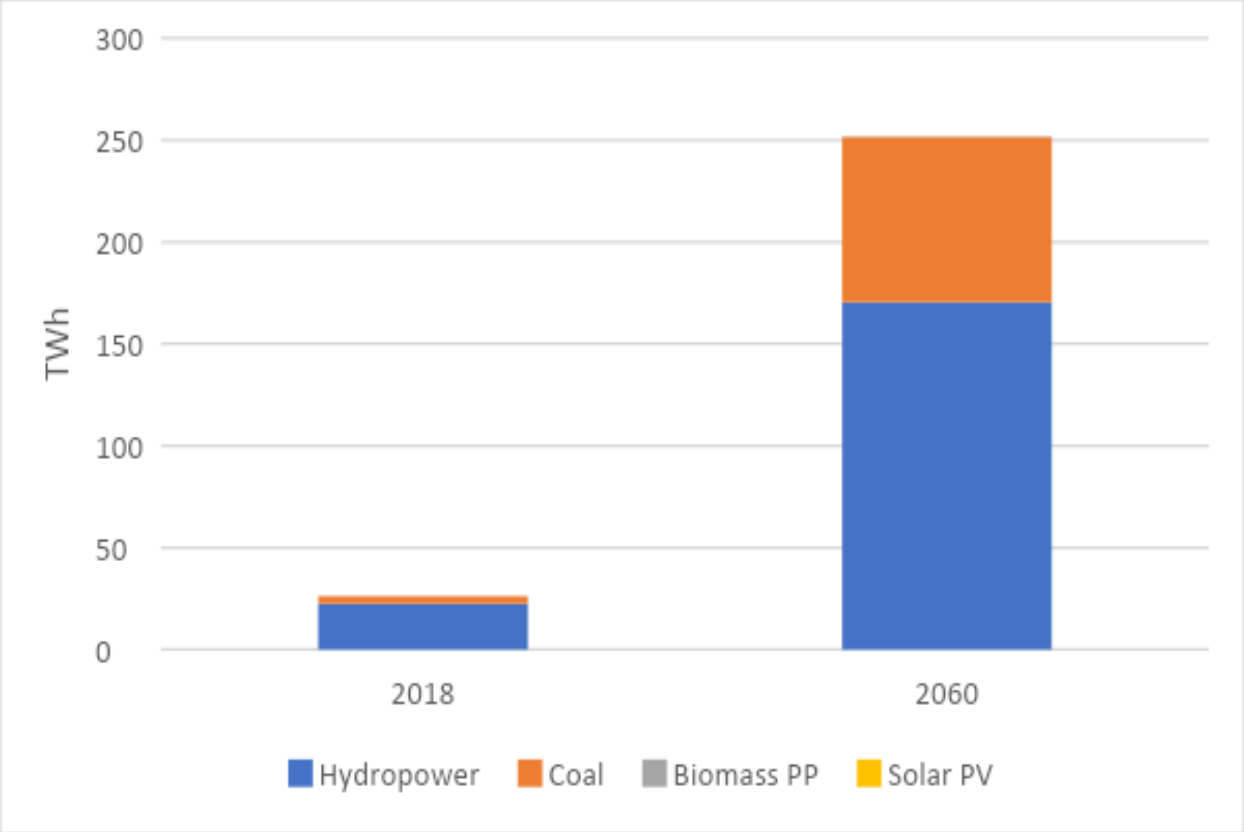

Figure 4-3: Electricity Generation by Fuel

4.3 GHG Emissions

Figure 4-4 depicts greenhouse gas (GHG) emissions data in 2018 and forecasted values for 2060, providing insights into the evolving emissions landscapes across various sectors. In both years, the highest-emitting sector in terms of greenhouse gas (GHG) emissions is the transport sector. In 2018, it accounted for 73.95% of the total emissions (3,179.77 thousand tCO2eq), and in 2060, it remained the dominant contributor at 69.01% (4,094.65 thousand tCO2eq). The transportation sector's sustained prominence underscores its significant impact on overall emissions, emphasizing the need for targeted strategies such as transitioning to cleaner fuels, promoting public transportation, and advancing sustainable mobility solutions to effectively address and mitigate climate change.
In 2018, the total GHG emissions is projected to be 4,295.05 k tCO2eq, with the residential sector contributing 8.65%, services at 2.51%, industry at 14.77%, and transport at 73.95%. Comparing this to 2060, the total GHG emissions increased to 5,934.86 k tCO2eq. Residential emissions decreased to 3.89%, services to 1.54%, industry increased to 25.54%, and transport decreased to 69.01%.

The ratio to total GHG emissions provides insight into the relative contribution of each sector to the overall emissions profile. It emphasizes the dominance of the transport sector in both years, highlighting its substantial role in the total emissions. The increase in industrial emissions underscores potential challenges in decarbonizing this sector. While the residential sector reduces its relative contribution, the transport and industry sectors' higher ratios indicate the necessity of targeted mitigation strategies in these areas to effectively address the overall increase in emissions by 2060.

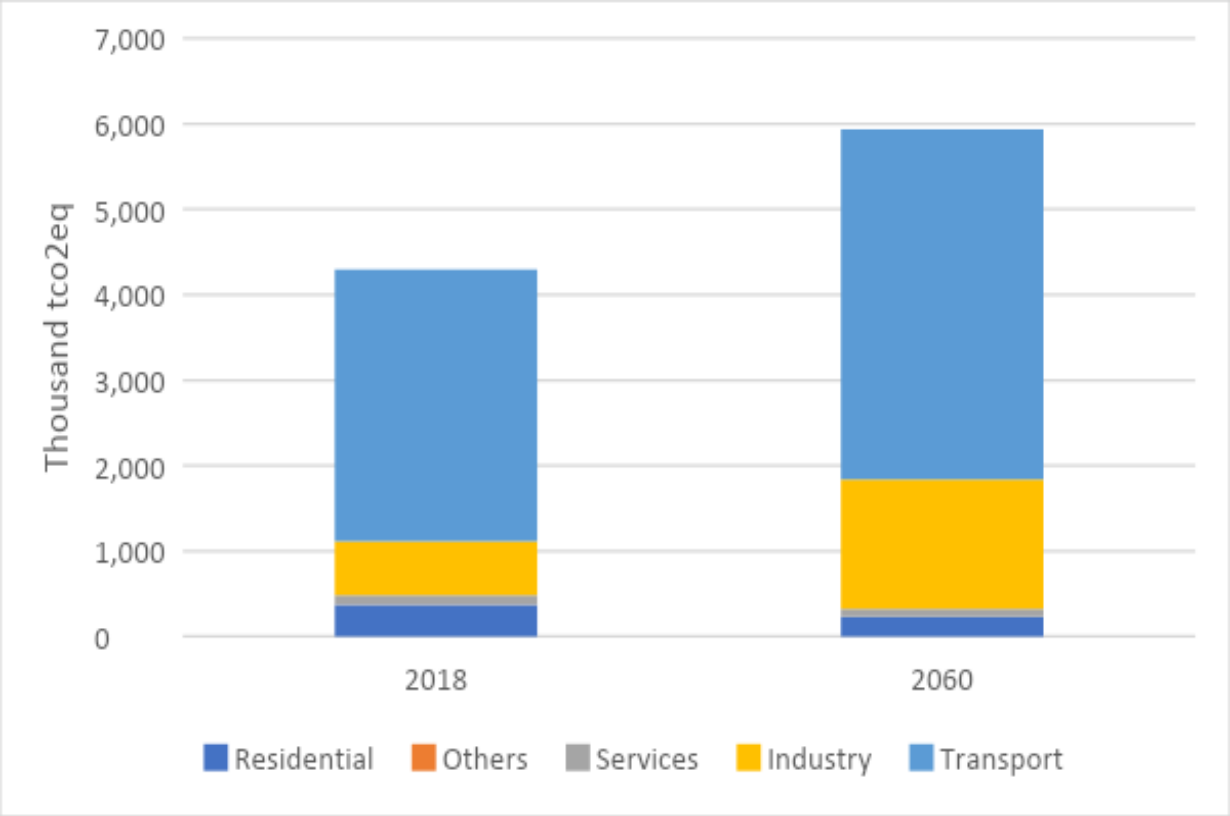

Figure 4-4: GHG Emission by Sector

5. RESULTS OF MORE AMBITIOUS POLICY SCENARIO

5.1 Final Energy Consumption

Looking at the change from the Existing Policy Scenario to the More Ambitious Scenario in 2060 (see Figure 5-1), we see clear differences in how much energy is used in different areas. There is a noticeable drop in energy use, from 1,191 thousand toe to 1,021.54 thousand toe in the More Ambitious Scenario. This is about a 14.2% reduction, suggesting a focus on using energy more efficiently and switching to cleaner and renewable sources.

The transport sector stands out with a sharp decrease from 1,404 thousand toe to 844.82 thousand toe, which is a significant 40% drop. This suggests a move towards more energy-efficient vehicles and better public transportation.

In summary, the shift from the Existing Policy Scenario to the More Ambitious Scenario indicates a deliberate move towards using less energy and doing so more sustainably. The changes in energy use patterns suggest a focus on cleaner technologies, being more efficient with energy, and reducing reliance on conventional high-emission sources.

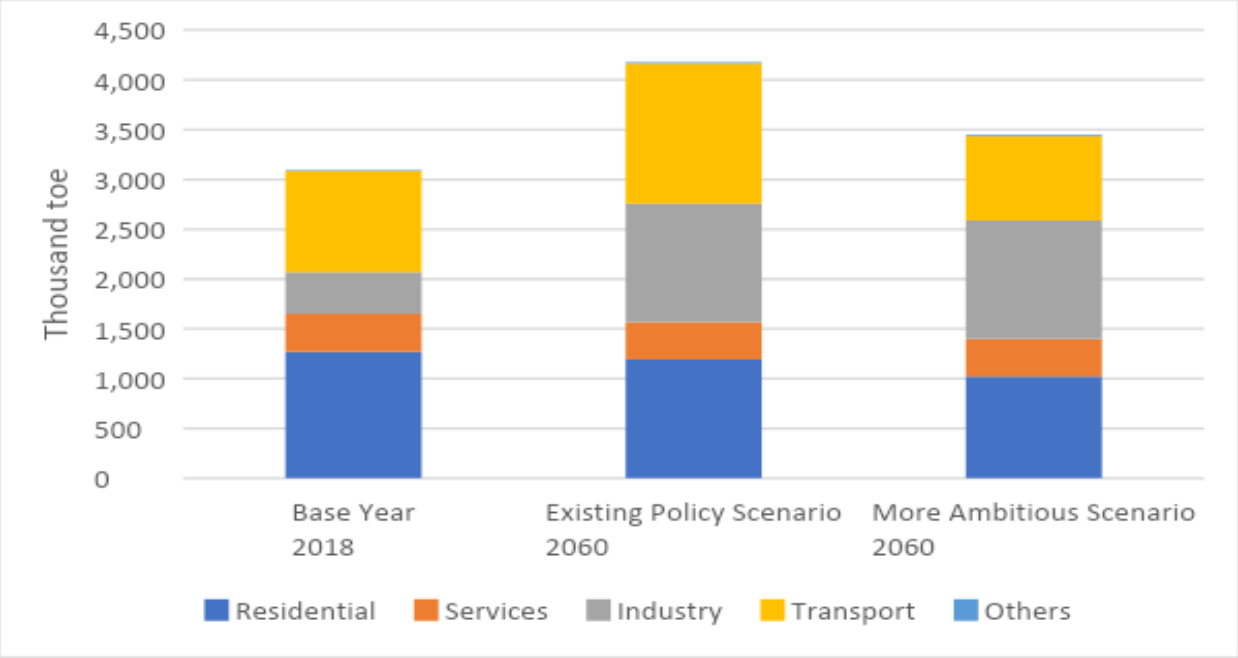

Figure 5-1: Final Energy Consumption by Sector

In the existing policy scenario, energy consumption rises to 4,177 thousand toe. There is a substantial uptick in electricity usage, and both gasoline and diesel also see an increase. Conversely, in the more ambitious scenario, total energy consumption decreases to 3,447.70 thousand toe. This reduction is primarily attributed to a significant surge in electricity consumption. Remarkably, there is a decline in the use of gasoline and diesel. In sum, the more ambitious scenario envisions a future with a considerable reliance on electricity and cleaner energy alternatives, moving away from conventional fuels (see Figure 5-2).

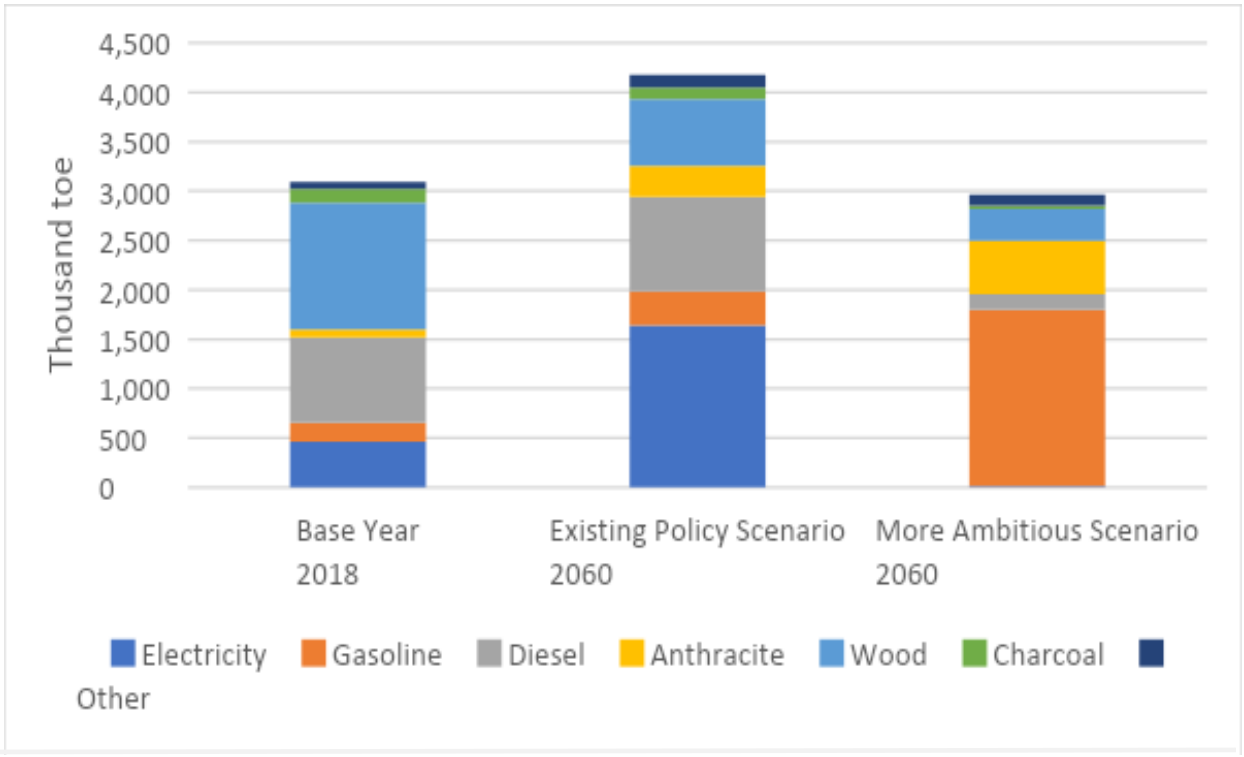

Figure 5-2: Final Energy Consumption by Fuel

5.2 Electricity Generation

Figure 5-3 shows projected electricity generation in the more ambitious scenario, the total electricity generation is projected to slightly increase compared to the existing policy scenario. hydropower maintains its dominant position, remaining constant at 170.52 TWh. Notably, the most significant change occurs in the coal sector, where electricity generation decreases from 81.04 TWh in the existing policy scenario to 41.03 TWh in the more ambitious scenario, marking a substantial 49.4% reduction. This reduction aligns with global trends emphasizing a transition away from coal due to environmental considerations. Simultaneously, solar PV observes remarkable upturn, increasing to 41.05 TWh in the more ambitious scenario, indicating a concerted effort to incorporate renewable energy sources. In sum, the more ambitious scenario stands out for its notable reductions in coal and the simultaneous increase in solar PV, reflecting a commitment to a more sustainable and diverse energy future in Laos.

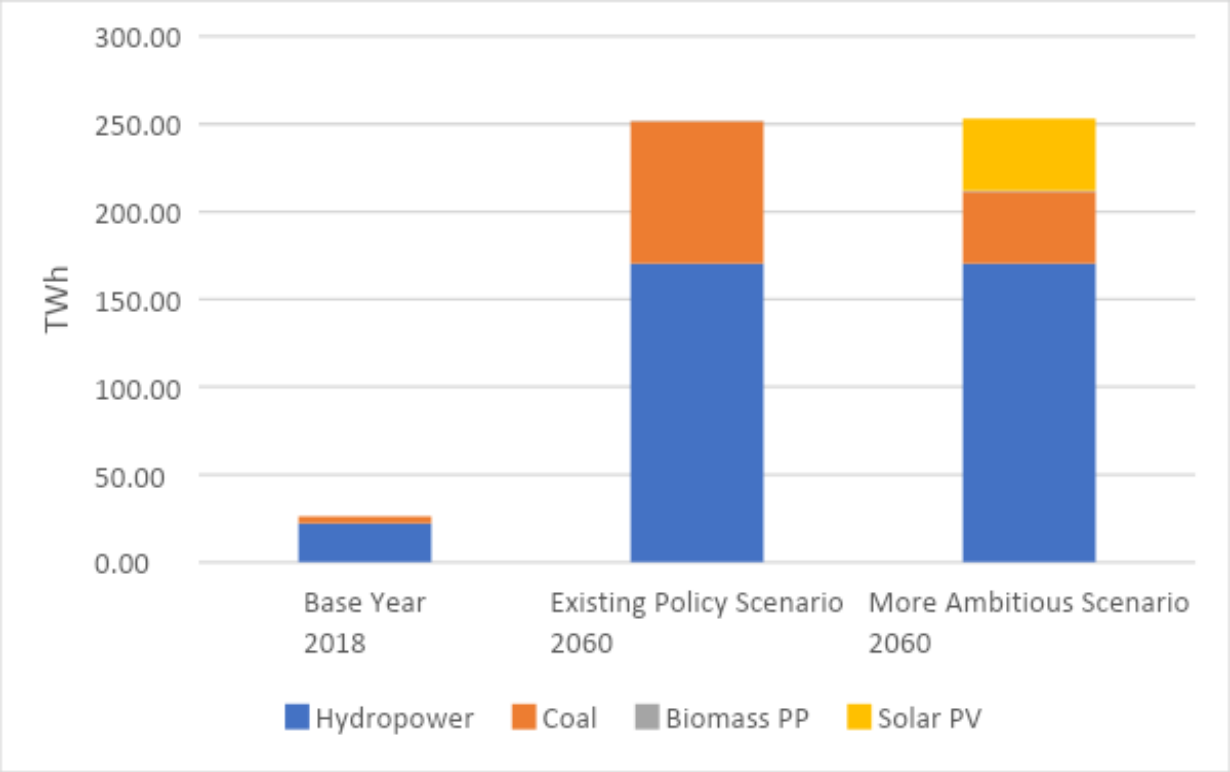

Figure 5-3: Electricity Generation by Fuel

5.3 GHG Emissions

Examining the transition from the Existing Policy Scenario (2060) to the More Ambitious Scenario (2060) offers valuable insights into the potential impact of heightened environmental measures on greenhouse gas (GHG) emissions (see Figure 5-4). Under the Existing Policy Scenario in 2060, the total GHG emissions amount to 5,935 thousand tCO2eq. Notably, the industrial and transport sectors play significant roles, contributing 1,517 thousand tCO2eq and 4,095 thousand tCO2eq, respectively.

In contrast, the More Ambitious Scenario for 2060 displays a noteworthy reduction in total emissions, amounting to 3,977 thousand tCO2eq, reducing approximately 33% compared to the Existing Policy Scenario. This scenario particularly stands out in the residential and transport sectors, where emissions decrease from 231 thousand tCO2eq to 143 thousand tCO2eq and from 4,095 thousand tCO2eq to 2,225 thousand tCO2eq, respectively. The residential sector witnesses a reduction of around 38%, while the transport sector sees a substantial decrease of about 46%. The pronounced reductions in these sectors underscore the effectiveness of more ambitious policies in curbing emissions. In summary, the transition from the Existing Policy Scenario to the More Ambitious Scenario in 2060 reveals a substantial reduction in overall GHG emissions, with the residential and transport sectors playing pivotal roles.

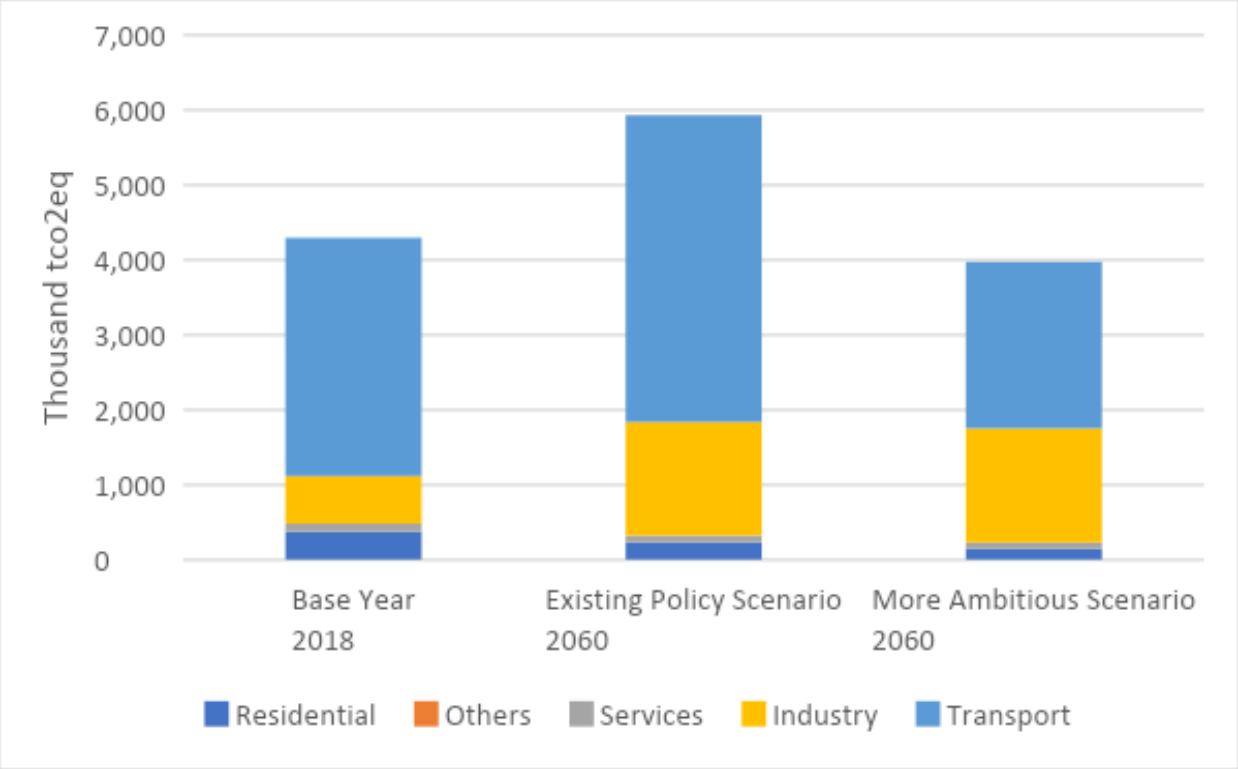

Figure 5-4: GHG Emission by Sector

6. CONCLUSION

This study utilized the LEAP model to simulate long-term energy strategy scenarios to achieve net-zero emissions by 2050 in Laos. Having followed the results in both the Existing Policy and More Ambitious Scenarios, it is evident that Lao PDR will not meet the net-zero GHG emissions target by 2060. Thus, the country should enhance its national strategies, particularly in the transport and industry sectors. This is because these sectors contribute the most GHG emissions in the country. Furthermore, there are also some recommendations related to the emission sector, as indicated in the table below:

Table 6-1: Recommendations to Reach Net Zero Emission by 2060

Sector	Recommendations
Residential	- Increase in electric cooking devices in both urban and rural areas. - Increase the utilization of the most efficient technologies for electricity devices (refrigeration, air conditioning, etc.) - Improve the energy efficiency and saving
Industrial	- Increase share of RE - Phase out coal - Improve the energy efficiency and saving
Transport	- Promote Electric Vehicle - Promote public transportation mode (electric train, electric bus, etc.) - Improve infrastructure to facilitate transportation (road, etc.) - Improve the energy efficiency
Power generation	- Smart grid technology development could reduce the T&D losses in the power system - Increase the utilization of RE (solar, wind, and hydro) in power generation - Phase out coal-fired power plants - Improve the energy efficiency

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