Impact of transport sector electrification on the Laotian power system

AUTHORS: Latsayakone Pholsena[1], Khamphone Nanthavong [2], Sounthisack Phommachanh[3], Vignesh Sridharan [4*]

This policy brief is part of a series developed by Laotian analysts during an OSeMOSYS (an open source modelling tool) modelling workshop in Vientiane, Lao PDR, in October 2024. There are four policy briefs in total, each addressing a question pertinent to the expansion of the Laotian electricity sector. This brief, first in the series, focuses on the impacts of increasing electric vehicle penetration on the Laotian Power system. The second brief highlights concerns related to energy security in the country during the dry season. The third explores the impact of ending of the concessionary power agreements in Laos and its impact on the power system. The fourth brief focuses on a Laotian future with no new investments in coal power plants. The briefs are based on analyses developed using an OSeMOSYS model of the Laotian Power sector co-created by Laotian analysts and CCG researchers.

Summary

Lao PDR (Laos) is transforming its energy and transport sectors through clean energy policies and promoting electric vehicles (EVs). In 2023, the country's electricity landscape features a generation mix dominated by hydropower and significant cross-border energy exchanges. The emerging EV ecosystem signals a critical infrastructure transition. Our analysis reveals that EV adoption could increase electricity demand by ~2.2 times by 2055, potentially straining the current system. However, this shift offers substantial benefits, including reduced fossil fuel dependence, potential fuel import savings that can compensate for electricity imports, and lower carbon emissions. To address Laos' energy transition challenges, policymakers should focus on improving regional transmission capacity and developing strategic EV adoption plans.

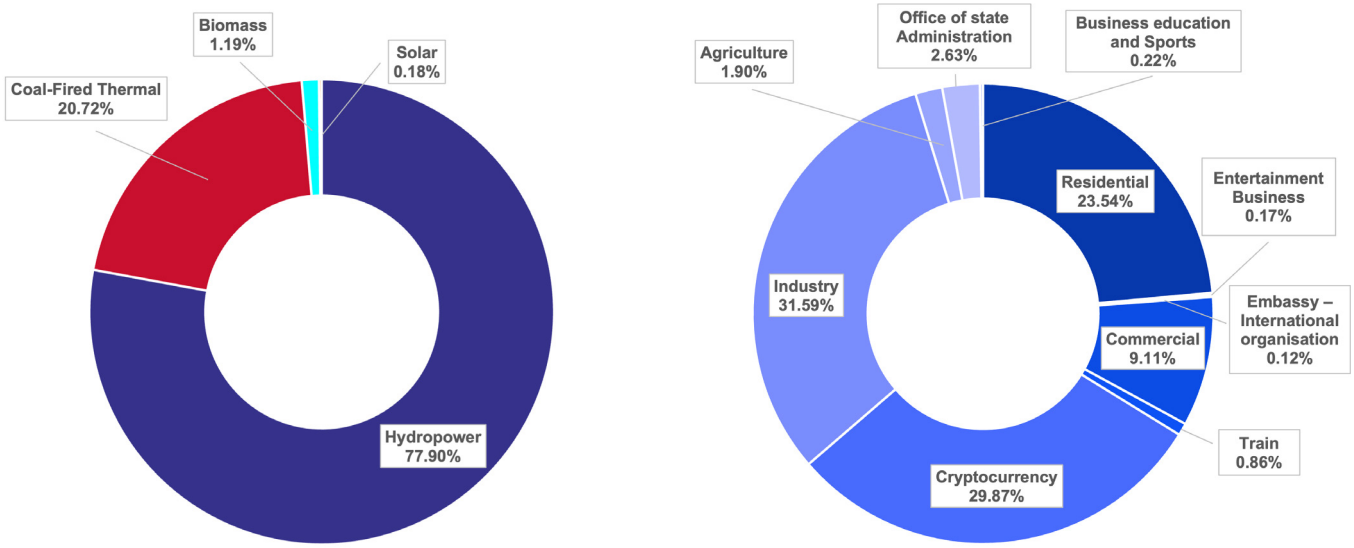
Key Messages

- Laos must strategically invest in transmission infrastructure to support the growing electric vehicle ecosystem.
- Electric vehicle adoption will significantly increase electricity demand across regional power networks.
- Strategic planning can transform potential energy challenges into sustainable economic development opportunities.

Introduction and context

The energy and transport sectors are pivotal in driving economic development in Lao PDR (Laos). Laotian clean energy policies and electric vehicle (EV) promotion present a significant strategic shift in national infrastructure planning. These developments are fundamentally reshaping the country's approach to energy consumption, transport, and environmental sustainability. As of 2023, Laos' electricity landscape presents a complex picture of production, consumption, and cross-border energy exchanges. **Figure 1** some of this complexity, along with details of sources of supply and demand by end-use type for the year 2023.

***Figure 1:** Electricity generation by technology type (left), Domestic electricity consumption by user type (right) in 2023*



With a hydropower dominant generation mix, the total electricity demand reached 11,583 GWh, representing 23.78% of the country's electricity production [1]. Notably, electricity import and export volumes were substantial, with 1,765 GWh imported and 37,538 GWh exported, indicating the country's significant role in regional energy markets. Laos' current EV ecosystem comprises 4,631 vehicles, comprising 2,592 light-duty trucks and 2,039 two-wheeled vehicles. By 2040, the Association of Southeast Asian Nations (ASEAN) region is expected to account for 56% of all global EV sales. This emerging EV market represents a critical transition point in the nation's transport and energy infrastructure, signalling potential transformations in electricity demand patterns and consumption strategies. The intersection of EV adoption, electricity demand, and national energy infrastructure presents a nuanced challenge for Laos. The increasing penetration of EVs introduces new dynamics to the country's energy framework, warranting a more comprehensive understanding of its impacts.

This policy brief explores the relationships between transport electrification and local electricity demand in Laos. This analysis provides insights into the interactions driving the country's energy transition.

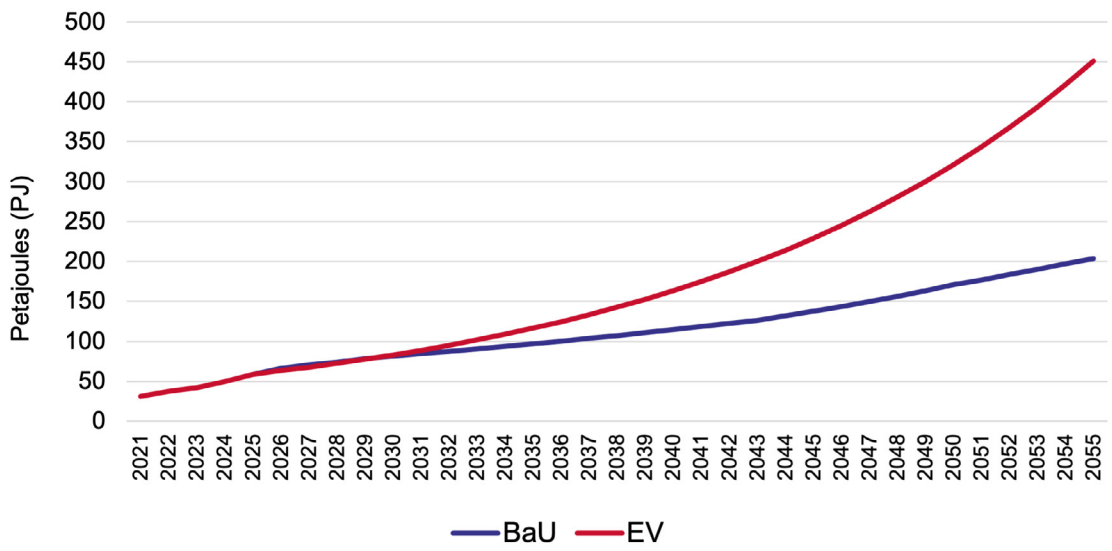
Methods

A comprehensive Energy System Optimisation Model (ESOM) for Laos' power sector (Lao-PSM) was developed using OSeMOSYS [2]. This framework was chosen for its flexibility, open-source nature, and proven track record in informing policy decisions across various temporal and spatial scales [3–6]. Lao-PSM is structured as a multi-regional power sector model with three distinct regions. The model operates on a temporal resolution of eight time steps, incorporating wet and dry seasons and four daily time divisions to capture demand and variable renewable energy (VRE) generation patterns. The model's horizon extends from 2021 to 2055, integrating the expansion plan from the latest edition of the National Power Development Plan (NPDP) [7]. The model is set up to easily incorporate sensitivities in electricity demand, which is required for this analysis. For this analysis, two scenarios were developed. The first is a Business-as-usual scenario (**BaU**) where the electricity demand projections are based on the National Power Development Plan (NPDP), which accounts for population growth, economic development, and current energy consumption patterns. The Electric Vehicle (EV) scenario incorporates an additional 10% annual increase in EV adoption. This is expected to result in ~7% average annual increase in the total electricity demand. The BaU case is expected to experience a ~5.5% average annual increase. The model accounts for the increased energy requirements of the growing EV fleet, which can significantly impact the overall electricity demand of the transport sector. The latest Graphical User Interface developed for OSeMOSYS was used to build Lao-PSM.

Findings and analysis

Figure 2 illustrates the difference in total electricity demand between the BaU and the EV scenarios. By 2055, the EV scenario is expected to experience ~2.2 times the demand in the BaU scenario. This is expected to affect different sections of the Laotian power sector.

***Figure 2:** Final Laotian electricity demand in the BaU and EV scenarios (in Petajoules)*



Our results indicate that the increase in demand, if unplanned, will result in increased electricity imports in the latter half of the modelling period and a loss of revenue from reduced exports. **Figure 3** illustrates the increase and decrease in imports and exports over the modelling period. In the BaU scenario, due to the increase in local demand, the imports are expected to increase gradually over the 2030s but rapidly after 2050, as there is not enough capacity in the local grid. These are predominantly imports during the dry season between November and April. With no certainty on the electricity import price and with precedence of import price shocks in Laos [8–9], this situation could seriously hamper the country's energy security. We can also notice that with the increasing demand, the excess generation, previously channelled to exports and contributing to fiscal revenue for Laos, will reduce gradually in the 2030s.

Figure 3: *Projected electricity imports (top) and electricity exports (bottom) for the BaU and EV scenarios*

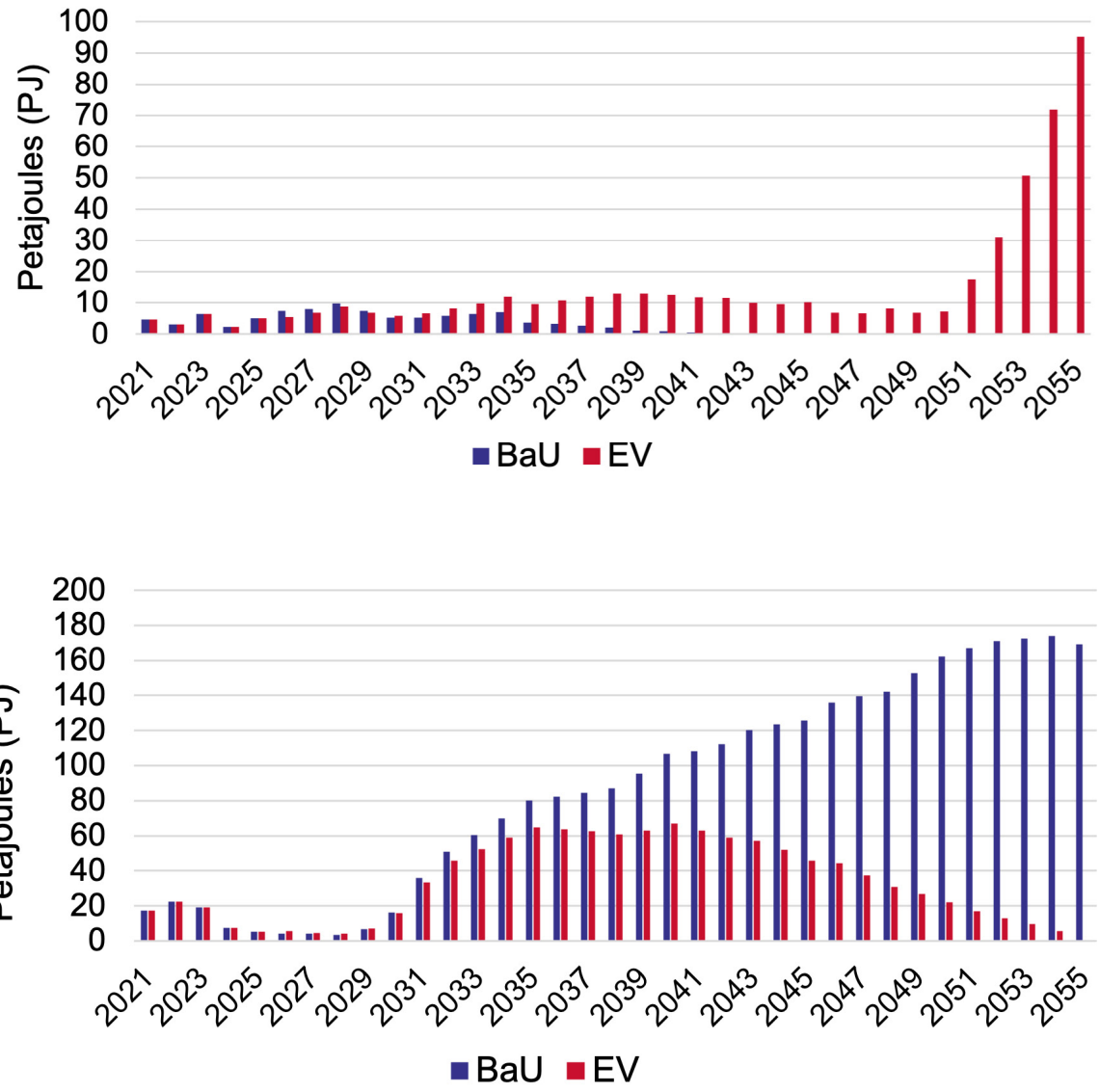
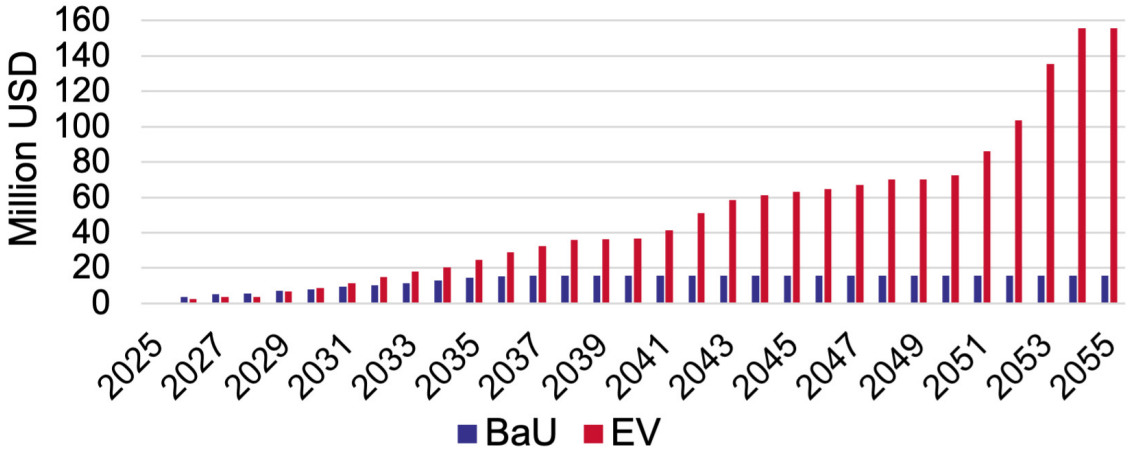


Figure 4: *Projected inter-regional investment in transmission lines (Million USD)*



Laos' power generation infrastructure is geographically distributed across three distinct regions (Southern, Central, and Northern), with the current inter-regional transmission capacity presenting a significant constraint to system optimisation. An analysis of the projected electricity demand growth indicates a critical need for enhanced inter-regional transmission infrastructure. As illustrated in **Figure 4**, the required transmission capacity expansion represents an additional capital investment of USD 1.5 billion (2021 prices) beyond the BaU scenario. Approximately 90% of this investment is to strengthen the transmission grid between the Southern and Central regions and the rest to improve the connections between the Northern and Central regions. The Southern region has a high concentration of future expansion capacity, and the demand centres are in the Central region. These investments are essential to enabling efficient power distribution, maintaining system reliability, and optimising the use of generation assets across all three regions. Significant investments are also required for last-mile distribution costs and charging infrastructure. However, those are outside the scope of this analysis.

EV charging points in Laos

Despite substantial investment requirements, Laos stands to gain significantly from transitioning to EVs. The country currently imports all its transport sector fossil fuel needs, with total import costs reaching 1.5 billion USD, annually, in 2022. This figure is projected to escalate in the coming decades. Electrifying public and private vehicle fleets offers multiple benefits, including reduced fossil fuel dependence, with potential cumulative import avoidance of US$2.3 billion during 2020–2030. Additionally, the environmental benefits are substantial, considering Laos emitted 3.4 million tCO2e in 2022 [1]. By systematically electrifying its vehicle infrastructure, Laos can effectively mitigate fossil fuel import price volatilities while promoting sustainable economic development and environmental conservation.

Conclusion

Laos is at a critical juncture in its energy and transport sectors, with a growing focus on electric vehicles (EVs) and renewable energy. The country's hydropower dominated electricity generation presents both opportunities and challenges. While EV adoption offers significant economic and environmental benefits, including reduced fossil fuel dependence and lower emissions, it also necessitates substantial investments in infrastructure. The projected increase in electricity demand due to EV growth could strain the current system, potentially leading to increased imports and reduced exports. However, with strategic planning and investment in transmission capacity and regional interconnections, Laos can leverage its renewable energy potential to support sustainable economic development and position itself as a key player in the regional energy market.

Policy Recommendations

a) **Improve Regional Transmission Capacity:** The generation capacity in Laos is spread across three regions with limited interconnections. This analysis suggests strengthening the domestic inter-regional transmission capacity to use domestic power generation sources in an efficient manner.

b) **Develop Strategic EV Adoption Planning:** The analysis shows a significant difference in electricity demand between Business-as-Usual and Electric Vehicle (EV) scenarios, with the EV scenario experiencing ~2.2 times the demand by 2055. This necessitates a comprehensive strategy for managing increasing electricity demand from EV adoption.

c) **Mitigate Electricity Import Risks:** The findings indicate potential increased electricity imports in the latter half of the modelling period, particularly during dry seasons. Future policies should focus on developing strategies to manage these import risks and potential price volatilities to maintain energy security.

Traffic around the Victory Gate in Vientiane

ISTOCKPHOTO

References

[1] 'Energy Security White Paper: Policy Direction for Inclusive and Sustainable Development for Lao PDR', Han Phoumin and Anousak Phongsavath (eds.), Economic Research Institute for ASEAN and East Asia, White Paper, Sep. 2024. Accessed: Dec. 18, 2024. [Online]. Available: https://www.eria.org/research/energy-security-white-paper--policy-direction-for-inclusive-and-sustainable-development-for-lao-pdr.

[2] M. Howells *et al*., 'OSeMOSYS: The Open Source Energy Modeling System', *Energy Policy*, vol. 39, no. 10, pp. 5850–5870, Oct. 2011, doi: 10.1016/j.enpol.2011.06.033.

[3] T. Barnes, A. Shivakumar, M. Brinkerink, and T. Niet, 'OSeMOSYS Global, an open-source, open data global electricity system model generator'', *Sci. Data*, vol. 9, no. 1, p. 623, 2022, doi: 10.1038/s41597-022-01737-0.

[4] A. Millot *et al*., 'The map behind the roadmap—Introducing a geospatial energy model for utility-scale solar and wind power buildout in Kenya', *Cell Rep. Sustain*., vol. 1, no. 10, Oct. 2024, doi: 10.1016/j.crsus.2024.100222.

[5] N. Moksnes, A. Korkovelos, D. Mentis, and M. Howells, 'Electrification pathways for Kenya–linking spatial electrification analysis and medium to long term energy planning', *Environ. Res. Lett*., vol. 12, no. 9, p. 095008, 2017, doi: 10.1088/1748-9326/aa7e18.

[6] N. Moksnes, M. Howells, and W. Usher, 'Increasing spatial and temporal resolution in energy system optimisation model – The case of Kenya', *Energy Strategy Rev*., vol. 51, p. 101263, Jan. 2024, doi: 10.1016/j.esr.2023.101263.

[7] MEM, 'Lao PDR National Power Development Plan 2021-2030 (NPDP)', Ministry of Energy of Mines (MEM), Vientiane, Lao PDR, Power development plan, 2021.

[8] M. Yogo and K. Sudo, 'Chapter 3: A Resilient Power System and Power Market in Lao PDR', in 'Energy Security White Paper: Policy Direction for Inclusive and Sustainable Development for Lao PDR', Han Phoumin and Anousak Phongsavath (eds.), Economic Research Institute for ASEAN and East Asia, White Paper, Sep. 2024. Accessed: Dec. 18, 2024. [Online]. Available: https://www.eria.org/research/energy-security-white-paper--policy-direction-for-inclusive-and-sustainable-development-for-lao-pdr.

[9] Organisation for Economic Cooperation and Development (OECD), 'Multi-dimensional Review of Lao PDR: Financing Sustainable Development', OECD Development Pathways, 2024. [Online]. Available: https://doi.org/10.1787/756b6663-en.

Fossil fuel transport is a major contributor of emissions

ISTOCKPHOTO

DISCLAIMER STATEMENT

(CCG) programme. CCG is funded by UK aid from the UK government. However, the views expressed herein do not necessarily reflect the UK government's official policies or that of any governmental agencies in Lao PDR. The work presented in this policy brief is intended solely for academic research to support policy dialogues.

CRediT AUTHOR STATEMENT

[1] **Latsayakone Pholsena** (Department of Energy Efficiency and Promotion (DEEP), Ministry of Energy and Mines): Conceptualisation, Methodology, Model Development, Validation, Data curation, Writing – review and editing.

[2] **Khamphone Nanthavong** (National University of Laos): Writing – review and editing, supervision, Translation.

[3] **Sounthisack Phommachanh** (National University of Laos): Writing – review and editing, supervision, Translation.

[4] **Vignesh Sridharan** (Imperial College London): Methodology, Model Development, Writing – review and editing.

**Corresponding Author*

Vignesh Sridharan *(v.sridharan@imperial.ac.uk)*

RECOMMENDED CITATION

Pholsena, L., Nanthavong, K., Phommachanh, S., and Sridharan V., (2025). Impact of transport sector electrification on the Laotian power system. Climate Compatible Growth Programme Policy Brief Series. DOI:10.5281/zenodo.14722088

The views expressed in this material do not necessarily reflect the UK government's official policies.