Power Shift: Lao PDR's electricity sector in the wake of expiring concessionary agreements

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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, third in the series, explores the impact of the ending of concessionary power agreements in Laos and its impact on the power system. The first policy brief 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 fourth 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

As of 2022, Laos operated numerous power plants, primarily hydroelectric, with significant generation capacity. The government aims to strategically expand electricity export revenues over the next two decades, transforming the nation's energy export potential. By 2050, control of many hydropower plants under concessionary agreements will shift to the government, impacting the energy sector and the entire socio-economic landscape. An energy systems model was developed to analyse these changes. The analysis indicates a reduced reliance on imports and increased export potential. Strategic investments in transmission infrastructure and local industries, such as green hydrogen production, are essential for sustainable growth and energy self-sufficiency.

Key Messages

- Laos anticipates reduced reliance on electricity imports and increased exports to Association of Southeast Asian Nations (ASEAN) neighbours post the expiry of concessionary power agreements.
- Projected net export revenue could reach approximately 12 billion USD by 2055.
- Investment in transmission infrastructure is crucial in order to use surplus electricity effectively and support local industries like green hydrogen.

Introduction

As of 2022, Lao PDR (Laos) operates 94 power plants, including 81 hydroelectric facilities, with a total installed capacity exceeding 11.6 GW [1]. The government aims to increase generation capacity and expand electricity exports. In 2022, electricity exports generated over 2.3 billion USD in revenue, while imports cost slightly over 40 million USD. Through large-scale hydroelectric projects and strategic concession agreements, Laos has become a key energy producer in Southeast Asia, selling electricity to neighbouring countries [2]. Some of these plants are built with the help of foreign investment and follow a concessionary arrangement with a build-operate-transfer (BOT) setup, sometimes in tandem with a power-purchase-agreement (PPA). This model involves a private entity or other ASEAN countries constructing and operating the facility for a specified period before transferring ownership to the government.

Between 2029 and 2050, approximately 5,642 MW of hydropower plants are expected to finish their concessionary contracts, and the control will be transferred to the Laotian Government. This transfer is expected to impact the energy sector and have broader implications on the socio-economic landscape. These transitions may influence future investments, energy market structure, and export revenue stability. However, it is also crucial to evaluate if the supporting power infrastructure in Laos can handle the influx of excess generation capacity. Our analysis, utilising an open source energy systems model, examines the potential techno-economic implications of this transfer of control.

Methods

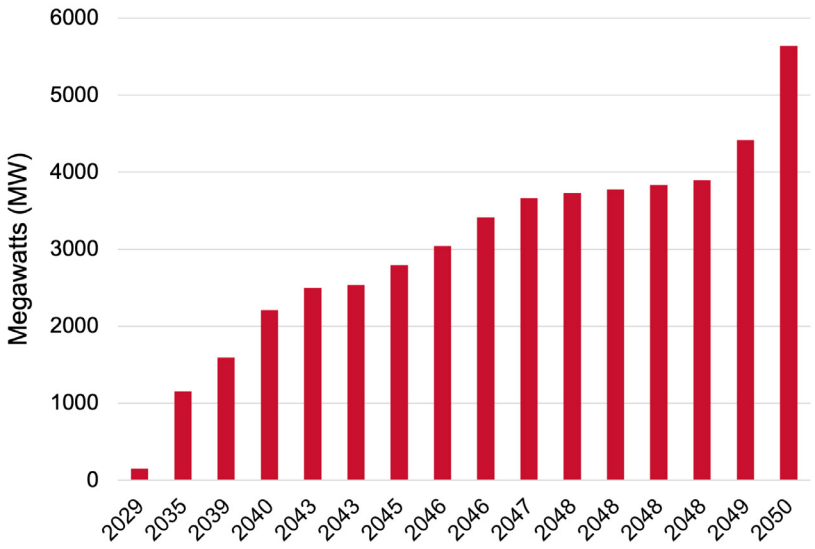
A comprehensive energy systems optimisation model (ESOM) for the Laotian power sector (Lao-PSM) was developed using the OSeMOSYS framework to investigate the impacts of concessionary contract expiry. OSeMOSYS [3] is a flexible and open source modelling tool known for its effectiveness in supporting policy discussions and building a robust evidence base across various temporal [4–6] and spatial dimensions [7–8]. Lao-PSM is designed as a multi-regional power sector model with three specific regional classifications (Central, Southern, and Northern). The current version of the model features a temporal resolution of eight time steps, incorporating a two season framework to account for wet and dry season dynamics, along with four daily time divisions to capture variations in demand profiles and variable renewable energy (VRE) generation. The modelling horizon for Lao-PSM extends from 2021 to 2055. The model incorporates the expansion plan outlined in the most recent revision of the National Power Development Plan (NPDP). This analysis employs two distinct scenarios. The first scenario, labelled Business-as-Usual (BaU), uses electricity demand projections from the National Power Development Plan (NPDP) [1]. These projections factor in population growth, economic development trends, and current energy consumption patterns. The BaU assumes renewal of concessionary agreements for some large hydropower plants at the end of their BOT period. The second scenario, labelled Bot-End, envisions large hydropower plants returning to the Laotian power grid as their concessionary agreements expire, starting in 2029. **Figure 1** shows the power plant capacity expected to be brought under Laotian control between 2029 and 2050. These numbers were obtained after

consultation with Laotian analysts[1]. It is essential to highlight that before the end of the BOT period, the power plants were exporting electricity directly to Association of Southeast Asian Nations (ASEAN) countries, with minor royalties provided to the Laotian Government. After the transfer, Laos has absolute control, and it can divert excess electricity to the local market or export it to its ASEAN neighbours. Within each scenario, the model accounts for variations in operating costs, installed capacity, and maintenance requirements.

Key input data for the model were provided by the Ministry of Energy and Mines. These data include technical characteristics (eg installed capacity and transformer specifications), economic parameters (eg fixed and variable operation and maintenance costs), and constraints related to the domestic transmission network.

[1] These data were obtained during a workshop with analysts from the Ministry of Energy and Mines (MEM) who also participated in writing this policy brief.

Figure 1: *Cumulative excess capacity in the system after the end of concessionary agreements (MW)*




Coal fired electric power plant – Hongsa city, Lao PDR

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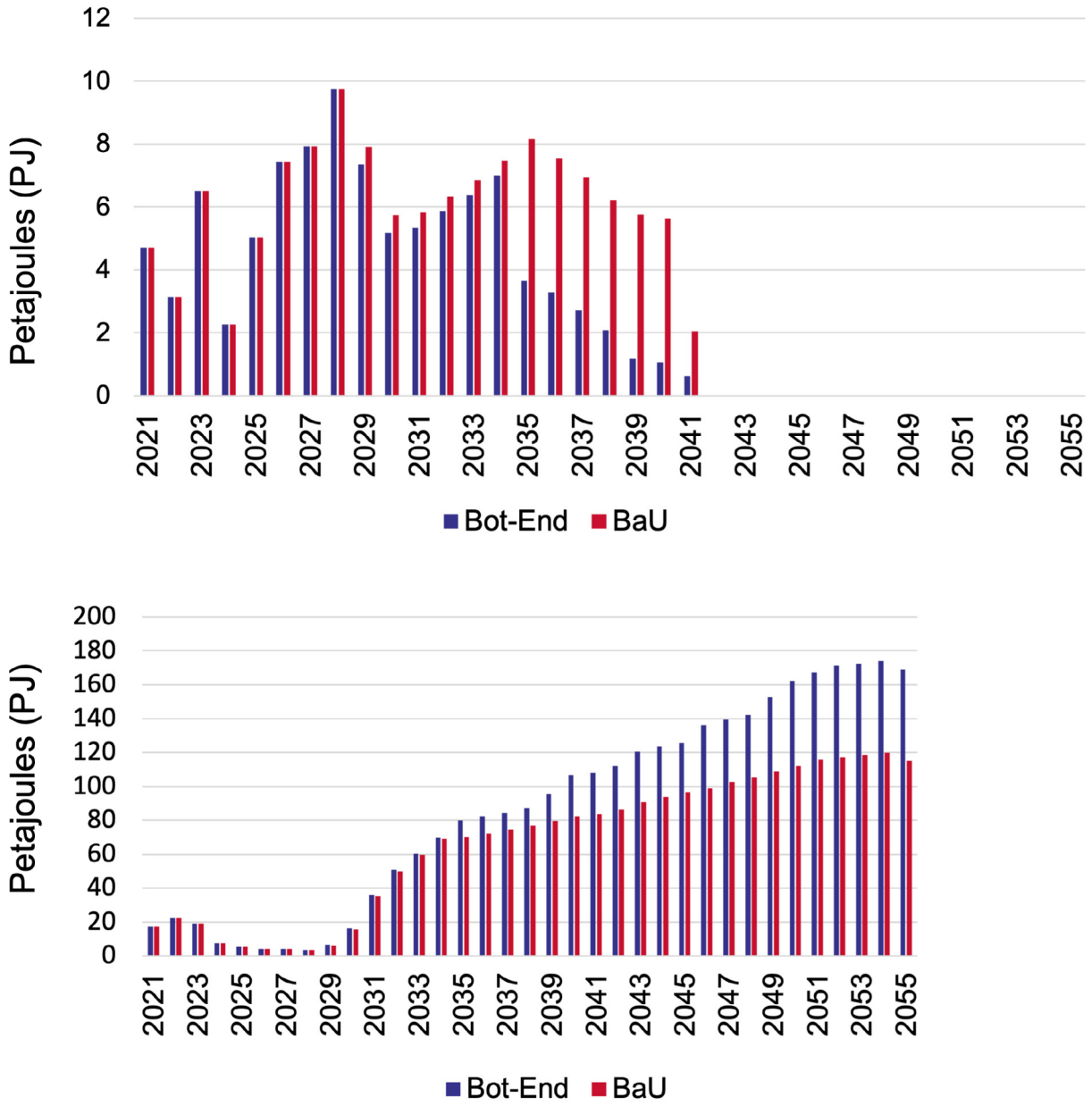
Results and analysis

The results indicate that two key changes are anticipated following the transfer of power plant control. Laos' reliance on ASEAN electricity imports, at unfavourable prices, is expected to decrease. Laos will have surplus electricity in the system that can be sold to its ASEAN neighbours.. Figure 2 illustrates the difference in imports and exports over the modelling period.

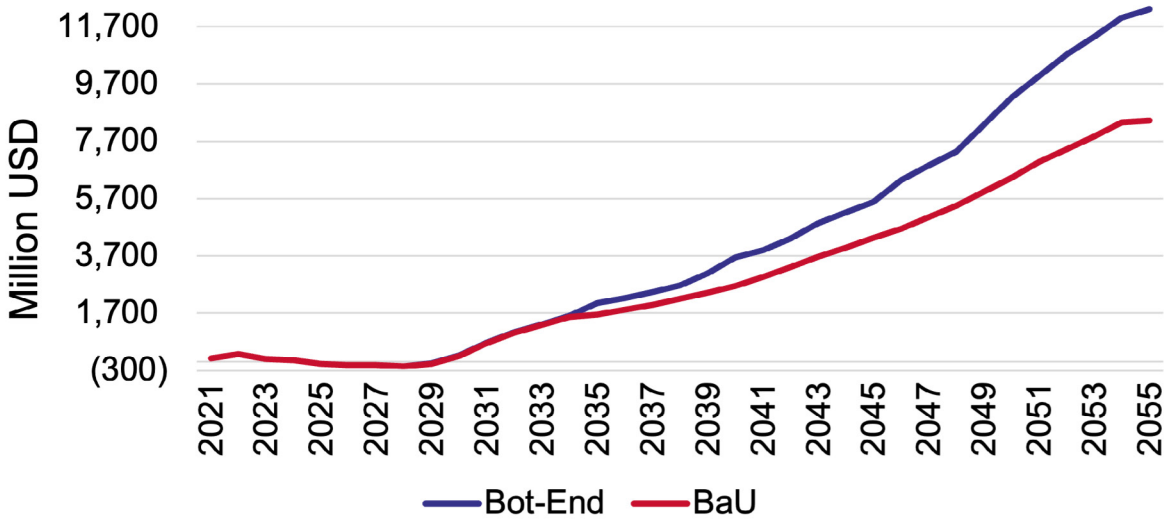
Figure 2: *Laotian electricity exports (top) and imports (bottom) expressed in PJ for the BaU and Bot-End scenarios*



Starting from 2029, with additional capacity in the system, exports increase in both scenarios, and the deficit during the dry season diminishes, contributing to an overall reduction in imports.

The net export revenue in the Bot-End scenario is projected to reach approximately 12 billion USD in total by 2055, about 45% more than the BaU scenario, as highlighted in **Figure 3**.

Figure 3: *Laotian net export revenue expressed in million USD for the BaU and Bot-End scenarios*

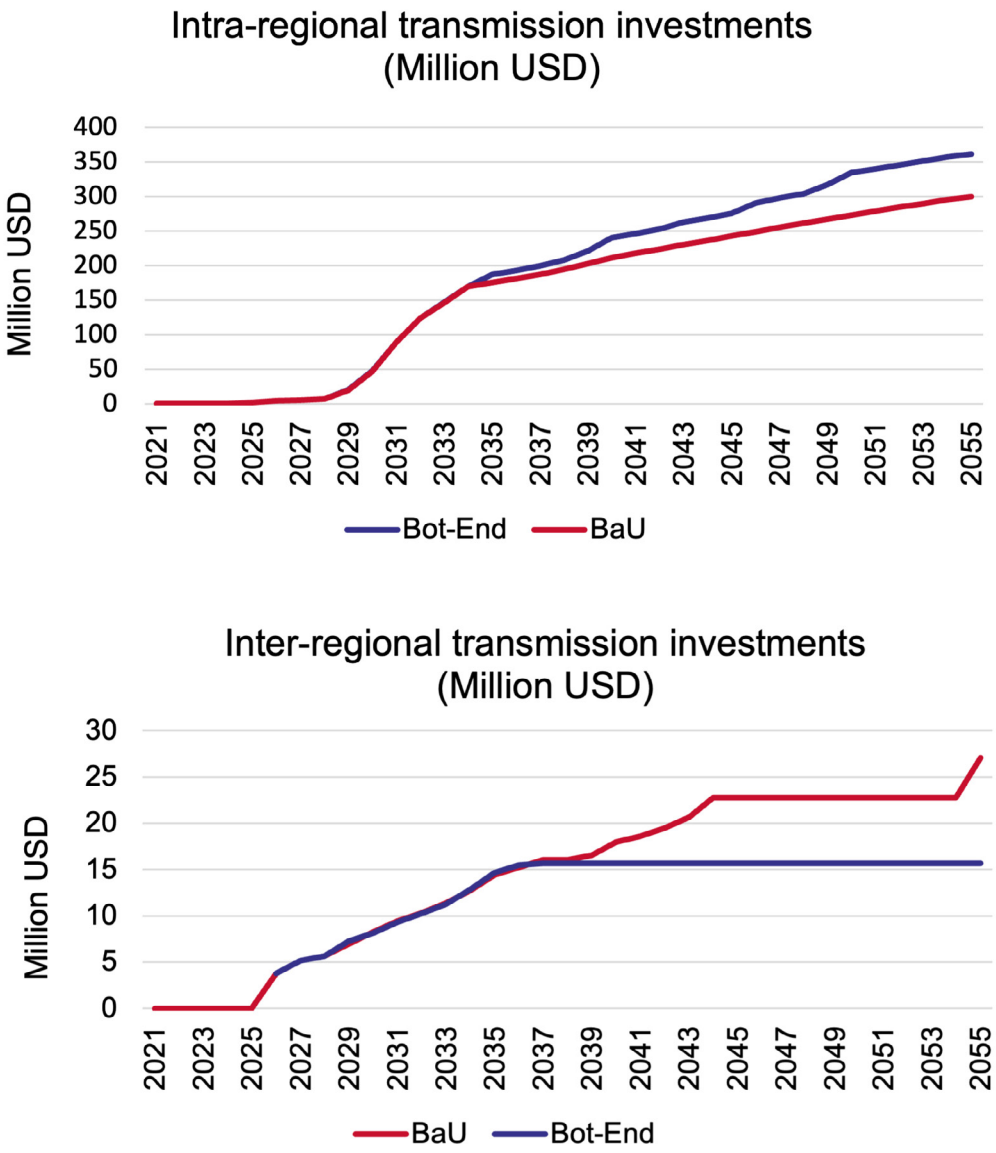


While export revenues could rise, adequate investment in transmission infrastructure must be established to capitalise on this capacity addition. **Figure 4** emphasises the capital investment required for inter- and intra-regional transmission within Laos during the modelling period.

Vientiane, Lao PDR ISTOCKPHOTO

In the Bot-End scenario, where concessionary agreements for power plants are not renewed, it is evident that from the mid-2030s, intra-regional capacity in the North, Central, and Southern regions will need to be enhanced to evacuate power from new capacity to meet local demand. Additionally, since electricity flows through the local transmission grid before being exported to neighbouring countries. This expansion is expected to cumulatively cost ~800 million USD more than the BaU scenarios. However, inter-regional investments are anticipated to decline as regions become more self-sufficient in the Bot-End scenario compared to the BaU scenario. Nevertheless, it is anticipated that not all excess electricity will be exported to other countries. There is an opportunity to use surplus capacity within Laotian borders to produce more value-added goods. For instance, a local green hydrogen or ammonia industry could enable Laos to become self-sufficient in nitrogenous fertilisers necessary for improving paddy yields. With proper planning, this surplus could be integrated with the electrification of the transport sector, which would reduce total greenhouse gas emissions in the country. Additionally, it would alleviate the pressure to import all fuel required for transport.

Figure 4: *Annualised investment in Intra (top) and Inter (bottom) regional transmission lines expressed in million USD for the BaU and Bot-End scenarios*



Conclusion

In conclusion, Laos is poised for significant transformation in its energy sector with the impending transfer of control over numerous hydropower plants from private entities to the government. This shift is expected to enhance Laos' capacity for electricity generation, reduce reliance on imports, and boost export revenues. The anticipated surplus electricity presents opportunities for domestic value-added industries, such as green hydrogen production, which can contribute to self-sufficiency in fertilisers and support electrification in transport. Strategic investments in all along the value chain will be crucial to manage this transition effectively, ensuring sustainable economic growth and environmental benefits for the country.

Policy recommendations

a) **Invest in Transmission Infrastructure:** Prioritise funding to enhance intra-regional transmission capacity to manage the expected surplus electricity effectively.
b) **Develop Local Industries:** Encourage the establishment of green hydrogen and ammonia production facilities to use surplus electricity and improve self-sufficiency in fertilisers.
c) **Optimise Energy Market Structure:** Create a framework for trading electricity with Association of Southeast Asian Nations (ASEAN) neighbours, ensuring favourable conditions for exports while reducing reliance on imports.

References

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

[2] Ember and Our World in Data, 'Net electricity imports'. Our World In Data, Jun. 2024. [Chart/table]. Available: https://ourworldindata.org/explorers/energy?tab=table&time=2021&facet=none&hideControls=false&Total+or+Breakdown=Total&Energy+or+Electricity=Electricity+only&Metric=Net+electricity+imports&country=USA~GBR~CHN~OWID_WRL~IND~BRA~ZAF.

[3] 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.

[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] M. Kihara *et al.*, 'Mid- to long-term capacity planning for a reliable power system in Kenya', *Energy Strategy Rev.*, vol. 52, p. 101312, Mar. 2024, doi: 10.1016/j.esr.2024.101312.

[6] C. Taliotis, E. Giannakis, M. Karmellos, N. Fylaktos, and T. Zachariadis, 'Estimating the economy-wide impacts of energy policies in Cyprus', *Energy Strategy Rev.*, vol. 29, p. 100495, May 2020, doi: 10.1016/j.esr.2020.100495.

[7] 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.

[8] 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.

Electric tuk-tuk in Luang Prabang, Lao PDR

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DISCLAIMER STATEMENT

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