Energy Security in Lao PDR: Effective strategies to reduce dry season electricity imports

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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, second in the series, highlights concerns related to energy security in the country during the dry season. The first policy brief focuses on the impacts of increasing electric vehicle penetration on the Laotian Power system. The third explores the impact of ending of the concessionary power agreements in Laos and its impact on the power system. 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

Lao PDR (Laos), with its significant hydropower potential, imports electricity during the dry season (November to April) despite having increased its generation capacity in the last decade. In this policy brief, an energy system expansion model is used to evaluate two scenarios to understand the dynamics around energy self-sufficiency and the impact of reduced dependence on electricity imports from its Association of Southeast Asian Nations (ASEAN) neighbours. The Business-as-Usual scenario projects prolonged electricity imports with significant financial costs, while the No-Import scenario highlights energy deficits in early years, underscoring challenges in halting imports abruptly. The findings emphasise the need for accelerated renewable energy deployment, particularly solar and wind, along with the planned hydropower infrastructure investments. Strategic energy planning, diversification of the energy mix, and grid enhancements are critical for improving Laos' energy security and reducing reliance on imports while aligning with the United Nations' Sustainable Development Goals (SDGs).

Key Messages

- Laos must strategically develop renewable energy infrastructure to reduce its dependency on seasonal electricity imports and enhance national energy security.
- Diversifying power sources beyond hydropower, through solar PV and wind can mitigate dry season supply challenges.
- Careful long-term energy planning and infrastructure investment are crucial for balancing domestic demand and export commitments.

Introduction

Lao PDR (Laos), situated in the Indochina peninsula, has a monsoon climate and rugged mountainous terrain covering approximately 70% of its total area [1]. These geographical characteristics make the country exceptionally favourable for clean energy development, particularly hydropower, with potential resources estimated at around 30 GW. The nation has experienced remarkable socio-economic growth, reflected in its power generation sector's continuous development from 2012 to 2022, with an annual growth rate of 14.4% [2]. Currently, Laos has 102 power plants, with a total installed capacity of ~11,620 MW. The power generation landscape is divided into two primary segments: domestic electricity supply and exclusively export-oriented generation. Export-oriented generation accounts for ~62 % of the installed capacity in the country with 7,160 MW. It is important to highlight that the electricity from these power plants is directly exported and does not even enter the local grid.

Electricity consumption has been on a continuous upward trajectory for the last decade. Électricité du Laos (EDL), the national systems operator, indicates a significant leap in demand, averaging 90–100 MW annually. Peak electricity demand increased from 1,540 MW in 2022 to 1,778 MW in 2023. Projections for 2023–2027 suggest an anticipated annual demand increase of 258 MW [3]. In 2022, Laos was the world's second-largest net electricity exporter, second only to France, with 33.75 TWh of electricity being exported (net) to its seven neighbours [3]. Despite being a net exporter, Laos still imports electricity from Thailand during the dry season, and at an unfavourable price – double that of its exports [4]. Additionally, electricity is imported to satisfy Laotian demand in the border towns not currently reached by the Laotian electricity grid. Reducing the dry season imports is of paramount importance to Laos to reduce its exposure to price shocks and improve its domestic energy security [4]. This policy brief explores this question by analysing the changes needed in the Laotian electricity system to improve its energy security.

Methods

A power system optimisation model for the Laotian power sector (Lao-PSM) was developed using the OSeMOSYS framework to explore questions related to Laotian electricity imports. OSeMOSYS [5] is an adaptable and open-source modelling tool, with a track record of effectively informing policy discussions and establishing a solid evidence base across diverse temporal [6–8] and spatial dimensions [9–10]. Lao-PSM is a multi-regional power sector model with three distinct regional classifications: Southern, Central, and Northern. The current model iteration considers a temporal resolution of eight time steps, incorporating a two-season structure to capture wet and dry season dynamics and four daily time divisions to reflect variations in demand profiles and variable renewable energy (VRE) generation. Lao-PSM's modelling horizon spans from 2021 to 2055. Lao-PSM considers the expansion plan presented in the latest revision of the National Power Development Plan (NPDP) [11], and accounts for electricity demand projections obtained from EDL.

To support this analysis, two scenarios are developed. A Business-as-Usual (BaU) scenario that considers the power supply options for Laos as prescribed in the NPDP and develops

an optimal expansion plan. It also estimates the electricity imports required to satisfy the dry season deficit in hydropower production. A No-Import (No-Imp) scenario was developed that restricts electricity imports into Laos from 2024 and allows the local electricity grid to develop its capacity to meet the dry season demand. The No-Imp scenario also reveals situations where no additional capacity is available to satisfy the dry season demand deficit.

Results and analysis

Power projects must be strategically selected and arranged to meet domestic electricity demand in each period and region to address energy supply insufficiency, focusing on increasing dry season production. The demand centres are expected to be in the Central and Northern regions, whereas the bulk of the future expansion capacity is in the South. This includes developing solar PV and wind power sources that are competitively priced and ensure technical compatibility with the grid. The BaU scenario determines the rollout of power sector infrastructure until 2055; the total imports into Laos through the different regions are also estimated. **Figure 1** highlights the capacity of the generation mix in the BaU scenario.

Figure 2 illustrates that, under the BaU, Laos will have to import electricity until 2042 to compensate for dry season deficits. However, when new generation capacity is introduced, imports will decrease gradually from 2035. Between 2024–2041, Laos is expected to import ~23.6 TWh of electricity with an average annual amount of ~1.4 TWh. Cumulatively, this is expected to cost the Laotian government ~1.5 billion USD (2021 prices). This is ~4.5% of the total Laotian budget in the same period, assuming the annual budget remains the same as in 2023. In the No-Imp scenario, several primary issues emerge when energy imports are restricted

***Figure 1:** Electricity generation capacity in Lao PDR under the BaU scenario (GW) – Note: CEN = Central region; SOU = Southern region; and NOR = Northern region.*

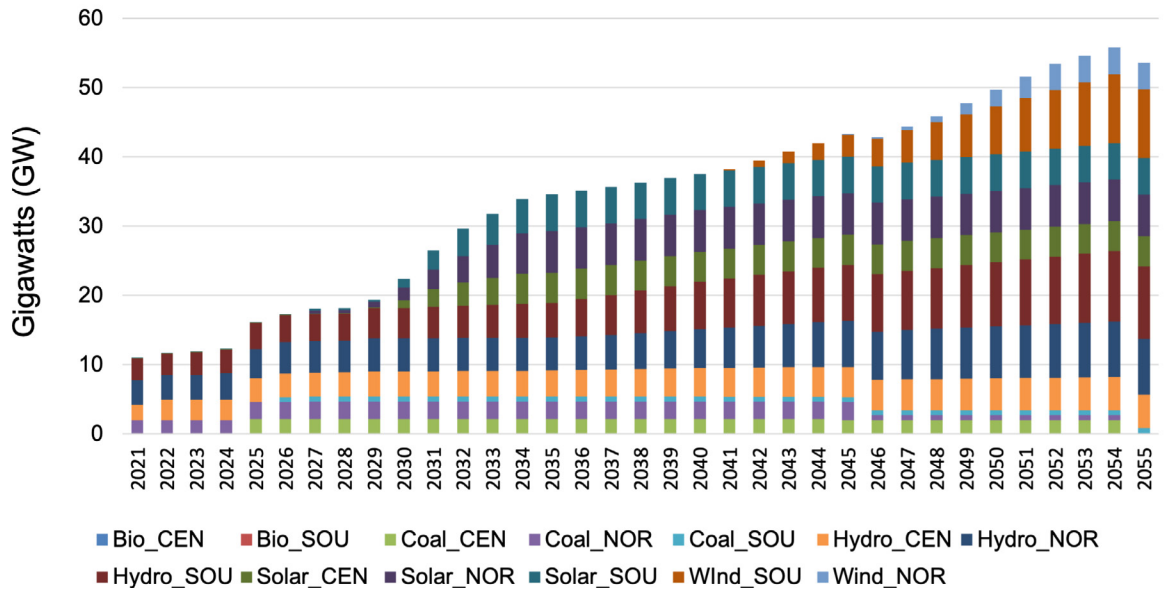
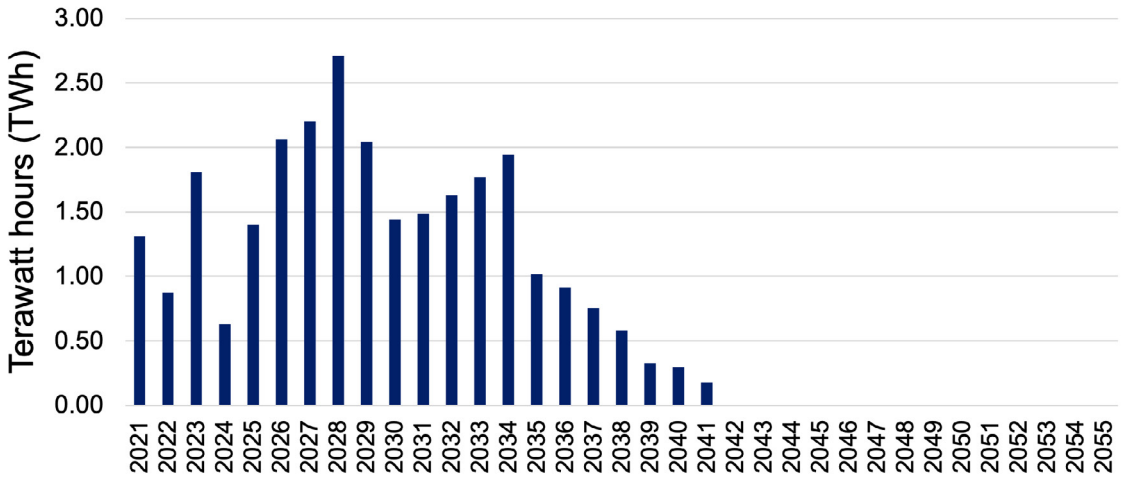


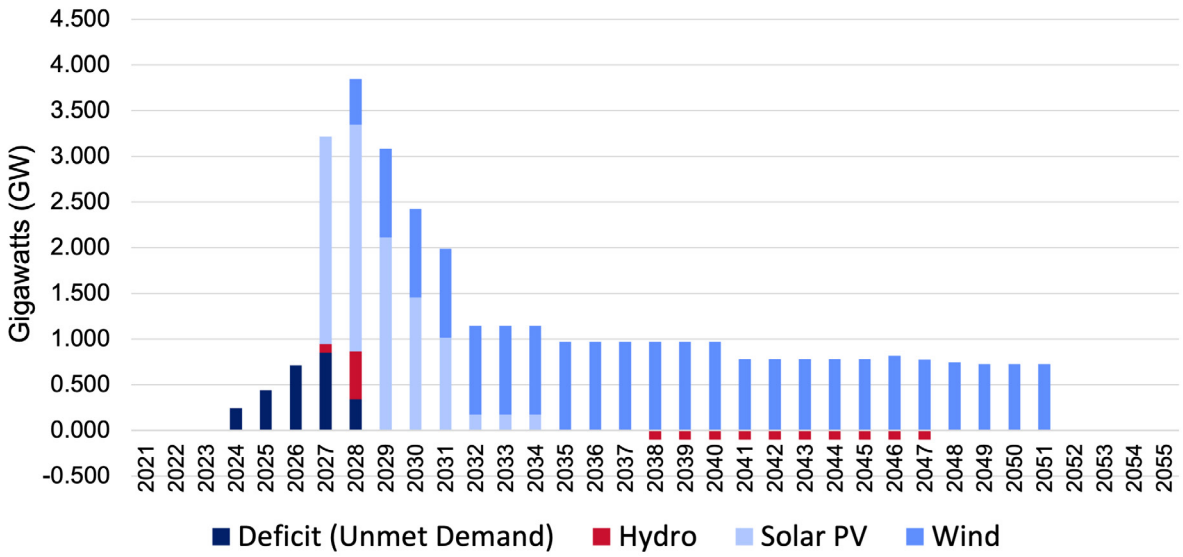
***Figure 2:** Laotian electricity import in the BaU scenario in terawatt hours*



from 2024. In 2024, the domestic grid will have no extra dispatchable capacity to meet the deficits in the dry season. All new production projects outlined in the NPDP are expected to be in their construction phase, leading to significant energy deficits in the first few years. In 2024, a deficit of 240 MW (~0.5 TWh of energy) is projected.

The shortfall is expected to increase to 850 MW (~1.08 TWh of energy) in 2027. By 2028, the deficit is anticipated to decrease to 340 MW. These projected shortfalls highlight the potential consequences of abruptly ceasing energy imports before adequately developing domestic production capacity. The shortfall denotes that either the Laotian demands will not be satisfied (blackouts), or the cost of supplying electricity will be very high as a result of using captive diesel generators, resulting in higher emissions. Additional new generation capacity is necessary for sufficient energy supply to meet demand. Our modelling results indicate that new capacity will be added to the system in 2027. **Figure 3** illustrates the difference in installed capacity in the system

***Figure 3:** Difference in electricity generation capacity (GW) between the No-Imp and BaU scenarios*

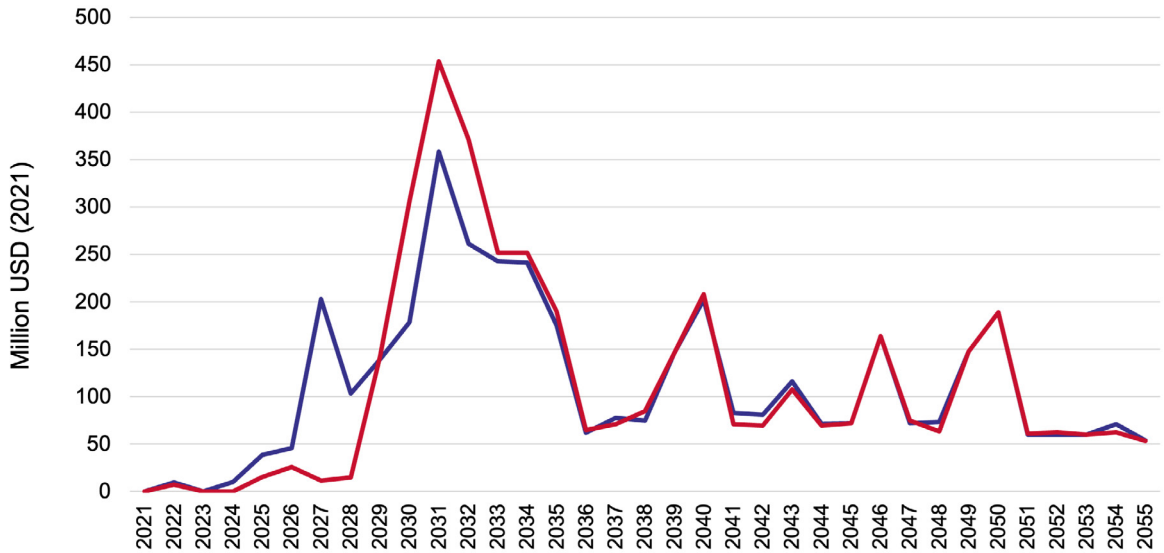


between the No-Imp and BaU scenarios. Most of the solar PV, wind, and hydro capacity considered cost-optimal in the BAU in later years get installed earlier in the No-Imp case to meet the local demand deficit. Additionally, wind power capacity (~1 GW) is higher in the No-Imp scenario as it is considered cost-optimal to export electricity from the installed extra capacity.

The additional solar PV and wind investments are expected to cost the Laotian govt ~1.01 and ~3.4 billion USD respectively. In addition to the system's extra solar PV and wind capacity, the investments in extra transmission capacity cannot be discounted. The results indicate that, cumulatively, the total investment in the local transmission grid is not different between the two scenarios, with the No-Imp scenarios requiring 5% more investment. However, the infrastructure investments in the No-Imp scenario will initially need to occur several years earlier, increasing between 2024–2031, than in the BaU scenario, as presented in **Figure 4**. That being said, a spatially explicit model of the grid is required to give more nuanced insights into these investments that are very province and region specific.

This is not trivial, considering that Laos has always been a step behind when it comes to expansion planning and investment in transmission infrastructure. Planning for a grid that can transmit electricity from remotely positioned VRE technologies to demand centres needs a robust grid, and planning for this is non-negotiable.

Figure 4: *Capital Investments in local transmission infrastructure under the analysed two scenarios (Million USD)*



Conclusions

Laos is at a critical juncture in its power sector reforms. While the country has ambitious plans to become the "Battery of Southeast Asia", it must balance its hydropower expansion with the need for energy security, particularly during dry seasons. The analysis reveals that ceasing electricity imports abruptly could lead to significant energy deficits in the first decade, highlighting the importance of a gradual transition. Timely investments in diverse renewable energy sources, particularly solar PV, wind, and necessary transmission infrastructure, emerge as a crucial strategy. However, these investments must be carefully timed and planned to avoid straining Laos' already high debt levels. The challenge lies in developing a resilient, sustainable energy system that can meet domestic demand, maintain export commitments, and reduce import dependency, all while navigating complex regional geopolitics and environmental concerns.

Policy Recommendations

a) **Diversify the energy mix:** Accelerate the development of non-hydro renewable energy sources, particularly solar PV and wind power, to complement hydropower and enhance energy security during dry seasons
b) **Strengthen grid infrastructure:** Prioritise investments in transmission and distribution networks to support the integration of variable renewable energy sources and improve overall system reliability
c) **Regional prioritisation: It** is critical that (a) and (b) should be prioritised in Laotian provinces with higher demand and generation potential.
d) **Enhance regional cooperation:** Engage in strategic negotiations with neighbouring countries to secure more favourable terms for electricity trading.
e) **Implement sustainable financing strategies:** Develop innovative financing mechanisms to fund renewable energy projects and grid upgrades while managing the country's debt levels

Wind turbines, Lao PDR

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Electrical grid – Thakhek loop, Lao PDR

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DISCLAIMER STATEMENT

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