

# Case study



## Setting the blueprint for green hydrogen and ammonia in Laos

November 2024

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Partnerships for Infrastructure acknowledges Aboriginal and Torres Strait Islander peoples as the traditional custodians of Country throughout Australia, and we pay our respects to Elders past and present. P4I also recognises early connections between Southeast Asia and the First Nations peoples of Australia.

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The Lao PDR National Green Hydrogen and Ammonia Roadmap is a strategic initiative aimed at supporting Laos's transition towards a more resilient, inclusive and sustainable energy system through the production, storage, distribution and use of green hydrogen (see Box 1) and ammonia. The initiative is delivered by Laos's Ministry of Energy and Mines and Australia's Partnerships for Infrastructure.

This case study examines the Lao energy sector in relation to the roadmap, detailing the processes to evaluate the development and expected impacts of green hydrogen and ammonia. It highlights the collaborative, multistakeholder engagement process that shaped the roadmap, emphasising the importance of sustainability, inclusion and resilience in a rapidly evolving energy landscape.

The participatory processes and analyses for the Lao PDR roadmap are readily adaptable. They can serve as a model for other Southeast Asian countries currently exploring hydrogen and ammonia as components of their broader energy transition strategies.

## Box 1

### Hydrogen production – terminology

Hydrogen (H<sub>2</sub>), as a component of ammonia (NH<sub>3</sub>), can be produced through several methods, including the gasification of coal or biomass, steam methane reforming, water electrolysis and methane pyrolysis. To foster transparency and encourage investment in hydrogen production, demand applications and infrastructure for hydrogen trade, there is a pressing need for clear regulations and certification systems based on the carbon emissions intensity of hydrogen production.<sup>1</sup>

Currently, various terms are used to classify hydrogen based on its production methods, including 'green', 'grey', 'blue' and 'brown'. The green hydrogen and ammonia roadmap emphasises hydropower for electricity generation through water electrolysis, defining green hydrogen as hydrogen produced using only renewable electricity sources.

According to the Green Hydrogen Coalition, carbon intensity is an important measure

for hydrogen and ammonia certification, where thresholds can indicate whether production is 'green'.<sup>2</sup> See N Connell, J Lin et al., *Green Hydrogen Guidebook*, 2nd edn, Green Hydrogen Coalition, 2022. In Australia, for example, an upper carbon intensity threshold of 1 to 2 kg CO<sub>2</sub>-e/kg H<sub>2</sub> or NH<sub>3</sub> is being used. As noted by the Mekong Region Futures Institute (MERFI) in a report submitted to Partnerships for Infrastructure, the same system could be used in Laos and other Southeast Asian countries as an agreed framework to facilitate regional collaborations and technology exchanges, as well as potential future trading of emission reduction certificates (carbon credits).

<sup>1</sup> International Energy Agency, *Towards Hydrogen Definitions Based on Their Emissions Intensity*, IEA, April 2023.

<sup>2</sup> N Connell, J Lin et al., *Green Hydrogen Guidebook*, 2nd edn, Green Hydrogen Coalition, 2022.



# Harnessing Laos's existing resources and reducing dependence on costly imports

Laos is rich in renewable energy resources, particularly hydropower, and with significant solar and wind potential. Commencing in 1971 with the Nam Ngum 1 hydropower plant, the country has harnessed its hydropower potential through the operation of 83 hydropower dams, with an additional 43 dams currently planned or under construction. This extensive hydropower fleet generates a surplus of renewable electricity during the wet season. However, grid constraints hinder the effective export of surplus electricity to regional customers, including Cambodia, Thailand and Vietnam. Contingent on wet season rainfall and without storage options, the country has periodically relied on importing electricity, primarily from Thailand, during the dry season to meet domestic electricity demand.<sup>1</sup> Laos is also entirely dependent on liquid fossil fuel imports and ammonia-based fertilisers and chemical feedstocks.

Additionally, projections point towards an increase in available electricity surplus at least until 2050, based on the 9th Five-Year National Socio-Economic Development Plan (2021–2025), where the Lao Government prioritises hydropower (including small hydropower) and diversifying energy sources through expanded solar and wind generation as cornerstones of its energy strategy.<sup>2</sup> Recognising this mismatch between demand and supply has been central to evaluating the opportunities of redeploying the current electricity surplus in the wet season to produce green hydrogen and ammonia.

Agriculture contributes about 16.5% to national GDP and employs almost 61% of the working population. However, Laos remains reliant on the import of fertilisers and chemical feedstocks, which are subject to price volatility and supply chain disruptions, as evidenced by the impacts of global conflicts. Local green ammonia production in Laos would support the country's agricultural development goals by providing a domestic source of mineral nitrogen fertilisers, while creating new employment opportunities across diverse sectors, thereby supporting the Lao Government's 9th Five-Year Agriculture, Forestry and Rural Development Plan (2021–2025).<sup>3</sup>

This dependence on fossil fuel and fertiliser imports highlights the need for a strategic transition towards diversifying energy sources and leveraging Laos's abundant renewable potential, a priority for the Ministry of Energy and Mines.

Under the Laos–Australia Sustainable Energy Partnership (LASEP), Australia, through Partnerships for Infrastructure (P4I), and Laos are working together to enhance Laos's energy stability, reliability and profitability while strengthening resilience to climate change. This energy partnership focuses on 2 main areas: advancing energy sector planning and accelerating the transition to renewable energy – including expanding diverse energy sources and storage technologies.



Knowledge exchange on energy regulation with key stakeholders from Laos and Australia, held in May 2023 in Luang Prabang, Laos. Source: P4I

<sup>1</sup> Stimson Center, [Mekong Infrastructure Tracker Dashboard](#), Stimson Center website, 2020, accessed 26 November 2024.

<sup>2</sup> Ministry of Planning and Investment, [9th Five-Year Socio-Economic Development Plan \(2021–2025\)](#), Lao Government, 2021.

<sup>3</sup> Australian Centre for International Agricultural Research, [Laos](#), ACIAR website, n.d., accessed 26 November 2024.



Training on green hydrogen and ammonia for 19 technical staff from key ministries and institutions, held between January and July 2023 at the Research Institute for Energy and Mines, Vientiane, Laos. Source: The Mekong Region Futures Institute (MERFI)

## A roadmap to provide a clear vision for technology development and uptake

The enthusiasm for green hydrogen and ammonia is growing. According to the International Renewable Energy Agency (IRENA), more than 50 countries (as of May 2024) have integrated renewable hydrogen and ammonia production and utilisation into their energy policy frameworks,<sup>4</sup> and green hydrogen will play a significant role in the energy transition as part of efforts to limit global warming to 1.5 °C.<sup>5</sup> However, several challenges must be addressed. The high costs associated with green hydrogen production through water electrolysis, compared to fossil fuel-based production, present a significant hurdle. Additionally, risks such as stranded assets and the need for demand stimulation could impede progress.

The roadmap, endorsed at the September 2024 national workshop organised by the Ministry of Energy and Mines, sets out the vision, strategies and actions, regulatory commitments and necessary financial support to develop and sustain a decarbonised hydrogen and ammonia industry in Laos, and maps the transition from an emerging technology to viable commercial assets.

Figure 1 on page 9 illustrates the steps involved in the production and endorsement of the roadmap.

By providing a strategic framework for action, the roadmap, led by the Ministry of Energy and Mines with support from P4I, facilitates the transition to a

sustainable energy system. It leverages the benefits of green hydrogen and ammonia while minimising risks and maximising opportunities for sustainable growth through feasible and phased development pathways. The roadmap also carefully considers the need for equitable access, workforce development, research capacity, innovation and investment, as well as the mitigation of environmental impacts.

The roadmap provides a foundation for revising or creating national policies that support technology diffusion.<sup>6</sup> Aligning the roadmap with the updated National Power Development Strategy, will be a critical future step towards realisation. The roadmap is also a clear signal for potential domestic and foreign investors, providing clearly defined, consensus-based long-term targets. Support from the Lao Government and development and private sector partners will need to be aligned with the different phases of the innovation and technology deployment cycle as outlined in the roadmap.<sup>7</sup>

Given the rapid pace of technological change, government-led roadmaps and strategies are dynamic, living documents that are regularly reviewed and updated. This adaptability ensures that planning and investments remain relevant and aligned with evolving government needs and technological advancements. Australia has recently updated its National Hydrogen Strategy (see Box 2).

<sup>4</sup> International Renewable Energy Agency, *Green Hydrogen Strategy. A guide to design*, IRENA, 2024.

<sup>5</sup> International Renewable Energy Agency, *'Green hydrogen: a key enabler to broaden the potential of renewable power solutions in hard-to-abate sectors'*, IRENA, 20 September 2023.

<sup>6</sup> Technology Executive Committee of the United Nations Framework Convention on Climate Change, *Background Paper on Technology Roadmaps*, UNFCCC, April 2013.

<sup>7</sup> International Energy Agency, *Technology Roadmap: Hydrogen and Fuel Cells*, IEA, 2015.

## Regional hydrogen outlook

### Southeast Asia

While hydrogen has sporadically appeared on the policy agenda in Southeast Asia, some countries are making notable progress. For instance, Singapore,<sup>1</sup> Indonesia, Malaysia and Vietnam<sup>2</sup> have released their national hydrogen strategies, while Brunei Darussalam<sup>3</sup> has started exporting grey hydrogen to Japan.<sup>4</sup> Some of these countries have also signed memorandums of understanding or initiated pilot hydrogen programs. However, few of these efforts are focused specifically on green hydrogen.

At the ASEAN level, the ASEAN Plan of Action for Energy Cooperation Phase II (2021–2025) was endorsed at the 38th ASEAN Ministers on Energy Meeting in November 2020. The plan of action provided policy measures to address emerging and alternative technologies, such as hydrogen storage and entry into the national energy mix, to accelerate the region's energy transition and strengthen energy resilience through innovation and cooperation.

### Australia

In 2018, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) published a National Hydrogen Roadmap, highlighting the significance of hydrogen and the opportunities it presents for Australia as a new energy export commodity.<sup>5</sup> Since then, several industry-led hydrogen projects have been piloted, with support from state governments and federal agencies such as the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation.

Australia adopted its first National Hydrogen Strategy in November 2019,<sup>6</sup> to develop a hydrogen industry, enhance energy security, create jobs and build an export industry. The strategy was revitalised in 2024, providing the framework for Australia to become a global hydrogen leader.<sup>7</sup>



<sup>1</sup> Singapore is not a P4I partner country.

<sup>2</sup> CSIRO, '[HyResource – International](#)', CSIRO website, n.d., accessed 26 November 2024.

<sup>3</sup> Brunei Darussalam is not a P4I partner country.

<sup>4</sup> T Kumagai, '[AHEAD launches Brunei–Japan hydrogen supply chain for power generation in Tokyo Bay](#)', S&P Global, 25 June 2020.

<sup>5</sup> CSIRO, '[National Hydrogen Roadmap](#)', CSIRO, 2018.

<sup>6</sup> Council of Australian Governments Energy Council, '[Australia's National Hydrogen Strategy](#)', Commonwealth of Australia, 2019.

<sup>7</sup> Department of Climate Change, Energy, the Environment and Water, '[National Hydrogen Strategy 2024](#)', DCCEEW, 2024.



## Major activities and milestones since the development of Australia's first hydrogen roadmap



\* CSIRO's [HyResearch](#) portal and [Hydrogen Knowledge Centre](#) are excellent sources of information on hydrogen research activities.

**Australia has made significant progress since releasing its initial roadmap, demonstrating how such frameworks can bridge the gap between technological enthusiasm and the development of realistic targets and actionable measures.**



Collaborative workshop with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), bringing together the Ministry of Energy and Mines, the Research Institute for Energy and Mines, the National University of Laos, and the Mekong Region Research Institute (MERFI) in September 2024. Source: MERFI

*'Laos has the potential to produce energy from hydropower, solar energy, and wind energy. These energies can be converted into hydrogen to replace the use of fossil fuel ... The use of this kind of energy will help to reduce pollution and support sustainable green development.'*

— Dr Sinava Souphanouvong, then Deputy Minister of Energy and Mines<sup>8</sup>

## Key steps undertaken to develop the roadmap

The roadmap emphasises a whole-of-energy-system approach, is ambitious, strives for just and sustainable energy transitions, is collaborative and participatory, and facilitates public-private partnerships in domestic manufacturing and production chains. The interdependencies that characterise energy transitions, spanning water management, transportation, agriculture, the environment, finance and investment, make it essential to adopt a cross-sectoral and cross-jurisdictional approach.

The roadmap details a systematic and incremental participatory process to craft short-, medium- and long-term hydrogen-ammonia strategies and actions. The roadmap development process consisted of 4 main steps, implemented from January 2023 to December 2024, as illustrated in Figure 1.

<sup>8</sup> J Meadley, '[Lao Government to utilize hydrogen ammonia as clean source of energy](#)', The Lao Times, 8 June 2023.



**Figure 1: The 4 main steps leading to the development and endorsement of the roadmap**



The participatory systems mapping exercise was a key element in the development of the roadmap. This mapping exercise was conducted early in the process (at step 1) to ensure that diverse perspectives – including from civil society organisations – were integrated into the planning process.

**Note:** The roadmap was endorsed at the national public consultation workshop in September 2024.

Participatory systems mapping is a practice-oriented network or system analysis tool to investigate and support cross-sectoral energy planning and natural resource governance.<sup>9</sup> This method combines systems thinking and participatory techniques to create visual representations, or maps, of the interconnections, causal relationships and feedback loops that exist between various elements within a system. Facilitated discussions among diverse stakeholders allowed for the identification of priorities, challenges and opportunities related to hydrogen and ammonia production.

## Expected impacts of implementing the roadmap

Transforming electricity into hydrogen and ammonia can be useful in various areas, but some of these areas may compete with one another. Governments will need to prioritise applications that align best with their immediate and longer-term broader economic and energy priorities, initially addressing sectors and operations that are difficult to electrify. Figure 2 shows potential immediate and longer-term applications of green hydrogen and ammonia in the Lao economy.

**Figure 2: Potential applications of green hydrogen and ammonia in Laos**



<sup>9</sup> P Barbrook-Johnson and A Penn, 'Participatory Systems Mapping', in P Barbrook-Johnson and A Penn, *Systems Mapping: How to build and use causal models of systems*, Palgrave Macmillan, 2022, [https://doi.org/10.1007/978-3-031-01919-7\\_5](https://doi.org/10.1007/978-3-031-01919-7_5).

Economic development is anticipated as the hydrogen and ammonia sector drives job creation and stimulates local economies through new business opportunities, including through partnerships with private entities in the manufacturing process. This growth will not only enhance the livelihoods of individuals but also foster a more diversified and resilient economic landscape. Crucially for Laos, domestic production of ammonia fertilisers could reduce imports, limit the outflow of foreign currencies and contribute to reducing national debt.

Transitioning to green hydrogen and ammonia is expected to significantly reduce greenhouse gas emissions through reduced imports of liquid fossil fuels and fossil fuel derivatives. The implementation of the roadmap strategies and actions could also allow Laos to contribute more actively to carbon trading once the appropriate governance system is in place, introducing an important national revenue stream.<sup>10</sup> Under Article 6 of the Paris Agreement, countries can transfer carbon credits earned from the reduction of greenhouse gas emissions to help other countries meet their climate targets.<sup>11</sup>

As hydrogen and ammonia become mainstream, policies and governance will need to cover their integration into the broader energy system, align with other sustainable development strategies and reflect the systemic, social value of decisions. The global hydrogen and ammonia economy is characterised by accelerating advances in technological innovations and end-use applications, rapid increases in both global demand and supply, and increasing early adopter competition to ensure market access.

*'By leveraging our abundant renewable energy resources, we aim to harness the transformative potential of hydrogen and ammonia to meet our net-zero energy transition goals, to nurture local talent, attract like-minded partners and to drive sustainable and just development for generations to come. We envision Lao PDR as a regional hub of the global carbon-neutral hydrogen and ammonia economy.'*

— Lao PDR Green Hydrogen and Ammonia National Technical Working Group, July 2024



Nam Ngum hydroelectric power station in Laos. Source: MatyasRehak/Shutterstock

The Lao PDR National Green Hydrogen and Ammonia Roadmap, and its strategies and action plans, represent a significant milestone in the country's energy transition journey. This initiative addresses several key challenges faced by Laos, including the utilisation of surplus hydropower during the wet season, and the reduction of fossil fuel imports and dependence, while supporting economic development through local fertiliser production and the creation of diversified economic opportunities and jobs. Other countries in the region could consider adopting a similar industry development pathway that emphasises a strong participatory engagement process. Australia, which embarked on its hydrogen and ammonia journey in 2018 with its National Hydrogen Roadmap, is well positioned to be a partner in this endeavour.

<sup>10</sup> With the support of Australia, Laos is currently implementing its Program for Open and Sustainable Carbon Markets in the Lao PDR. See Global Green Growth Institute, *'Lao PDR launches innovative carbon market program with Australia and GGGI support'*, GGGI, 14 September 2023.

<sup>11</sup> United Nations Climate Change, *'Unlocking climate ambition: the significance of Article 6 at COP28'*, UN Climate Change News, 10 December 2023.



### **About Partnerships for Infrastructure**

The Australian Government's flagship infrastructure initiative for Southeast Asia, Partnerships for Infrastructure (P4I), leads the implementation of the Laos–Australia Sustainable Energy Partnership (LASEP). For more information about LASEP, see the [Laos–Australia Sustainable Energy Partnership fact sheet](#). P4I collaborates with partners to strengthen infrastructure decision-making and practices across Southeast Asia's energy, transport and telecommunications sectors. Our approach integrates principles of gender equality, disability and social inclusion, disaster risk reduction, and climate change adaptation and mitigation.



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