Chapter 1

Energy Landscape of Lao PDR

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1. Introduction

Lao People's Democratic Republic (Lao PDR) – as well as the rest of Association of Southeast Asia Nations (ASEAN) Member States – is facing tremendous challenges regarding its future energy landscape. Lao PDR must embrace a new architecture, including sound policies and technologies, to ensure energy access as well as affordability, security, and sustainability. Moreover, increasing energy demand in every ASEAN Member State threatens the region's energy security and environment; hence, investment in sustainable energy infrastructure – such as clean technologies; energy efficiency; clean use of fossil fuels and renewable energy; and development and adoption of ecotowns, smart grids, and electric vehicles – is needed.

Although Lao PDR exports electricity to neighbouring countries, it still has a very high importation dependency for transport as well as commercial and residential consumption (e.g. 100% importation of finished oil products like gasoline, diesel, and kerosene). For the medium term, Lao PDR will continue to increase this importation, putting pressure on its energy security; thus, it is imperative that emergency response and preparedness at the national level regarding energy security be established.

Although Lao PDR is landlocked, it is in the middle of the Greater Mekong Subregion and is surrounded by three large economies – China, Thailand, and Viet Nam – and two medium economies – Cambodia and Myanmar.[1] As a result, Lao PDR can position itself as a 'land-linked' country and leverage the advantages thereof. Accordingly, building on its longstanding history of trading electricity with Thailand, Lao PDR has now expanded its policy to export electricity to neighbouring countries such as Cambodia and Viet Nam, and within ASEAN through the ASEAN Power Grid.[2]

This chapter uses existing data from *Decarbonisation of Energy Systems: Optimum Technology Selection Model Analysis up to 2060*, from the Economic Research Institute of ASEAN and East Asia (ERIA), to help analyse the energy landscape of Lao PDR (Kimura et al., 2022). This linear programming model helps minimise the total cost of an energy system when various constraints – such as emissions and power supply–demand balance – are supplied to examine the maximum contribution of all available clean technologies and renewables in various scenarios, including a decarbonisation scenario for Lao PDR. The key findings will help show policymakers how Lao PDR can scale up its renewables and associated technologies in an affordable manner given the barriers and costs associated with deep decarbonisation. This chapter also provides policy directions towards a secure, reliable, and sustainable energy system that meets the country's unique socio-economic environment.

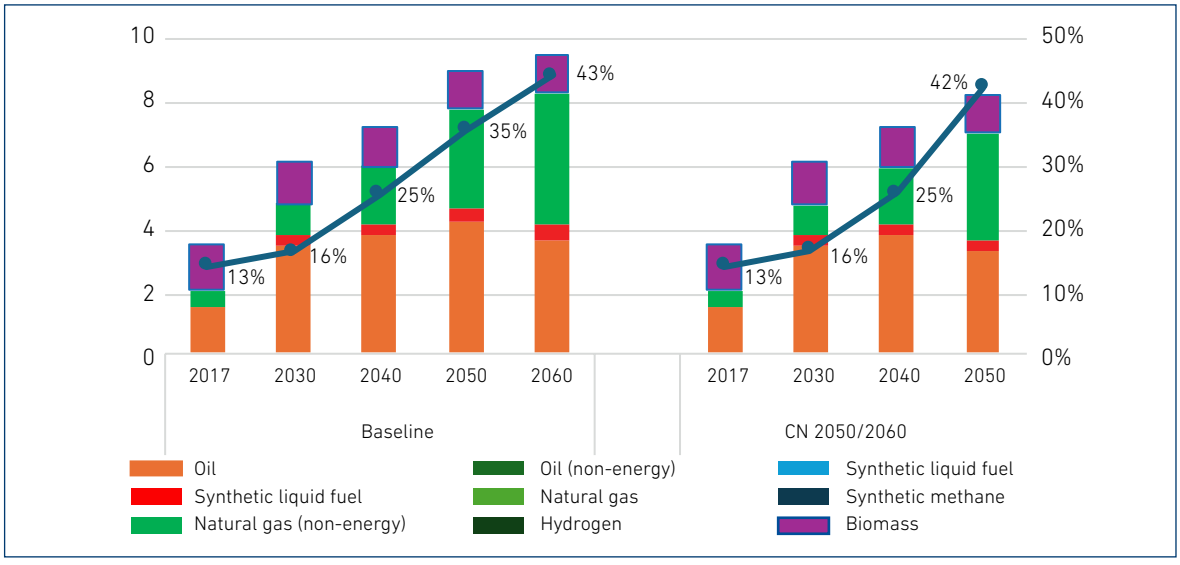
[1] Energy policy in Lao PDR has gained much public attention since the establishment of the Ministry of Energy and Mines (MEM) in 2006. Under MEM, the country's energy policy has evolved from a singular power sector policy to broader policies supporting the development of a sustainable and environmentally friendly energy sector.

[2] The ASEAN Power Grid is an initiative to construct regional power interconnection, first through cross-border bilateral terms and then on a sub-regional basis, leading to a totally integrated South-east Asian power grid system.

2. Lao PDR's Energy Demand

As shown in Figure 1.1., electricity will have the largest share in the final energy consumption of Lao PDR by 2050 under both the baseline and carbon-neutral scenarios. Electricity's share is expected to increase from 13% in 2017 to 42% or 43% by 2050. Oil and biomass would remain dominant fuel sources in 2050 under the carbon-neutral scenario. Oil would be the second-most used fuel in end-use sectors, such as transport and some industries, with 3.15 million tonnes of oil equivalent (Mtoe) or a 39% share. Biomass would be the third-largest fuel source, with a 15% share of total final energy consumption.

Figure 1.1. Final Energy Demand by Fuel Sources, Baseline versus Carbon-Neutral 2050 Scenarios (Mtoe)



CN = carbon-neutral, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

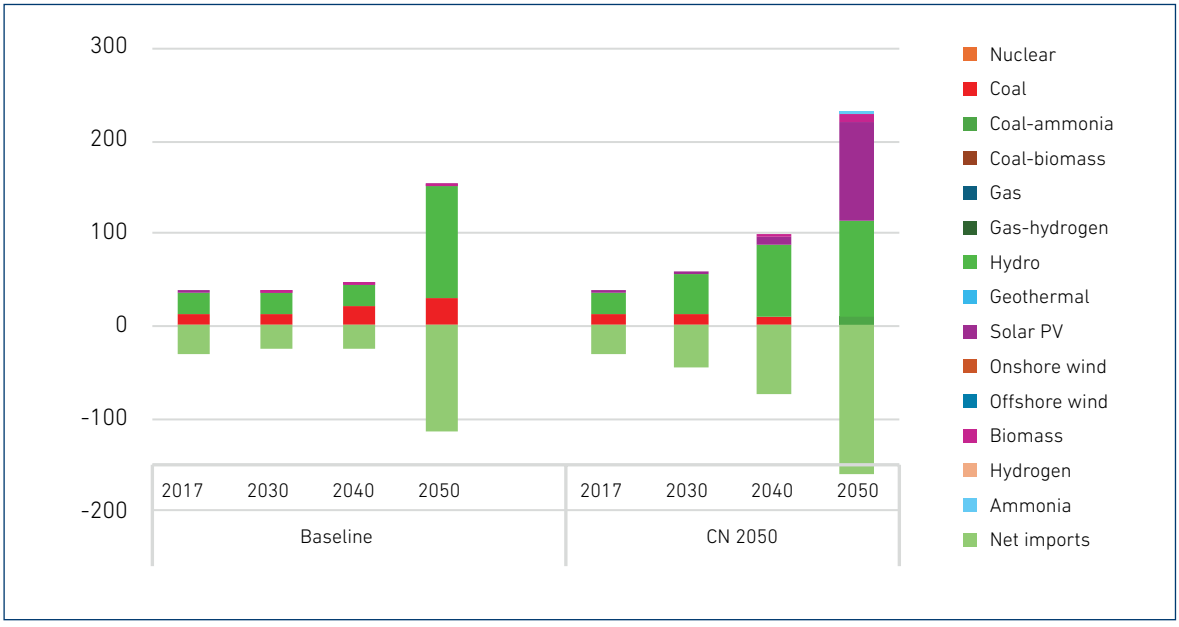
Although oil would remain the second-largest fuel source in final energy consumption by 2025 under both scenarios, the use of electricity, biomass, and clean fuels are key to decarbonise end-use sectors. Lao PDR can do more to accelerate the use of electricity in transport to reduce oil consumption, by, for example, embracing electric vehicles by 2050. Industries could also move towards the use of electricity or green hydrogen; Lao PDR has much potential for green electricity from hydropower, solar, wind, and biomass. It could use these resources to help decarbonise its own system, and the excess electricity could be traded on the ASEAN Power Grid, helping decarbonise neighbouring countries. The excess electricity could also be converted into hydrogen or battery storage.

Meanwhile, green hydrogen could also help decrease petroleum product imports as well as the use of fertilizer in agriculture. Lao PDR could produce green fertilizer from green hydrogen – the secret of which is green electricity – to help guide Lao PDR into a green and resilient economy.

3. Lao PDR's Power Generation

The country's great potential for hydro, solar, wind, and biomass could allow Lao PDR to maximise its electricity net export on the ASEAN Power Grid. It could have 45 terawatt-hours (TWh) of expected capacity by 2030, 73 TWh by 2040, and 161 TWh by 2050 under the carbon-neutral scenario (Figure 1.2). Renewables – such as hydropower, solar, wind, and biomass – would then be the dominant fuel source by 2050. Other clean fuels, such as ammonia, could also help decarbonise the power sector through coal/ammonia co-combustion.

Figure 1.2. Power Generation by Fuel Sources, Baseline versus Carbon-Neutral 2050 Scenarios (TWh)



CN = carbon-neutral, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculations.

Exportation of electricity could bring about US$121 billion in cross-revenue by 2050, excluding the potential of carbon credits from renewable energy projects of carbon off-setting and forest reserves.[3] Lao PDR could also earn foreign exchange through electricity export, cutting the cost of imported petroleum products and fertilizer. As electricity is key to Lao PDR's current and future economy, appropriate strategies to drive investment into this sector are crucial. High-grade infrastructure, a transparent investment climate, and good governance are necessary to attract investment into Lao PDR as well.

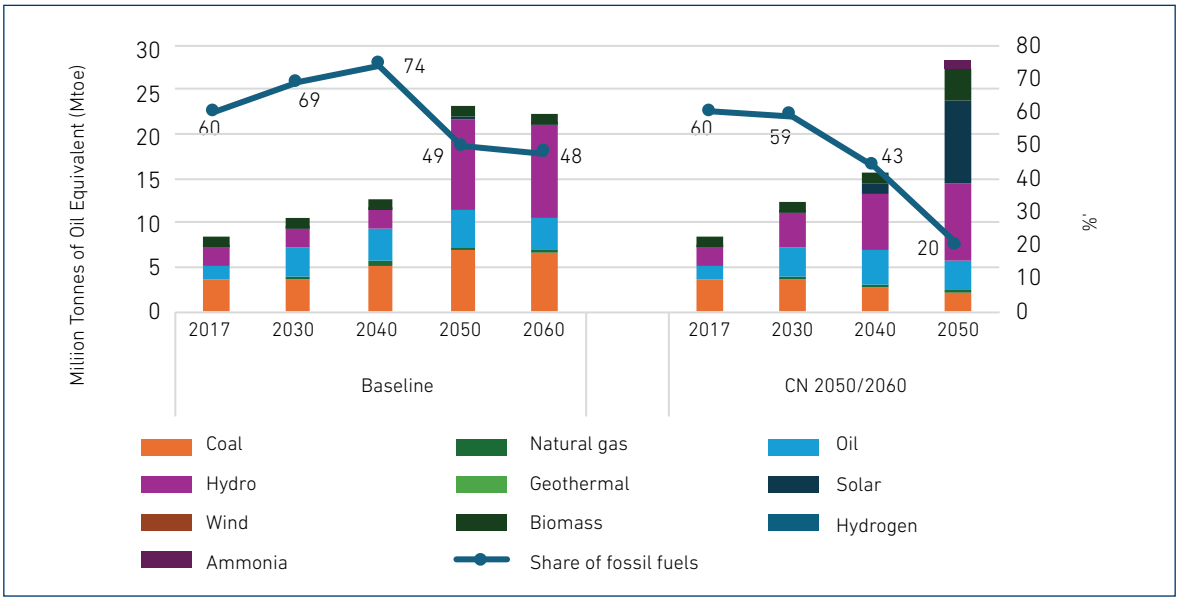
[3] Note that this is the author's calculation from the estimated power purchasing agreement and is not a net-present value.

4. Lao PDR's Primary Energy Supply

As shown in Figure 1.3, coal and oil combined constituted the largest share – 60% – of the total energy supply of Lao PDR in 2017. However, these are expected to fall to about 20% by 2050 under the carbon-neutral scenario. In 2017, hydropower had the second-largest share of the total energy supply after coal, and the combined share of both renewables and clean fuels would increase from 40% in 2017 to 80% in 2050 under the carbon-neutral scenario.

The demand for oil is forecasted to increase 2.4-fold from 2017 to 2050 under both scenarios, implying that oil will remain a key fuel for transport and industries. However, this forecast assumes that the transport and industrial sectors will continue to primarily use oil. This could change if Lao PDR's policy shifts towards electric vehicles, battery storage, and hydrogen fuels.

Figure 1.3. Primary Energy Supply by Fuel Source, Baseline versus Carbon-Neutral 2050 Scenarios



CN = carbon-neutral.

Source: Author's calculations.

Under the carbon-neutral scenario, solar and hydropower would constitute the largest share in the primary energy supply (Figure 1.3). Lao PDR also has great potential for wind and biomass; however, this depends on policies to promote this potential as well as investment. The government did sign an agreement with Savan Vayu Renewable Energy (SVARE) in February 2024 for the development of a 1,200-megawatt (MW) wind power project, which will be the largest of its kind in South-east Asia (Lao News Agency, 2024).

5. Lao PDR's Emissions and Abatement Costs

Lao PDR has a long journey ahead in decarbonising its whole energy system; it has the current 1,878-MW Hongsa coal-fired power plant as well as additional already-committed coal-fired power plants in the southern part of the country. Lao PDR must find appropriate strategies to deal with these current and committed coal-based power plants in the pipeline. One may be to combine clean coal technology with carbon capture, utilisation, and storage (CCUS). Since Lao PDR will produce clean hydrogen, carbon from power plants could be used to produce synthetic fuels for transport.

Figure 1.4. Emissions, Baseline versus Carbon-Neutral 2050 Scenarios ($MtCO_2$)

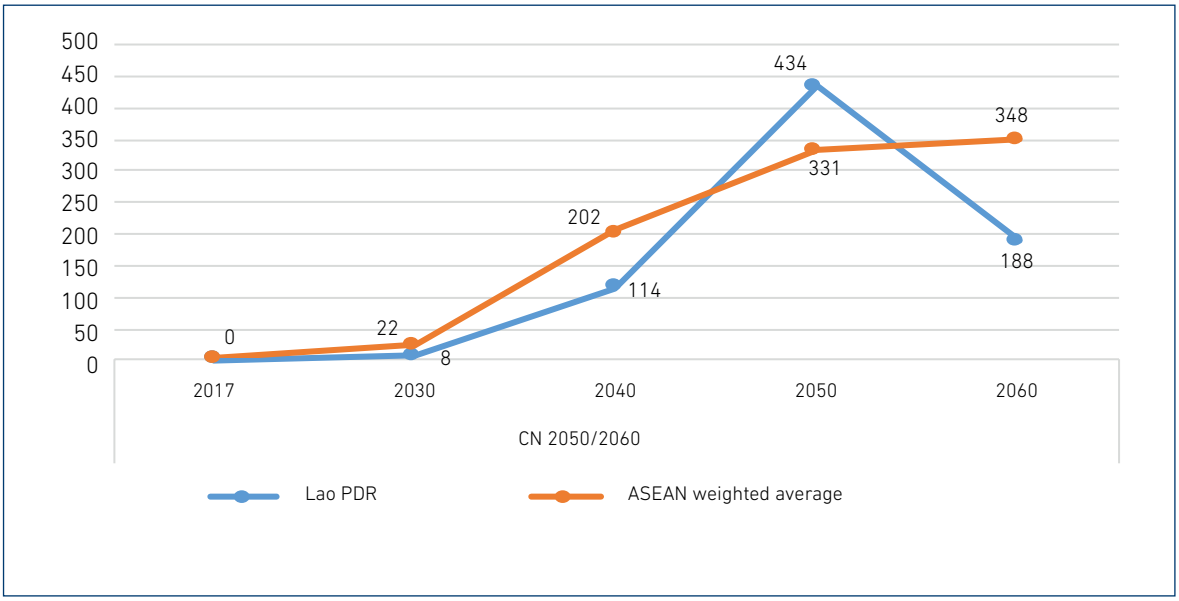
CN = carbon-neutral, CO_2 = carbon dioxide; DACCS = direct air capture with carbon storage; LULUCF = land use, land-use change, and forestry; $MtCO_2$ = million tonnes of carbon dioxide.

Source: Author's calculations.

Under the carbon-neutral scenario, emissions from the power sector will be mostly decarbonised through technologies such as CCUS (Figure 1.4). Only emissions from transport, industries, and 'other end use' will still need to be captured, as those sectors will continue to use fossil fuels. Thus, it is best to have a policy to replace fossil fuels with synthetic fuels. Moreover, Lao PDR has the potential of green hydrogen production as well as carbon capture from existing coal-fired power plants, which could further help decarbonise the sectors.

The best means to decarbonise the energy system is to retire coal-fired power plants by 2050 and to cease the development of additional coal-fired power plants by 2050. Coal should also be co-combusted with ammonia and be integrated with CCUS under the carbon-neutral scenario.

Figure 1.5. Marginal Abatement Cost of Emissions, Baseline versus Carbon-Neutral 2050 Scenarios (US$/tCO2)



ASEAN = Association of Southeast Asian Nations, CN = carbon-neutral, tCO_2 = tonne of carbon dioxide.

Source: Author's calculations.

For Lao PDR, the marginal abatement cost is predicted to drop from US$434/tonne of carbon dioxide (tCO_2) in 2050 to US$188/$tCO_2$ in 2060. In general, this decarbonisation cost is lower than that of the ASEAN average almost by half (Figure 1.5). Considering the potential of carbon credits from forests and carbon-offsetting from renewables, Lao PDR could be in the position of economic gain from selling carbon credits.

6. Conclusion and Policy Implications

Meeting a carbon-neutral goal requires a country to achieve large-scale emissions reduction through fundamental transformation of its energy system – the decarbonisation of the power sector, followed by the electrification or decarbonisation of energy consumption, and offsetting of remaining emissions using negative-emissions technologies. However, the availability of power systems or low-carbon energy and the possibility of using alternative energy vary significantly across countries and regions; energy transition cannot be accomplished uniformly across the globe. While numerous opportunities to reduce emissions exist, the transition to carbon neutrality must safeguard energy supplies and recognise some countries' limited ability to fully embrace renewables due to economic constraints and huge decarbonisation costs.

Lao PDR's energy primarily comes from coal, oil, hydropower, and 'others' (including biomass, solar, and electricity for export). The combined shares of coal and oil are expected to fall to about 20% of the primary energy supply by 2050 under the carbon-neutral scenario. As Lao PDR has great potential towards hydro, solar, wind, and biomass, this could allow the country to maximise its electricity net exports on the ASEAN Power Grid and to make renewable energy the dominant fuel source by 2050. Other clean fuels, such as ammonia, could also play a role in decarbonising the power sector through coal/ammonia co-combustion.

For end-use sectors, it is expected that electricity will comprise the largest share of Lao PDR's final energy consumption by 2050. The increasing share of electricity consumption in end-use sectors will be key for decarbonisation as well. However, oil and biomass will remain the dominant fuel sources of energy by 2050 even under the carbon-neutral scenario. Lao PDR can do more to accelerate the use of electricity in transport to reduce oil consumption by, for example, embracing electric vehicles. Further, the industrial sector could use electricity or green hydrogen much more, as Lao PDR also has great potential towards green electricity from hydropower, solar, wind, and biomass.

Lao PDR faces many challenges towards decarbonisation, including its reliance and commitment to large coal-fired power plants. It could, however, encourage clean coal technology with CCUS as well as using carbon to produce synthetic fuels for transport. The country is also encouraged to retire coal-fired power plants by 2050 and to stop their development outside of the existing pipeline. Coal should also be co-combusted with ammonia for the energy transition and be integrated with CCUS.

Broad policy directions include (i) energy supply security; (ii) a resilient power system and power market; (iii) sustainable transport systems; (iv) affordable energy for all; (v) energy efficiency improvement and electrification in end-use sectors, promotion of the energy management system and energy service companies, and creation of energy performance standards; (vi) alternative energy, especially renewables and clean technologies; (vii) sustainable hydropower development; (viii) carbon market and carbon credit mechanisms; (xi) regional and international cooperation for energy technological transfer; (x) bridging knowledge gaps; and (xi) financing sustainable energy infrastructure for Lao PDR and ASEAN.

Lao PDR should accelerate the penetration of variable renewables as well as other carbon-free (e.g. hydro, geothermal, biomass, nuclear, carbon dioxide-free hydrogen, and CCUS) and negative emissions technologies and forest carbon sinks. All should contribute to the country's carbon neutrality by the 2050 goal and promote sustainable economic development. During the energy transition period, fuel switching from coal to natural gas, deployment of more efficient turbines, and co-firing with hydrogen or ammonia will play important roles in decarbonisation and energy security. While affordable technologies must be deployed in the mid-term, more niche – and expensive – technologies are required in the last stage of carbon neutrality, including those concerning CCUS, hydrogen, and ammonia. The cost of decarbonisation remains a concern; in this regard, costs must be reduced through technology innovation, large-scale deployment of low-carbon technologies, and regional and international cooperation.

There are three important steps to ensure a smooth energy transition:

(i) **Early decarbonisation transition technologies**. These technologies involve immediate switching from coal to natural gas power generation, waste to energy plants in the power sector, and leak detection for fugitive emissions reduction upstream. These technologies can be deployed in the early phases of a country's transition pathway and may be retired before reaching net-zero emissions.

(ii) **Partial emissions reduction transition technologies.** These technologies include the co-combustion of coal-fired power generation with biomass or ammonia and the co-combustion of gas-fired power generation with hydrogen fuel. The share of biomass, ammonia, and hydrogen to the power generation mix must increase over time. For the upstream sector, electrification in gas production and processing should be introduced.

(iii) **Deep decarbonisation transition technologies.** These technologies include CCUS combined with coal/gas power generation, blue hydrogen, blue ammonia, and CCUS in gas processing. More technologies that involve the power and end-use sectors should also be embraced.

Financing clean technologies and renewables is still a critical issue in Lao PDR. Striving for a circular economy may help – as well as offer environmental benefits – through recirculating a larger share of materials, reducing waste in production, lightweighting products and structures, and extending the lifetime of products. All of these activities also offer the opportunity for new business models. In addition, the role of digitalisation will help the economy become more efficient through energy savings and efficiency, which, in turn, contributes to overall emissions and cost reduction, particularly the energy intensity reduction.

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Annex

Table 1.A1. Final Energy Demand of Lao PDR
(Mtoe)

	Baseline					Carbon-Neutral 2050/2060			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Coal	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.00
Oil	1.47	3.38	3.65	4.12	3.50	1.47	3.38	3.65	3.15
Oil (non-energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synthetic liquid fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas	0.00	0.32	0.41	0.41	0.55	0.00	0.27	0.36	0.36
Natural gas (non-energy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synthetic methane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.47	0.96	1.79	3.14	4.10	0.47	0.97	1.79	3.36
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	1.44	1.34	1.27	1.21	1.21	1.44	1.34	1.27	1.21
Total	**3.49**	**6.11**	**7.22**	**8.97**	**9.46**	**3.49**	**6.07**	**7.18**	**8.08**
Share of electricity	**0.13**	**0.16**	**0.25**	**0.35**	**0.43**	**0.13**	**0.16**	**0.25**	**0.42**

Lao PDR = Lao People's Democratic Republic, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Table 1.A2. Power Generation of Lao PDR
(TWh)

	Baseline					Carbon-Neutral 2050			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	13.66	13.66	22.04	29.65	29.15	13.66	13.66	10.35	0.00
Coal-ammonia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.35
Coal-biomass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Baseline					Carbon-Neutral 2050			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas-hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	23.04	23.24	23.24	120.71	120.71	23.04	43.51	76.61	103.06
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar PV	0.01	0.01	0.01	0.62	0.74	0.01	0.01	10.89	107.24
Onshore wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Offshore wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.06	8.76
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammonia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86
Net imports	–30.97	–25.10	–23.37	–112.55	–100.40	–30.97	–45.24	–72.93	–161.13

Lao PDR = Lao People's Democratic Republic, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculations.

Table 1.A3. Primary Energy Supply of Lao PDR

(Mtoe)

	Baseline					Carbon-Neutral 2050			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	3.60	3.60	5.22	6.83	6.49	3.60	3.60	2.75	2.12
Natural gas	0.00	0.32	0.41	0.41	0.55	0.00	0.27	0.36	0.36
Oil	1.47	3.38	3.65	4.12	3.50	1.47	3.38	3.65	3.15
Hydro	1.98	2.00	2.00	10.38	10.38	1.98	3.74	6.59	8.86
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar	0.00	0.00	0.00	0.05	0.06	0.00	0.00	0.94	9.22

	Baseline					Carbon-Neutral 2050			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biomass	1.44	1.34	1.27	1.21	1.21	1.44	1.34	1.29	3.62
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammonia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95
Share of fossil fuel	59.69	68.62	73.94	49.38	47.50	59.68	58.80	43.42	19.90
Share of renewables and clean fuels	40.31	31.38	26.06	50.62	52.50	40.32	41.20	56.58	80.10

Lao PDR = Lao People's Democratic Republic, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Table 1.A4. Emissions of Lao PDR

(MtC)

	Baseline					Carbon-Neutral 2050			
	2017	2030	2040	2050	2060	2017	2030	2040	2050
Electricity	13.84	13.84	20.27	26.63	25.30	13.84	13.84	1.26	–9.32
Industry	0.59	1.73	2.94	5.08	5.86	0.59	1.59	2.47	1.25
Transport	3.15	4.50	4.61	4.69	3.78	3.15	4.50	4.61	4.39
Other end use	1.23	5.46	5.26	4.57	3.15	1.23	5.35	5.14	4.46
Other including DACCS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–0.77
LULUCF						0.00	0.00	0.00	0.00
Energy-related emissions	18.80	25.54	33.07	40.98	38.09	18.80	25.28	13.47	0.00

DACCS = direct air capture with carbon storage; Lao PDR = Lao People's Democratic Republic; LULUCF = land use, land-use change, and forestry; MtC = million tonnes of carbon.

Source: Author's calculations.