

# Energy Security White Paper: Policy Directions for Inclusive and Sustainable Development for Lao PDR and the Implications for ASEAN

Edited by

Han Phoumin

Anousak Phongsavath



**Energy Security White Paper:**

**Policy Directions for Inclusive and Sustainable Development for The People's Democratic Republic of Lao and the Implications for the Association of Southeast Asian Nations**

© Economic Research Institute for ASEAN and East Asia, 2024.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means electronic or mechanical without prior written notice to and permission from ERIA.

The findings, interpretations, conclusions, and views expressed in their respective chapters are entirely those of the author/s and do not necessarily reflect the views and policies of the Economic Research Institute for ASEAN and East Asia, its Governing Board, Academic Advisory Council, or the institutions and governments they represent. Any error in content or citation in the respective chapters is the sole responsibility of the author/s.

Material in this publication may be freely quoted or reprinted with proper acknowledgement.

Cover Art by Artmosphere

Book Design by Artmosphere

National Library of Indonesia Cataloguing-in-Publication Data

ISBN no. 978-602-5460-57-9

Photo cover note; clockwise from top left

Sepon Mine Vilabouly district, Savannakhet Province, Southern Lao

Nam Ngum 1 Dam Hydropower

Keo Oudom District, Vientiane Province

Hongsa Coal Fired Power Plant

Ban Han, Hongsa, Sainyabuli, Lao

# Foreword

Saleumxay Kommasith  
Deputy Prime Minister and Minister of Foreign Affairs  
Lao People's Democratic Republic

---

Over the past decades, rapid economic development has transformed Southeast Asia, preparing the region to join the international production network. This transformation has enabled vibrant exports of manufacturing products, textiles, and other high-valued-added goods, including energy, from the Association of Southeast Asia Nations (ASEAN) to the global market. This success is largely due to global investments attracted by the region's favourable labour force, growing connectivity, innovation, and regional political stability driven by ASEAN's vision.

This achievement reflects the collective efforts of ten Southeast Asian countries to promote mutual trust and cooperation, broadening collaboration with nations worldwide for regional prosperity. However, the ASEAN region, like others, faces numerous challenges, including maintaining economic growth, addressing climate change, managing natural disasters, and tackling both traditional and non-traditional security issues. Lao PDR, in particular, must broaden its macroeconomic structure and policies to address current economic issues – such as inflation, currency depreciation, and employment – and future challenges related to green growth for sustainable development.

In 2024, Lao PDR has set the theme for its ASEAN Chairmanship as 'ASEAN: Enhancing Connectivity and Resilience.' Under this theme, energy security remains a key priority for ASEAN, supporting inclusive and sustainable economic growth in the region.

ASEAN countries are parties to the Paris Agreement, committing to reducing global greenhouse gas emissions (GHGs) as outlined in each country's Nationally Determined Contributions (NDCs). To achieve the carbon neutrality target by mid-century, countries must pursue alternative fuel pathways, shifting from fossil fuel-based energy systems to cleaner energy systems. Multiple decarbonisation pathways are essential. Amongst the policies and measures encouraging investment in a sustainable energy system and energy security, energy efficiency and conservation are considered low-hanging fruits for curbing energy consumption and reducing CO<sub>2</sub> emissions.

Many ASEAN countries are rich in natural resources and renewable energy, including solar, wind, biomass, geothermal, and hydropower. With the right policies, the region can accelerate the deployment of these renewable resources to green its energy system. Lao PDR, in particular, can play a significant role in contributing renewable electricity to help decarbonise the ASEAN grid through power connectivity and trade. The gradual adoption of hydrogen and ammonia as fuel presents untapped potential for clean energy, converting surplus renewable energy from hydropower, solar, wind, and biomass into clean fuel molecules like hydrogen and ammonia. These could be used in transportation, power generation, and industries, benefiting countries that can produce green hydrogen and ammonia. Lao PDR stands to gain significantly from this, given its abundant renewable resources.

---

Despite exporting electricity to neighbouring countries, Lao PDR has a high dependency on imported finished petroleum products such as gasoline, diesel, liquefied petroleum gas (LPG), and kerosene for domestic consumption in transportation, commercial, and residential sectors. This dependency makes Lao PDR's energy supply security vulnerable, necessitating an appropriate energy security strategy to mitigate potential risks.

This White Paper provides key policy directions for all involved sectors, emphasising the importance of cooperation, collaboration, and investment in creating a resilient, inclusive, and sustainable energy system. Sustainable finance, through investments in clean technologies, renewables, energy efficiency, ecotowns, smart grids, electric vehicles, and battery energy storage, can drive sustainable development and decarbonisation in the region.

While policies are advancing to support clean and renewable energy development, unnecessary energy subsidies must be scrutinised. These subsidies place an economic burden on many countries, particularly developing economies in ASEAN, deter investment in energy infrastructure and efficient technologies, and undermine renewable energy initiatives. Although some ASEAN countries have acted to remove these subsidies, governments must do so cautiously, as removing subsidies can be politically sensitive. Inefficient subsidies can lead to increased energy demand, fiscal pressure, harmful emissions, and hinder sustainable green growth. However, targeted subsidies are essential to support the energy poor.

Financing clean technologies and renewables is a critical issue in Lao PDR and ASEAN. Innovative financing mechanisms, including blended finance, can help make renewable projects and clean energy development technologies bankable. New sources of capital mobilisation through green bonds, sustainable bonds, social bonds, and climate transition bonds can accelerate the deployment of clean and renewable technologies in the region.

ASEAN must enhance cooperation under its three community pillars: promoting infrastructure connectivity, narrowing the development gap, promoting greater economic integration and people-to-people exchanges, and strengthening relations with external partners. This approach will maintain ASEAN's relevance and centrality in the evolving regional architecture. Regional and international cooperation can facilitate technological transfers and lower the cost of clean and renewable energy deployment in ASEAN. Under Lao PDR's ASEAN Chairmanship, the country aims to expand ASEAN's external relations, strengthen ASEAN's centrality and unity, and construct a regional architecture for stability, peace, and development.

---

Promoting carbon neutrality and ensuring national and regional energy are critical for inclusive and sustainable development. This energy policy white paper calls for cooperation from all stakeholders in policy design and implementation at all levels. Lao PDR is ready to support the development of policies and measures suggested in the White Paper and to collaborate bilaterally, regionally, and internationally to achieve carbon neutrality by 2050.

**Saleumxay Kommasith**

Deputy Prime Minister and Minister of Foreign Affairs  
Lao People's Democratic Republic

# Preface

Phoxay Sayasone  
Minister of Energy and Mines  
Lao People's Democratic Republic

---

I am very delighted to see the comprehensive development of the Energy Policy White Paper on 'Energy Security Policy Directions for Inclusive and Sustainable Development for Lao PDR and the Implications for ASEAN.' This White Paper has been developed through careful processes, including two extensive stakeholder consultations to gather views and feedback from line ministries, involved agencies, embassies, and experts on key issues around energy security, inclusive growth, and sustainability of the energy system.

The White Paper reflects the commitment of both parties, 'The Ministry of Energy and Mines (MEM), Lao PDR, and the Economic Research Institute for ASEAN and East Asia,' as outlined in the signed 3-year Memorandum of Understanding (MoU). Under this MoU, ERIA provides technical support to MEM during Lao PDR ASEAN Chairmanship and follows up on the Energy Security White Paper. I am also very pleased that ERIA plays critical role in supporting ASEAN countries in the energy transition. As you may be aware, Lao PDR, as well as the rest of ASEAN, are facing tremendous challenges regarding the future energy landscape and how the energy transition will embrace a new architecture, including sound policies and technologies to ensure energy access with affordability, energy security, and energy sustainability. Pathways towards carbon neutrality could be diverse amongst countries. Availability, accessibility, and affordability of energy supply are the most fundamental requirements for Lao PDR with respect to the energy security and sustainable development.

Lao PDR's high potential renewable energy resources, such as hydro, solar, wind, and biomass, could be utilised at optimum levels to accelerate the share of renewables in the energy mix. These renewable resources could allow Lao PDR to build a green and resilient economy. Lao PDR is in a good position not only to achieve the decarbonisation of its own energy system, but also to help green the ASEAN Grid through power exchange and the future power market of ASEAN.

In the context of energy security, Lao PDR could be more resilient if all end-use sectors move towards electricity usage. The adoption of electric vehicles (EV) could be a good strategy, as it would reduce the import of petroleum products such as gasoline, diesel, LPG, and kerosene. Accelerating the use of electricity in all sectors will bring about new opportunities for developing clean fuels such as ammonia and hydrogen, which could be used for industries and heavy-duty transport modes for both inland and waterway transportation. Furthermore, green ammonia will provide a new opportunity for producing green agricultural fertilisers domestically, reducing the need to import fertilisers and petroleum products.

Although Lao PDR is expected to have a high share of renewables, some petroleum products will continue to play roles in the energy mix. Therefore, it is crucial for Lao PDR to leverage energy cooperation through existing ASEAN mechanisms such as the ASEAN Petroleum Security Agreement (APSA) to ensure mutual assistance during times of distress when energy supplies are disrupted by extreme weather conditions or terrorist attacks. Nonetheless, Lao PDR must also have systems in place to respond to supply disruptions, requiring reserve capacity and the ability to act in emergencies.

The next steps involve accelerating energy cooperation to ensure that Lao PDR is equipped with the human resources needed to handle required technologies for the transition and future challenges. This includes gaining knowledge of smart grids, the Internet of Things, possibly Artificial Intelligent (AI) and automation in the power sector, as well as understanding EVs and recycling if transportation shifts towards electricity and hydrogen fuel. Closing knowledge gaps in technology know-how for energy transitions and future technologies is paramount.

The Ministry of Energy and Mines, Lao PDR (MEM), seeks cooperation at all levels within the government, line ministries, agencies, and involved stakeholders to participate in the process of building strategic policies to safeguard Lao PDR's energy security while ensuring inclusiveness and sustainable development. I extend my sincere appreciation to ERIA and the experts led by Dr Han Phoumin, my senior staff such as Permanent Secretary Mr Khamso Kouphokham, Director General of the Research Institute for Energy and Mines Dr Anousak Phongsavath, and all DGs and key staff for their strong collaboration and hard work in shaping this important policy direction on energy security for inclusiveness and sustainable development for Lao PDR, with significant implications for ASEAN.

### **Phoxay Sayasone**

Minister of Energy and Mines  
Lao People's Democratic Republic

# Preface

Tetsuya Watanabe

President of Economic Research Institute for ASEAN and East Asia (ERIA)

---

Since the 2020s, the world has navigated complex socio-political challenges, including the Covid-19 pandemic, the prolonged Russia–Ukraine war, Middle East tensions, and the ongoing economic conflict between the United States and China. Amongst the numerous issues arising from these black swan events, high energy costs have the potential to divert countries from long-term decarbonisation efforts. These events have also served as a wake-up call for countries to secure their energy sources while maintaining commitments to achieve carbon neutrality by 2050.

The Economic Research Institute for ASEAN and East Asia (ERIA) has actively supported the Association of Southeast Asia Nations (ASEAN) by crafting a regional decarbonisation roadmap and providing perspectives on energy transition technologies. These efforts help countries embark on the right paths for a smooth energy transition. Moving towards a green and clean energy system will depend on clean technologies, fuels, and the deployment of renewable energy resources. In this regard, energy policy and planning must facilitate and accommodate investments in clean technologies and renewables, providing new opportunities for investment and adding value to the economy.

Technically, ASEAN is rich in solar photovoltaic (solar PV) resources, though only a few countries, such as Viet Nam, Indonesia, and the Philippines, have significant offshore wind resources. The Mekong subregion countries (Thailand, Myanmar, Lao PDR, Cambodia, and Viet Nam) are abundant in hydropower resources. High penetration of hydropower, solar PV, wind, and biomass power generation in ASEAN could be facilitated by future power connectivity and trade within the entire region. If the ASEAN electricity market gradually evolves into a multilateral electricity market, hydropower resources from the Mekong subregion could play a significant role as baseload power, complementing the high penetration of solar and wind energy. In the absence of thermal power plants, large capacity electrical discharge ‘battery energy storage’ will be needed to back up power shortages during periods of low sunshine and wind. Battery energy storage, hydrogen fuel, and ammonia could be considered as they can be produced from excess electricity generated by hydropower, solar PV, wind, and biomass.

To support Lao PDR’s ASEAN Chairmanship, ERIA and the Ministry of Energy and Mines, Lao PDR, signed a Memorandum of Understanding (MoU) to conduct a study and develop a Strategic White Paper on ‘Energy Security for Inclusiveness and Sustainable Development for Lao PDR and the Implications for ASEAN.’ This study is significant for ASEAN countries as it examines energy security while providing a direction for inclusive growth and sustainable development. The study aligns energy security objectives with countries’ long-term climate commitments as reflected in their Nationally Determined Contributions (NDCs) and carbon neutrality goals by mid-century.

ERIA's experts, together with experts from the Ministry of Energy and Mines, approached this task diligently, including a scoping analysis of key energy issues and stakeholder involvement. Key energy issues were identified by analysing the entire energy system of Lao PDR in relation to neighbouring countries. These issues related to energy security include fossil fuel import dependency, energy efficiency, power grid connectivity, power systems, transportation (including the introduction of electric vehicles), carbon credits and mechanisms, carbon markets, regional and international cooperation for innovative technological transfer, financing sustainable energy infrastructure, and closing knowledge gaps. Experts used Strength, Weakness, Opportunity, and Threat (SWOT) analysis to understand the detailed aspects of opportunities and challenges, such as establishing energy security mechanisms, scaling up renewable penetration into the energy system, introducing electric vehicles and hydrogen fuel, and developing the carbon market.

This Energy White Paper provides broad policy directions with options best suited to various energy systems. Importantly, the White Paper is based on evidence-based research findings conducted by energy experts with input from a wide range of stakeholders. I am very pleased with the entire process of developing the 'White Paper on Energy Security Policy Directions for Inclusive and Sustainable Development for Lao PDR and the Implications for ASEAN.'

I hope this White Paper will open up new opportunities for developing detailed policies to support investment in clean technologies and the uptake of renewable resources. Fast-tracking energy finance for the energy transition is critical to ensure countries can secure enough funds for their energy transformation while maintaining energy security. I also want to thank all experts, especially Dr Han Phoumin, the Senior Energy Economist who led the team of experts in this important task. I also thank Mr Khamso Kouphokham, the Permanent Secretary; Dr Anousak Phongsavath, Director General of Research Institute for Energy and Mines; and all other key stakeholders involved in developing the White Paper. Additionally, I thank the Mekong River Commission Secretariat (MRCS) for deploying their experts to contribute to the analysis of sustainable hydropower development in the Mekong subregion.



**Tetsuya Watanabe**

President of ERIA

# Acknowledgements

---

The Energy Security White Paper was developed by a working group consisting of teams from Lao PDR and the Economic Research Institute for ASEAN and East Asia (ERIA). Laotian team included experts from the Ministry of Energy and Mines (MEM), while the ERIA team brought together specialists in energy economics and policy, power systems, sustainable transport, energy efficiency and conservation, green financing, and capacity-building training. Extensive consultations were conducted with various local experts in Lao PDR's energy sector, whose feedback greatly informed the international experts on the policy directions necessary to achieve energy security in the country.

This White Paper was led by Dr Han Phoumin, Senior Energy Economist at ERIA, and co-led by Dr Anousak Phongsavath, Director General of the Research Institute of Energy and Mines (RIEM), MEM, Lao PDR.

This White Paper would not have been possible without the contributions and support of all the authors: Dr Alloysius Joko Purwanto (ERIA), Mr Kei Sudo (ERIA), Mr Jeremy Gross (ERIA), Ryan Wiratama Bhaskara (ERIA), Citra Endah Nur Setyawati (ERIA), Dr Weerawat Chantanakome (Ministry of Energy, Thailand), Prof. Farhad Taghizadeh-Hesary (Tokai University, Japan), Dr Ruengsak Thitirasakul (Petroleum Institute of Thailand), Prof. Phouphet Kyophilavong (National University of Laos), Ir. Leong Siew Meng (Green Technology Solutions Plt, Malaysia), Ir. Ong Ching Loon (Cofreth (M) Sdn Bhd, Malaysia), Ir. Lam Kim Seong (Prudenergy Consulting Sdn Bhd, Malaysia), Dr Anoulak Kittikhoun (Mekong River Commission Secretariat (MRCS)), Mr Sophearin Chea (MRCS), Mr Sopheak Meas (MRCS), Ms Ly Thim (MRCS), Mr Peeti Ngamprapasom (MRCS), and Dr Hoyyen Chan (Invite Green Consultancy).

The team also acknowledges the support from ERIA colleagues: Mr Stefan Wesiak, Ms Fadriani Trianingsih, and Ms Eunike Septiani for their work in editing and typesetting, as well as Ms Tri Muliani Manik for her administrative and logistical assistance during the consultations and preparation of the White Paper.

**Khamso Kouphokham**

Permanent Secretary  
Ministry of Energy and Mines  
Lao People's Democratic Republic

**Naoto Okura**

Director General for Research and Policy Design  
ERIA

# List of Project Members

---

**Khamso Kouphokham**

Permanent Secretary, Ministry of Energy and Mines, Lao PDR

**Anousak Phongsavath**

Director General, Dr Anousak Phongsavath, Research Institute for Energy and Mines, Ministry of Energy Mines, Lao PDR

**Han Phoumin**

Senior Energy Economist, ERIA

**Alloysius Joko Purwanto**

Energy Economist, ERIA

**Kei Sudo**

Programme Manager on Energy, ERIA

**Jeremy Gross**

Director of Mekong Affairs and Capacity Building, ERIA

**Weerawat Chantanakome**

Special Councilor on International Affairs, Ministry of Energy, Thailand

**Ong Ching Loon**

Managing Director, Cofreth (M) Sdn Bhd, Malaysia

**Leong Siew Meng**

Energy Efficiency Expert of Appliances and Building, Green Technology Solutions PLT, Malaysia

**Anoulak Kittikhoun**

Chief Executive Officer, Mekong River Commission Secretariat

**Sophearin Chea**

Chief River Basin Planner, Mekong River Commission Secretariat

**Sopheak Meas**

Stakeholder Engagement Specialist, Mekong River Commission Secretariat

**Ly thim**

Water Policy and Planning Expert, Mekong River Commission Secretariat

---

**Peeti Ngamprapasom**

Sustainable Hydropower Specialist, Mekong River Commission Secretariat

**Phouphet Kyophilavong**

Vice President, National University of Laos

**Ruengsak Thitirasakul**

Advisor, Petroleum Institute of Thailand

**Lam Kim Seong**

Director, Prudenergy Consulting Sdn Bhd, Malaysia

**Masaharu Yogo**

Senior Consultant, International Business Development Office, TEPCO Power Grid

**Farhad Taghizadeh-Hesary**

Associate Professor, Tokai University, Japan

**Hoyyen Chan**

Energy-Climate Expert, Invite Green Consultancy

**Ryan Wiratama Bhaskara**

Research Associate, ERIA

**Citra Endah Nur Setyawati**

Research Associate, ERIA

# Table of Contents

---

Foreword by the Deputy Prime Minister, Lao PDR	iii
Preface by the Minister of Energy and Mines, Lao PDR	vi
Preface by the President of ERIA	viii
Acknowledgements	x
List of Project Members	xi
Table of Contents	xiii
List of Figures	xv
List of Tables	xix
List of Abbreviations	xxi
<b>Part I: Energy Security White Paper:</b> <b>Policy Directions for Inclusive and Sustainable Development for The People’s Democratic Republic of Lao and the Implications for the Association of Southeast Asian Nations</b>	<b>2</b>
<b>Part 2: Evidence-Based Findings to Support the Energy Security White Paper:</b>	<b>38</b>
<b>Chapter 1 Energy Landscape of Lao PDR</b> Han Phoumin	<b>42</b>
<b>Chapter 2 Energy Supply Security of Lao PDR and Implications for ASEAN</b> Ruengsak Thitirasakul	<b>56</b>
<b>Chapter 3 A Resilient Power System and Power Market in Lao PDR</b> Masaharu Yogo and Kei Sudo	<b>70</b>
<b>Chapter 4 Sustainable Transport Systems in Lao PDR and Implications for ASEAN</b> Alloysius Joko Purwanto, Citra Endah Nur Setyawati, Ryan Wiratama Bhaskara	<b>88</b>

---

<b>Chapter 5</b>	<b>Securing Affordable Energy for the Growing Industrial, Commercial, and Residential Sectors in Lao PDR</b> Phouphet Kyophilavong	124
<b>Chapter 6</b>	<b>Energy Efficiency in End-use Sectors – Implications for ASEAN and Lao People’s Democratic Republic</b> Leong Siew Meng	140
<b>Chapter 7</b>	<b>Energy Management Systems and Energy Service Companies</b> Ong Ching Loon	158
<b>Chapter 8</b>	<b>Minimum Energy Performance Standards</b> Lam Kim Seong	184
<b>Chapter 9</b>	<b>Renewable Electricity and Energy Transition in Lao PDR: Opportunities for Green Hydrogen and Ammonia</b> Anousak Phongsavath	198
<b>Chapter 10</b>	<b>Optimising Sustainable Hydropower Development on the Mekong: What Direction Should Lao PDR Take?</b> Anoulak Kittikhoun, Sophearin Chea, Sopheak Meas, Ly Thim and Peeti Ngamprapasom	232
<b>Chapter 11</b>	<b>Voluntary Carbon Markets and Mechanisms in Lao PDR’s Energy Sector</b> Hoyyen Chan	254
<b>Chapter 12</b>	<b>Regional and International Cooperation to Advance Innovative Technology Transfer for Lao PDR and ASEAN</b> Weerawat Chantanakome	290
<b>Chapter 13</b>	<b>Latest Developments in Carbon Capture, Utilisation, and Storage and Hydrogen in ASEAN – Lessons for Lao PDR</b> Ryan Wiratama Bhaskara, Citra Endah Nur Setyawati	310
<b>Chapter 14</b>	<b>Ways to Finance Energy Supply Security in Lao PDR and Implications for ASEAN</b> Farhad Taghizadeh-Hesary	330
<b>Chapter 15</b>	<b>Capacity-Building Needs for Energy Security for Lao PDR</b> Jeremy Gross	346
<b>Annex: Summary</b>		352

# List of Figures

---

<b>Figure 1.1</b>	Final Energy Demand by Fuel Sources, Baseline versus Carbon-Neutral 2050 Scenarios (Mtoe)	43
<b>Figure 1.2</b>	Power Generation by Fuel Sources, Baseline versus Carbon-Neutral 2050 Scenarios (TWh)	44
<b>Figure 1.3.</b>	Primary Energy Supply by Fuel Source, Baseline versus Carbon-Neutral 2050 Scenarios	45
<b>Figure 1.4</b>	Emissions, Baseline versus Carbon-Neutral 2050 Scenarios (MtCO <sub>2</sub> )	46
<b>Figure 1.5</b>	Marginal Abatement Cost of Emissions, Baseline versus Carbon-Neutral 2050 Scenarios (US\$/tCO <sub>2</sub> )	47
<b>Figure 2.1</b>	Lao PDR's Total Energy Supply	56
<b>Figure 2.2</b>	Risk Analysis to Evaluate Energy-Related Emergencies	61
<b>Figure 2.3</b>	Lao PDR's Access to Clean Cooking	63
<b>Figure 3.1</b>	Electricity System of Lao PDR	71
<b>Figure 3.2</b>	Power Generation Installed Capacity and Available Power Generation Energy	72
<b>Figure 3.3</b>	Monthly Electric Power Demand in Terms of Available Power Generation Energy, 2022	73
<b>Figure 3.4</b>	Maximum Domestic Power Demand Forecast, 2021–2030 (megawatts)	74
<b>Figure 3.5</b>	Power Generation Sources for Domestic Power Supply, 2030 (megawatts)	75
<b>Figure 3.6</b>	Monthly Available Electric Power Generation and Electric Power Demand, BAU (gigawatt-hours)	75
<b>Figure 3.7</b>	Power Sector Players	77
<b>Figure 3.8</b>	Monthly Electric Power Energy Available from Export-Dedicated Hydropower Plants, 2022	78
<b>Figure 3.9</b>	Current Electric Power System	81
<b>Figure 3.10</b>	Proposed Electric Power System	81
<b>Figure 4.1</b>	Main Economic Corridors in the Greater Mekong Subregion	90
<b>Figure 4.2</b>	Cargo Transported through Lao PDR, 2022 ('000 tonnes)	93
<b>Figure 4.3</b>	Tourist Arrivals in Lao PDR, 2003–2015 ('000)	94
<b>Figure 4.4</b>	Lao PDR–China Railway Route	96
<b>Figure 4.5</b>	Lao PDR Railway Planning	97
<b>Figure 4.6</b>	Lao PDR Key Road Corridors	100

<b>Figure 4.7</b>	Total Number of Cars in Lao PDR, 2018–2040 ('000 units)	103
<b>Figure 4.8</b>	Total Number of Motorcycles in Lao PDR, 2018–2040 ('000 units)	103
<b>Figure 4.9</b>	Total Number of Trucks and Buses in Lao PDR, 2018–2040 ('000 units)	104
<b>Figure 5.1</b>	Electricity Use Trends in Lao PDR, 2023–2024 (gigawatt-hours)	125
<b>Figure 5.2</b>	Electricity Demands of the Industrial, Commercial, and Residential Sectors in Lao PDR, 2023–2024	125
<b>Figure 5.3</b>	Gaps in Electricity Demand and Supply, 2023 (GWh)	128
<b>Figure 5.4</b>	Comparison of Electricity Prices in ASEAN (US\$/kilowatt-hour)	129
<b>Figure 5.5</b>	Electricity Prices across ASEAN (US¢/kilowatt-hour)	130
<b>Figure 6.1</b>	Significance and Impact of Energy Efficiency and Conservation Strategies	140
<b>Figure 6.2</b>	Key Directions to Kickstart EEC Implementation	144
<b>Figure 6.3</b>	Suggested Stakeholders in Partnering Programme	146
<b>Figure 6.4</b>	Generic Pyramid of Energy-Efficiency Indicators for the Industrial and Commercial Buildings Sectors	148
<b>Figure 6.5</b>	Significance and Benefits of Energy-Efficiency Indicator Benchmarking	149
<b>Figure 6.6</b>	Overall Demand- and Supply-side System Efficiency Improvement by Digitalisation	150
<b>Figure 6.7</b>	Capacity-Building Programmes and Awareness Campaigns	151
<b>Figure 6.8</b>	Overview of Energy Efficiency and Conservation Implementation and Legislative Framework	152
<b>Figure 7.1</b>	Implementation of Energy Management Systems – Benefits	158
<b>Figure 7.2</b>	Main Criteria of an Energy Management System	160
<b>Figure 7.3</b>	Typical Energy Policy	161
<b>Figure 7.4</b>	Core Workflow of Energy Planning	162
<b>Figure 7.5</b>	Monitoring of Specific Energy Consumption	164
<b>Figure 7.6</b>	Example of Results of Implementing Energy-Saving Action Plans	166
<b>Figure 7.7</b>	Example of the Energy Performance of a Company with an Energy Management System	167
<b>Figure 7.8</b>	Risks Assessment of Energy Performance Contracts	171

---

<b>Figure 7.9</b>	Core Differences between Energy Performance Contracts	172
<b>Figure 7.10</b>	Process of Energy Performance Contracts	173
<b>Figure 7.11</b>	Relationship between Energy Management Systems and Energy Service Companies	174
<b>Figure 7.12.</b>	Strengths, Weaknesses, Opportunities, and Threats for Energy Management Systems and Energy Service Companies	175
<b>Figure 7.13</b>	Organisational Structure of Implementation Agency	179
<b>Figure 8.1</b>	Flow Diagram of MEPS and Energy Labelling Programme	188
<b>Figure 8.2</b>	LED Lighting – MEPS Comparison (lumens per watt)	189
<b>Figure 8.3</b>	Regional Roadmap for Air Conditioner MEPS	191
<b>Figure 8.4</b>	Strengths, Weaknesses, Opportunities, and Threats for MEPS in Lao PDR	193
<b>Figure 9.1</b>	Total Lao PDR Final Energy Consumption by Sector, 2015–2040	199
<b>Figure 9.2</b>	Lao PDR Electricity Generation by Source, 2023	201
<b>Figure 9.3</b>	Renewable Electricity Development Plan	202
<b>Figure 9.4</b>	Classification of Hydrogen Production According to Carbon Intensity	204
<b>Figure 9.5</b>	Production of Hydrogen and Oxygen via Alkaline Electrolysis	205
<b>Figure 9.6</b>	PEM Electrolyser for Green Hydrogen Production	206
<b>Figure 9.7</b>	Economic Cycle of Ammonia from Production to Utilisation	207
<b>Figure 9.8</b>	Ammonia Synthesis Using Water, Air, and Renewable Electricity	208
<b>Figure 9.9</b>	Global Green Hydrogen Supply in 2020, 202.3 and 2050 under a 1.5oC Scenario	209
<b>Figure 9.10</b>	Historical Progress and Targets for Hydrogen Production	210
<b>Figure 9.11</b>	Urea Production	216
<b>Figure 9.12</b>	Sensitivity Analyses of the Levelised Costs of Green Urea Production in Lao PDR (US\$)	218
<b>Figure 9.13</b>	Emissions by Fuel Type or Industry, 1955–2022 (million tonnes)	220
<b>Figure 11.1</b>	Illustration of Corresponding Adjustment	258
<b>Figure 11.2</b>	ITMO Project Development Process	260

---

<b>Figure 12.1</b>	Technology Transfer Process in Thailand	293
<b>Figure 12.2</b>	Technology Transfer Policy in Singapore	296
<b>Figure 13.1</b>	Green Hydrogen Production Outlook by Country (million tonnes)	320
<b>Figure 13.2</b>	Blue Hydrogen Production Outlook by Country (million tonnes)	321
<b>Figure 14.1</b>	Spillover Effects of Electricity Supply	335
<b>Figure 14.2</b>	Green Credit Guarantee System Flow of Operations	336
<b>Figure 14.3</b>	Green Credit Guarantee Scheme and Loan Supply to Low-Carbon Projects	337

# List of Tables

---

<b>Table 1.A1</b>	Final Energy Demand of Lao PDR (Mtoe)	51
<b>Table 1.A2</b>	Power Generation of Lao PDR (TWh)	51
<b>Table 1.A3</b>	Primary Energy Supply of Lao PDR (Mtoe)	52
<b>Table 1.A4</b>	Emissions of Lao PDR (MtC)	53
<b>Table 2.1</b>	Lao PDR's Coal Reserve Status	56
<b>Table 2.2</b>	ASEAN Mandatory Oil Stockpiles	59
<b>Table 2.3</b>	Lao PDR's National Determined Contribution and Net-Zero Emissions Target	64
<b>Table 4.1</b>	Sectoral-based Freight Transport Demand in Lao PDR	91
<b>Table 4.2</b>	Road Vehicle Stock Data from Lao PDR	101
<b>Table 4.3</b>	SWOT Analysis of Electric Vehicle Adoption in Lao PDR	107
<b>Table 4.4</b>	SWOT Analysis of Biofuel Development for the Transport Sector in Lao PDR	109
<b>Table 4.5</b>	SWOT Analysis of Public Transport Development in Lao PDR	110
<b>Table 4.6</b>	SWOT Analysis of Lao PDR–China Railway	111
<b>Table 4.7</b>	SWOT Analysis of Logistics and Distribution Centres	113
<b>Table 5.1</b>	Electricity Balance in Lao PDR, 2000–2015 (gigawatt-hours)	126
<b>Table 5.2</b>	Characteristics of the Electricity Production by Owner	127
<b>Table 5.3</b>	Characteristics of the Electricity Production by Source	127
<b>Table 5.4</b>	Projects to Enhance Amount of Electricity in Lao PDR	128
<b>Table 5.4</b>	Electricity Prices for the Residential Sector	130
<b>Table 5.A1</b>	Electricity Prices with EGAT (B/kWh)	135
<b>Table 5.A2</b>	Wholesale Rate of Electricity (B/kWh)	135
<b>Table 5.A3</b>	Energy Price Setting, 2023	135
<b>Table 6.1</b>	Legislative Frameworks across ASEAN	143
<b>Table 7.1</b>	Example Agenda of a Management Review Meeting	165
<b>Table 7.2</b>	Levels of an Energy Audit	169

---

<b>Table 8.1</b>	Countries Adopting MEPS and Energy Labelling	184
<b>Table 8.2</b>	Equipment/Appliances with MEPS Implemented for Regional Economies	185
<b>Table 8.3</b>	Roadmap and Implementation Programme for MEPS in Lao PDR	187
<b>Table 8.4</b>	Air Conditioner MEPS of Regional Economies	190
<b>Table 8.5</b>	Star Ratings of Refrigerators in Malaysia	192
<b>Table 8.6</b>	MEPS for Refrigerators in Singapore	192
<b>Table 9.1</b>	Production Variables for the Green Urea Base Case, 2022	217
<b>Table 10.1</b>	Hydropower Projects in the Lower Mekong Basin by Country	236
<b>Table 10.2</b>	Total Installed Capacity of Hydropower Projects in the Lower Mekong Basin by Country (megawatts)	237
<b>Table 11.1</b>	Lao PDR's Nationally Determined Contribution Mitigation Targets for Energy-related Measures	254
<b>Table 11.2</b>	Examples of Emissions Reduction and Removal Activities	257
<b>Table 11.3</b>	Steps of ITMO Project Development Process	260
<b>Table 11.4</b>	Existing International Cooperation Frameworks Similar to the ITMO Mechanism	261
<b>Table 11.5</b>	Projects with Authorisation Statements under the Cooperation Framework of Article 6.2	262
<b>Table 11.6</b>	Voluntary Carbon Markets in ASEAN	266
<b>Table 13.1</b>	Estimated Storage Resources in ASEAN Member States	314
<b>Table 13.2</b>	Hydrogen-producing Potential from Unused Energies Compared to Hydrogen Demand Potential in the East Asia Summit Region in 2040 (million normal cubic metres)	319

# List of Abbreviations

---

<b>ADB</b>	Asian Development Bank
<b>ASEAN</b>	Association of Southeast Asian Nations
<b>CCS</b>	carbon capture and storage
<b>CCUS</b>	carbon capture, utilisation, and storage
<b>CN2050</b>	Carbon Neutral Scenario 2050
<b>CO<sub>2</sub></b>	carbon dioxide
<b>EDL</b>	Électricité du Laos (Electricity of Lao PDR)
<b>EE</b>	energy efficiency
<b>EEC</b>	Energy efficiency and conservation
<b>EGAT</b>	Electricity Generating Authority of Thailand
<b>EnMS</b>	Energy management system
<b>EPC</b>	energy performance contract
<b>ESCO</b>	Energy Services Companies
<b>EV</b>	electric vehicle
<b>FDI</b>	Foreign direct investment
<b>GCGS</b>	green credit guarantee scheme
<b>GDP</b>	gross domestic product
<b>GHG</b>	greenhouse gas
<b>IPP</b>	Independent Power Producers
<b>JCM</b>	Joint Credit Mechanism
<b>kWH</b>	kilowatt hour
<b>Lao PDR</b>	The People's Republic of Lao
<b>LCR</b>	Lao–China Railway
<b>LPG</b>	liquefied petroleum gas

<b>IPP</b>	Independent Power Producers
<b>MEM</b>	Government of Lao PDR, Ministry of Energy and Mines
<b>MEPS</b>	minimum energy performance standard
<b>MONRE</b>	Ministry of Natural Resources and Environment
<b>MRC</b>	Mekong River Commission
<b>Mtoe</b>	millions tonnes of oil equivalent
<b>MRV</b>	Measuring, reporting, and verification
<b>NDC</b>	Nationally Determined Contribution
<b>PNPCA</b>	Procedures for Notification, Prior Consultation, and Agreement
<b>R&amp;D</b>	research and development
<b>SEZ</b>	special economic zone?
<b>TTO</b>	technology transfer offices
<b>TWH</b>	terawatt-hour
<b>VCM</b>	voluntary carbon market