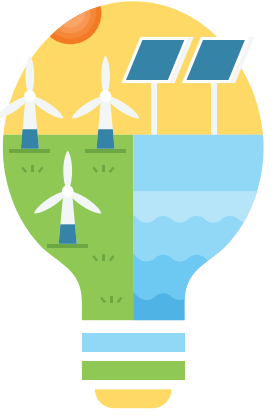


Lao PDR
Energy Statistics 2018

Prepared by
Ministry of Energy and Mines, Lao PDR

Supported by
The Economic Research Institute for ASEAN and East Asia

ERIA
Economic Research Institute
for ASEAN and East Asia

Cover Art by Artmosphere Design.

Book Design by Artmosphere Design.

National Library of Indonesia Cataloguing-in-Publication Data
ISBN: 978-602-5460-02-9

Disclaimer
The statistics contained in this book were prepared by the Department of Energy, Policy and Planning (DEPP) of the Ministry of Energy and Mines (MEM), Lao People's Democratic Republic, with the technical support of the Economic Research Institute for ASEAN and East Asia (ERIA). The data and statistics contained herein do not reflect the views or policies of MEM or ERIA but will help facilitate the data collection and future work of DEPP and improve energy data accuracy in the Lao PDR.

Foreword

Lao People's Democratic Republic (Lao PDR) has remarkably achieved high economic growth. Its average Gross Domestic Product (GDP) growth rate was 7.79% during the period 2000-2016, the highest growth rate among the Association of Southeast Asian Nations (ASEAN) member states during the same period. In 2016, its real GDP per capita was US$ 2,352. This strong economic growth during the last six years was also accompanied by an increase in energy consumption by all sectors. Despite this, Lao PDR still lacks comprehensive national energy statistics, especially energy balances tables. Consequently, nobody has accurate information about energy demand and supply due to the information are spread out in different line agencies. Lao PDR established energy policies to promote energy efficiency, renewable energy, best energy mix to maintain energy security, and so on, but these are not working because there is no official, historical, and consistent energy statistics.

The Ministry of Energy and Mines of Lao PDR realizes the need to have accurate and reliable energy statistics to design appropriate energy policies and planning. Therefore, to fulfil the gap in energy data and statistics in Lao PDR, the Ministry of Energy and Mines requested the Economic Research Institute for ASEAN and East Asia (ERIA) to support its Department of Energy Policy and Planning (DEPP) in preparing accurate energy statistics in Lao PDR. ERIA and DEPP established a team in October 2017 and worked on data collection. In addition, energy consumption surveys were carried out for the transportation, industry, residential, and commercial sectors. During the project period, ERIA also conducted capacity building trainings to DEPP staff such as basic understanding of energy statistics.

On behalf of the Ministry of Energy and Mines, Lao PDR, I am very grateful for the technical and financial support for this Energy Statistics Project. We will continue to consult ERIA to build the energy data to support energy policies and planning in Lao PDR.

24 May 2018

Dr. Khammany INTHIRATH
Minister of Ministry of Energy and Mines, Lao PDR

Acknowledgements

I express my sincerest gratitude to the members of the working group for their tireless efforts in developing this publication. The working group, consisting of experts from the Department of Energy, Policy and Planning of the Ministry of Energy and Mines and other line ministries of Lao People's Democratic Republic (Lao PDR), and the Economic Research Institute for ASEAN and East Asia (ERIA), contributed their time and expertise in building the energy statistics. They have produced brilliant work that will help formulate Lao PDR's future energy policies and plans. I would also like to express my gratitude to the Lao State Fuel Company, Electricité du Laos, Ministry of Industry and Commerce of Lao PDR, Lao National Chamber of Commerce and Industry, Department of Aviation, Lao Airlines, Lao Skyway, Ministry of Agriculture and Forestry, Department of Tax, Ministry of Information, Culture and Tourism, and other ministries and agencies for providing data and information and for their cooperation.

I give special thanks to Mr Shigeru Kimura of ERIA and his team for their excellent contribution to this project.

Dr Daovong Phonekeo
Permanent Secretary of Ministry of Energy and Mines, Lao PDR
June 2017

Contents

List of Tables

List of Figures

Abbreviations and Acronyms

BEI	building energy intensity
CO_2	carbon dioxide
DEPP	Department of Energy, Policy and Planning
EBT	energy balance table
EDL	Electricité du Laos / Electricity of Lao PDR
ERIA	Economic Research Institute for ASEAN and East Asia
GCV	gross calorific value
GDP	gross domestic product
GWh	gigawatt-hour
IPP	independent power producer
ISIC	International Standard Industrial Classification
kl	kilolitre
kt	kiloton
ktoe	thousand ton oil equivalent
kWh	kilowatt-hour
Lao PDR	Lao People's Democratic Republic
LPG	liquefied petroleum gas
MEM	Ministry of Energy and Mines
MWh	megawatt-hour
NCV	net calorific values
PPP	purchasing power parity
TFEC	total final energy consumption
TPES	total primary energy supply

List of Project Members

From the Ministries and Agencies of the Lao PDR

Mr Khamso KOUPHOKHAM, Acting Director General, Department of Laws, Ministry of Energy and Mines (MEM) and former Deputy Director General, Department of Energy Policy and Planning, MEM

Mr Litthanoulok LASPHO, Director of Division, Department of Energy Policy and Planning, MEM

Mr Phaysone PHOUTHONESY, Technical Officer, Department of Energy Policy and Planning, MEM

Ms Khonetavanh DOUANGCHANH, Technical Officer, Department of Energy Policy and Planning, MEM

Mr Anousith BOUNSOU, Technical Officer, Department of Energy Policy and Planning, MEM

Mr Sonepasit KHAMPHA, Technical Officer, Cabinet Office, MEM

Mr Vansit VAYONGSA, Technical Officer, Department of Mining Management, MEM

Mr Latsayakone PHOLSENA, Technical Officer, Institute of Renewable Energy Promotion, MEM

Mr Chanthavilay PHOMMACHACK, Technical Officer, Institute of Renewable Energy Promotion, MEM

Mr Sypaseut NAVONGSA, Technical Officer, Lao Statistics Bureau, Ministry of Planning and Investment (MPI)

Mr Somchay DUANGDY, Technical Officer, Lao Statistics Bureau, MPI

Mr Daosadeth KINGKEO, Technical Officer, Department of Planning and Cooperation, Ministry of Public Works and Transport

Mr Tingkham CHANTHAPHONE, Technical Officer, Department of Planning and Cooperation, Ministry of Industry and Commerce (MIC)

Mr Soulaxay HEUNGPHOXAY, Technical Officer, Department of Import and Export, MIC

Mrs Phimpha PHUNMALA, Deputy Manager, Lao State Fuel Company

Mr Vassana PHETLAMPHANH, Deputy Manager, Loss Reduction Office and Demand Side Management Project, Technical Department, Electricité du Laos (EDL)

Mr Hongsakoum KONGSAP, Deputy Chief of Unit, System Planning Office, Technical Department, EDL

Mr Phetsamone BOUNNOUVONG, Deputy Chief of Planning Team, National Control Centre, EDL

Mr Souphalack SINGSAYYACHACK, Engineer, National Control Centre, EDL

From the Economic Research Institute for ASEAN and East Asia (ERIA)

Mr Shigeru KIMURA, Special Advisor to President for Energy Affairs, Energy Unit, Research Department, ERIA

Dr Han PHOUMIN, Energy Economist, Energy Unit, Research Department, ERIA

Ms Cecilya Laksmiwati MALIK, ASEAN Energy Policy Planning Expert, Indonesia

Mr Ir. Leong Siew MENG, Consultant, Green Tech Solution Inc. (ASHRAE, Malaysia Chapter)

Ms Suharyati NUGROHO, Head of Sub-division of Energy Planning, Secretariat General of National Energy Council, Ministry of Energy and Mineral Resources, Indonesia

Executive Summary

The total primary energy supply (TPES) of the Lao People's Democratic Republic (Lao PDR) increased from 1,618 thousand ton oil equivalent (ktoe) in 2000 to 4,765 ktoe in 2015, at an average annual growth rate of 7.5%. Coal saw the highest increase over the 2000–2015 period, at an average rate of 42.2% per year. This was because the Hongsa power plant started its production in 2015, resulting in a significant increase of coal supply that year. The second-highest growth during the period was hydro at 9.8% per year. Hydro is the major energy source for electricity production in the Lao PDR. Petroleum supply also increased rapidly at an average of 8.5% a year. Since the power sector does not use oil products, most of the increase in demand came from the transport sector. The Lao PDR exports most of its electricity products to Thailand while also importing from neighbouring countries to meet the demand during the dry season and from the border areas not connected to the grid. The electricity supply in the TPES of the Lao PDR reflects the net trade of electricity. In 2000, the largest share in the TPES was biomass at 78%, followed by petroleum (15%), hydro (5%), and coal (0.5%). Since coal supply had grown very rapidly by 2015, coal's share in the total TPES increased significantly to 33%. The share of biomass, on the other hand, had declined to 34% by 2015. The slower growth of biomass supply indicates a substitution in the use of biomass for cooking in the residential sector. The shares of the other supplies increased, but not as drastically as coal. Hydro shares had increased to around 9% by 2015 while those of petroleum products had reached 20%.

The total final energy consumption (TFEC) of the Lao PDR increased at an average annual growth rate of 5% from 1,509 ktoe in 2000 to 3,122 ktoe in 2015. By type of fuel, coal grew the fastest at 28.4% per year, followed by electricity at 13.4% per year. Consumption of petroleum products and biomass, which are the most used types of fuel in the country, grew at a slower rate than that of coal and electricity. The average annual growth rate of petroleum products consumption was 8.5% while biomass consumption grew by only 1.4% per year over 2000–2015. Despite the high average annual growth rate of consumption during this period, the share of coal in the TFEC was only 13% in 2015. Electricity share in the TFEC was the lowest at 12% in 2015. Petroleum products and biomass had a total share of more than 76% during the 2000–2015 period. Biomass share in the TFEC decreased from 78% in 2000 to 46% in 2015.

These statistics led to some key findings:

1. On TFEC by energy and sectors: Elasticity is less than 1 but commercial energy increased by more than 10%.
2. On TPES per capita: TPES increased at an average annual growth of 5% from 0.3 to 0.72 toe/person while the TPES/gross domestic product (GDP) remained at around 0.1 toe/thousand $ (at constant 2011 purchasing power parity [PPP]) over the 2000–2015 period. There is a relatively small improvement in energy intensity (TPES/GDP) from 2000 to 2015.
3. On combustion of fossil fuels: The combustion of fossil fuels, particularly coal, is the main contributing factor to the increase in carbon dioxide (CO_2) emission in the Lao PDR. In 2015, coal started to be consumed by the power sector. Consequently, Lao PDR's CO_2 emission increased very sharply in 2015. The CO_2/GDP intensity increased by 9.8% per year, from 68 kg CO_2/thousand $ PPP to 278 kg CO_2/thousand $ PPP.

This first Lao PDR National Energy Statistics used the energy consumption survey which covered the industry, road transport, residential, and commercials sectors. This was the first energy consumption survey in the Lao PDR and improvements are still needed. However, several remarkable findings have been extracted.

1. From the road transport survey – Meaningful transport information such as fuel economy and mileage of types of vehicles have been extracted.
2. From the result of the biomass use of the residential sector survey – Biomass use of the residential sector was lower than the data of the Department of Energy Policy and Planning (DEPP). The authors suggest that DEPP conduct a survey of the residential sector using a new unit of consumption of biomass. Reasonable data on building energy intensity (BEI) by each building type was also extracted through the survey.

The efforts to come up with the first Lao PDR National Energy Statistics were challenging as the expert team from the Economic Research Institute for ASEAN and East Asia (ERIA), the Ministry of Energy and Mines (MEM), and other related ministries and agencies pulled all their existing data on the Lao PDR and combined them with the energy consumption survey data to arrive at a meaningful national energy data. The team encountered several issues such as missing data and inappropriate data recording of both primary and sales data. The efforts to clean the data as well as fill out the missing data were daunting, but it was a successful experience as the project also built Lao PDR's capacity in data

collection and the preparation of national energy statistics. The following are a few key recommendations to strengthen data collection and analysis:

1. DEPP needs to build a strong team to improve the preparation of primary energy data on both supply and demand, including sales data. It also needs to prepare a system to collect data from the market players and validate the collected data regularly.
2. Ministries need to collaborate in terms of energy data and other energy-related data.
3. MEM may need to consider conducting national-level energy consumption surveys to collect accurate demand side data in the Lao PDR.
4. Staff need to strengthen their skills in understanding, analysing, updating, and releasing energy balance tables on the website.

As this is the first-ever published Lao PDR National Energy Statistics, improvements in data quality and analysis could be expected gradually from this year onwards. It is important that staff at the energy data centres have a strong network for collecting data and conducting surveys and analysis to regularly produce energy data that will support energy policies and planning in the Lao PDR.

Chapter 1
Primary Energy Data

The primary energy sources of the Lao People's Democratic Republic (Lao PDR) consist of coal, oil, hydro, and biomass. The country imports oil products to meet its domestic requirements, while it uses its coal resources domestically and exports these at the same time. It exports electricity to Thailand and Cambodia and imports electricity from Thailand, China, and Viet Nam. Its primary source of electricity is hydropower. Since 2015, it has also consumed coal to generate electricity for export purposes. The country also consumes other renewable energies: biomass and solar.

This chapter elaborates on the primary energy data of the Lao PDR that was collected by its Department of Energy, Policy and Planning (DEPP), Ministry of Energy and Mines.

Coal

The Lao PDR classifies its coal resources as anthracite and lignite. It exports most of the lignite it produces. The country exported anthracite from 2012, but in 2015 the goverment stopped its coal export to prioritise the use of coal to meet the demand of the industry sector. The Hongsa coal power plant started operating in 2015; since then coal has been consumed to generate power.

Coal Production Data

The Ministry of Energy and Mines collects data on coal production and DEPP maintains these data. As shown in Table 1.1, coal production from 2000 until 2015 increased from 229 kiloton (kt) to 4,793 kt.

Table 1.1. Coal Production (kt)

Year	Production		
	Anthracite	Lignite	Total
2000	15	214	229
2001	20	227	247
2002	31	234	265
2003	38	253	291
2004	46	300	346
2005	51	320	371
2006	62	342	404
2007	75	382	457
2008	105	399	504
2009	112	456	568
2010	212	522	733
2011	225	621	846
2012	233	709	941
2013	245	810	1,055
2014	257	911	1,168
2015	136	4,658	4,793

Source: Department of Mines, Ministry of Energy and Mines, Lao PDR.

Coal Export and Import Data

The Department of Customs, Ministry of Finance, collects data on coal exports and DEPP maintains these data (Table 1.2). Lao PDR's coal export is mainly lignite. Anthracite was only exported only from 2012 to 2014. Exports increased from 2000–2012 and declined in 2013–2014. There was no coal export in 2015.

Table 1.2. Coal Export (kt)

Year	Export		
	Anthracite	Lignite	Total
2000		214	214
2001		227	227
2002		234	234
2003		253	253
2004		300	300
2005		320	320
2006		319	319
2007		682	682
2008		379	379
2009		400	400
2010		445	445
2011		465	465
2012	16	498	513
2013	45	200	245
2014	54	254	309
2015	0	0	0

Source: Department of Customs, Ministry of Industry and Commerce, Lao PDR.

Originally, DEPP's coal data included the 2015 import of anthracite totalling 175 kt. After confirmation from the Department of Mines, DEPP deleted this import data. Thus, the Lao PDR has no coal import.

Coal Consumption for Power Generation

In 2015, the Lao PDR constructed the Hongsa Mine Mouth Coal Power Plant, based on its memorandum of understanding with Thailand, to meet electricity demand in Thailand. Thus, electricity produced from the Hongsa power plant is exported to Thailand. Based on DEPP data, the capacity of the Hongsa power plant in 2015 was 1,878 megawatts (MW) and its coal consumption was 3,817 kt lignite.

Coal Consumption of the Industry Sector

Aside from power generation, coal is consumed by the industry sector. The data on total coal consumption by the industry sector is shown in Table 1.3 but it is not broken down into sub-sectors such as cement, textile, and many others.

Table 1.3. Coal Consumption Data (kt)

Year	Industry		
	Anthracite	Lignite	Total
2000	15		15
2001	20		20
2002	31		31
2003	38		38
2004	46		46
2005	51		51
2006	62		62
2007	71		71
2008	84		84
2009	93	36	129
2010	114	47	161
2011	125	50	175
2012	131	50	181
2013	135	55	190
2014	141	68	209
2015	108		108

Source: Department of Energy, Policy and Planning, Ministry of Energy and Mines, Lao PDR.

Oil

Lao PDR's oil data consists of imports and consumption data from DEPP, and sales survey data from some petroleum companies. The country consumes the following types of petroleum products:

- Jet A-1 : kerosene type jet fuel
- Gasoline : motor gasoline
- Diesel oil : gas/diesel oil
- Fuel oil : fuel oil (residual oil)
- Lubricant : lubricant
- LPG : liquefied petroleum gas.

Import Data on Petroleum Products

The Department of Customs of the Ministry of Industry and Commerce collects data on import of petroleum products (Table 1.4).

Table 1.4. Import of Petroleum Products

Year	Jet A-1	Gasoline	DO	FO	Lubricant	LPG
	(kl)	(kl)	(kl)	(kl)	(kl)	(ton)
2000	45,730	101,676	214,461	3,875	260	1,801
2001	45,730	102,439	245,641	3,931	273	1,811
2002	45,730	108,002	247,574	4,392	349	1,892
2003	45,730	112,200	255,769	4,496	383	1,897
2004	45,730	119,879	262,904	4,505	433	1,926
2005	45,730	129,356	271,031	4,646	497	1,936
2006	45,730	143,473	375,295	4,682	588	2,132
2007	45,730	152,502	381,944	10,778	5,389	2,052
2008	45,730	159,455	457,327	9,812	4,038	2,151
2009	18,359	178,296	538,769	6,105	2,960	1,630
2010	13,359	178,296	538,769	6,130	2,960	1,510
2011	17,712	166,442	550,844	8,741	1,987	2,851
2012	29,256	159,627	601,588	8,459	1,900	2,954
2013	37,968	219,251	643,276	8,611	1,952	3,110
2014	47,866	212,950	688,907	10,067	1,594	3,510
2015	46,262	234,199	849,151	11,106	229	3,650

DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Department of Customs, Ministry of Industry and Commerce, Lao PDR.

Consumption Data on Petroleum Products

DEPP collects oil consumption data from the Lao State Fuel Company (Table 1.5). Data, however, is available for 2012–2015 only. LPG consumption data , on the other hand, is broken down into commercial and residential sectors.

Table 1.5. Consumption of Petroleum Products

Year	Jet A-1	Gasoline	DO	FO	Lubricant	LPG	
	Transport	Transport	Transport	Industry	Transport	Commercial	Residential
	kl	kl	kl	kl	kl	ton	
2000	54,420	100,476	201,569			970	540
2001	68,009	100,439	236,513			970	541
2002	69,154	107,002	238,059			979	589
2003	78,622	110,200	250,615			981	590
2004	81,992	117,879	257,323			1,001	591
2005	88,909	124,301	266,825			1,001	600
2006	89,908	134,654	282,850			1,122	616
2007	97,723	161,672	307,177			1,130	620
2008	67,564	165,401	365, 013			1,136	701
2009	18,359	155,118	430,015			1,389	857
2010	13,359	152,885	436,034			1,431	883
2011	17,712	144,804	439,805			1,506	929
2012	29,256	139,559	510,293	7,459	1,840	1,560	963
2013	37,968	215,650	533,735	8,611	1,852	1,642	1,014
2014	42,603	210,416	654,122	9,717	1,919	1,854	1,144
2015	46,262	223,318	863,281	229	3,904	1,944	1,264

DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Department of Customs, Ministry of Industry and Commerce, Lao PDR.

Sales Data on Petroleum Products

DEPP collects data on petroleum sales from the survey of private petroleum companies in the Lao PDR. The survey, conducted in 2015, involved 24 private oil companies under the Lao State Fuel Company.

Since only 14 out of the 24 companies submitted their questionnaires, Table 1.6 does not show the actual total sales of petroleum in 2015 in the Lao PDR. However, these data are classified into the following main categories:

- Sales to power producers
    - Electricité du Laos (EDL)
    - Independent power producers, rural producers, etc.
- Sales to large-scale industrial users
    - Iron and steel
    - Chemical (including petrochemical)
    - Non-ferrous metals
    - Transportation equipment
    - Machinery
    - Mining and quarrying
    - Food, beverages, and tobacco
    - Pulp, paper, and printing
    - Wood and wood products
    - Construction
    - Textiles and leather
    - Not elsewhere specified (Industry)
- Sales to other large-scale transport taxi, bus, road freight, etc.
    - International civil aviation
    - Domestic air transport
    - Inland waterways
    - International marine bunker
- Sales to other large-scale users including
    - Commercial services such as malls, hotels, schools, hospitals, office buildings
    - Public services such as central and local governments
    - Residential
    - Agriculture
    - Fishing
    - Petroleum wholesalers
- Sales to gas stations
    - Company-owned stations
    - Company franchises

Table 1.6. Petroleum Sales Data, 2015

Quantity Descriptions	LPG	Naptha	Motor Gasoline	Kerosene Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen
	ton	kl	kl	kl	kl	kl	kl	kl	Specify
Import	**-**	**-**	**134,108.01**	**49,487.93**	**-**	**479,612**	**9,332.29**	**194.83**	**308.87**
Stock (at the end of the year)	-	-	-	-	-	112,840	-	-	-
Total Sales	**-**	**-**	**117,890.83**	**49,487.93**	**-**	**438,736**	**9,245.00**	**216.95**	**308.87**
Sell to Power Producers	**-**	**-**	**20.00**	**-**	**-**	**34,323**	**-**	**68.97**	**-**
IPP, Rural, etc.	-	-	20.00	-	-	34.323	-	68.97	-
Sell to Large-Scale Industrial Users	**-**	**-**	**8.00**	**-**	**-**	**124,423**	**9,245.00**	**13.17**	**308.87**
Iron and Steel	-	-	-	-	-	370	5,163.00	-	-
Non-ferrous Metals	-	-	-	-	-	797	-	-	-
Transportation Equipment	-	-	-	-	-	6,397	-	-	-
Mining and Quarrying	-	-	8.00	-	-	93,033	-	0.21	-
Food, Beverages, and Tobacco	-	-	-	-	-	1,907	4,082.00	-	-
Pulp, Paper, and Printing	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	578	-	-	-
Construction	-	-	-	-	-	18,140	-	2.93	308.87
Not Elsewhere Specified (Industry)	-	-	-	-	-	3,202	-	10.03	-
Sell to Other Large-Scale Users	**-**	**-**	**4.00**	**49,487.93**	**-**	**753**	**-**	**-**	**-**
Taxi, Bus, Road Freight, etc.	-	-	4.00	-	-	753	-	-	-
International Civil Aviation	-	-	-	-	-	-	-	-	-
Domestic Air Transport	-	-	-	41,074.98	-	-	-	-	-
International Marine Bunker	-	-	-	8,412.95	-	-	-	-	-
Sell to Gas Station	**-**	**-**	**117,858.83**	**-**	**-**	**279,237**	**-**	**134.82**	**-**
Company-Owned Stations	-	-	10,631,32	-	-	19,145	-	-	-
Company Franchises	-	-	107,227.51	-	-	260,092	-	134.82	-

IPP = independent power producer.

Source: Lao State Fuel Company.

Electricity

Electricity Production by Source

DEPP maintains electricity data based on the electricity yearbook published by the EDL-Generation Public Company, which collects power generation data from stakeholders. Until 2013, electricity has been produced solely by hydro plants and by a small fraction of biomass plants. Some small solar power generation plants started operation in 2014. Then, in 2015, the Lao PDR started producing electricity from coal for export purposes. Table 1.7 shows the trend in electricity production.

Table 1.7. Electricity Production by Source (GWh)

Year	Hydro	Coal	Solar	Biomass	Total Production
2000	3,438				3,438
2001	3,654				3,654
2002	3,604				3,604
2003	3,178				3,178
2004	3,348				3,348
2005	3,509				3,509
2006	3,595				3,595
2007	3,374				3,374
2008	3,717				3,717
2009	3,366				3,366
2010	8,449				8,449
2011	12,969				12,969
2012	13,057				13,057
2013	15,505			5	15,510
2014	15,270		0.001	5	15,275
2015	14,039	2,259	0.001	4	16,302

Source: Electricité du Laos.

Electricity Export and Import Data

Lao PDR is a net electricity exporting country since its electricity export is larger than its import (Table 1.8).

Table 1.8. Export–Import of Electricity (GWh)

Year	Export	Import	Net Trade
2000	2,793	180	2,613
2001	2,871	184	2,688
2002	2,798	201	2,598
2003	2,285	229	2,055
2004	2,425	278	2,147
2005	2,506	330	2,176
2006	2,487	631	1,856
2007	1,741	793	948
2008	2,315	845	1,471
2009	1,921	1,175	746
2010	6,646	1,210	5,437
2011	10,669	904	9,764
2012	10,363	1,329	9,034
2013	12,494	1,272	11,222
2014	11,936	1,559	10,377
2015	11,549	2,050	9,499

Source: Electricité du Laos.

Electricity Consumption

The electricity sales data prepared by EDL are broken down into final users in the Lao PDR – residential, commercial, industry, and other sectors (Table 1.9).

Biomass

Biomass Production

Biomass production data in the Lao PDR from 2000 to 2015 is only on fuelwood (Table 1.10).

Table 1.9. Electricity Consumption (GWh)

Year	Residential	Commercial	Industry	Other	Total
2000	325	147	135	33	640
2001	371	163	135	41	710
2002	395	173	164	35	767
2003	454	194	203	32	884
2004	455	189	219	39	903
2005	511	229	237	35	1,011
2006	567	250	549	40	1,406
2007	642	300	626	47	1,616
2008	707	461	703	44	1,916
2009	813	645	760	39	2,258
2010	943	749	707	43	2,441
2011	1,004	765	740	46	2,556
2012	1,160	993	883	39	3,075
2013	1,278	949	1,118	35	3,381
2014	1,424	768	1,564	36	3,792
2015	1,595	866	1,745	33	4,239

Source: Electricité du Laos.

Table 1.10. Fuelwood Production (kt)

Year	Fuelwood
2000	2,469
2001	2,528
2002	2,589
2003	2,651
2004	2,715
2005	2,780
2006	2,847
2007	3,075

Year	Fuelwood
2008	3,300
2009	3,187
2010	2,101
2011	1,514
2012	1,228
2013	1,041
2014	985
2015	819

Source: Department of Energy, Policy and Planning, Ministry of Energy and Mines, Lao PDR.

Transformation Sector

Fuelwood is utilised in transformation processes to produce charcoal. DEPP maintains the charcoal production data (Table 1.11).

Table 1.11. Charcoal Production (kt)

Year	Charcoal Production	Year	Charcoal Production
2000	53	2008	79
2001	54	2009	94
2002	55	2010	95
2003	56	2011	325
2004	58	2012	405
2005	59	2013	532
2006	60	2014	650
2007	67	2015	766

Source: Department of Energy, Policy and Planning, Ministry of Energy and Mines, Lao PDR.

Biomass Consumption

Fuelwood is used in the industry sector of the Lao PDR. Both fuelwood and charcoal are used in the commercial and residential sectors (Table 1.12).

Table 1.12. Biomass Consumption (kt)

Year	Fuelwood			Charcoal	
	Residential	Commercial	Industry	Commercial	Residential
2000	420	2,346	123	53	50
2001	430	2,402	126	54	51
2002	440	2,459	129	55	52
2003	451	2,518	133	56	53
2004	461	2,579	136	58	55
2005	473	2,641	139	59	56
2006	484	2,704	142	60	57
2007	523	2,922	154	67	64
2008	561	3,135	165	79	75
2009	542	3,028	159	94	89
2010	527	2,946	155	95	91
2011	512	2,864	151	97	92
2012	498	2,781	104	98	93
2013	502	2,699	156	103	90
2014	508	2,727	149	108	91
2015	514	2,754	146	113	92

Source: Department of Energy, Policy and Planning, Ministry of Energy and Mines, Lao PDR.

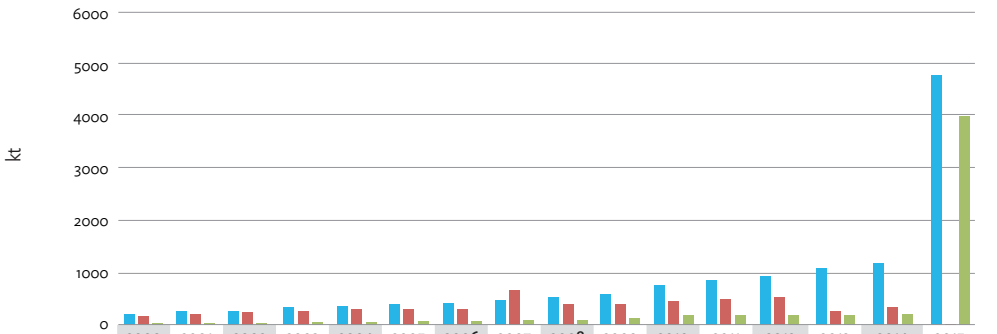
Data Consistency and Missing Data

DEPP energy data from 2000 to 2015 have been analysed for consistency. Inconsistent data have been revised. Although the energy data required to produce an energy balance table (EBT) from 2000 to 2015 in the Lao PDR is available at DEPP, there are still missing data, which require estimation. This chapter identifies the inconsistent and missing data. The methods used to revise the data are discussed in Chapter 2.

Coal Data

DEPP data cover coal production, export, and consumption data (Figure 1.1).

Figure 1.1. Lao PDR Coal Data (kt)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production	229	247	265	291	346	371	404	457	504	568	733	846	941	1055	1168	4793
Export	214	227	234	253	300	320	319	682	379	400	445	465	513.57	245	3048.46	0
Total Consumption	15	20	31	38	46	51	62	71	84	129	161	175	181	190	209	4008

kt = kiloton.

Source: Authors' calculation.

The following observations were made:

- Prior to 2006, DEPP coal data showed a difference between supply and consumption. Coal supply to the domestic market is production data minus export data.
- In 2006, coal export decreased but increased again in 2007. Coal export in 2007 was higher than production, which implies inconsistency in the export data.
- Coal data from 2008 to 2015 also showed increasing excess in coal supply.
- The high increase in coal production in 2015 is due to the operation of the Hongsa coal power plant.

Refining the coal data was necessary to generate the country's EBT. The improvement consisted of

- revising the coal export data in 2006 and 2007, particularly the export data on lignite; and
- revising the consumption of coal from 2008 to 2015 in the industry sector.

Oil Data

The Lao PDR imports all of its petroleum products. Table 1.13 shows the combined DEPP import and consumption data by type of fuel.

The jet kerosene consumption data is higher than the import data. This is similar to the other fuels, but only for certain years. In addition, some import data – such as the gasoline from 2010 to 2012, fuel oil in 2007 and 2008, and LPG data in 2009 and 2010 – do not match the trend. These inconsistent import data have been refined prior to its use in generating the EBT.

DEPP's data on the consumption of petroleum products was only for the final sector and none for power generation. These included the transport, residential, and commercial sectors. The last two sectors only consumed LPG. There was no consumption data for the industry sector.

The oil company survey revealed that oil companies sold to different sub-sectors of the industry and power producers. Since not all oil companies in the Lao PDR submitted their data, other measures had to be taken to estimate the missing industry and power sector consumption.

In addition, jet kerosene is only consumed for air transport. Since the Lao PDR also provided jet kerosene for international flights, it was necessary to separate the domestic and international flights to calculate the country's CO_2 emission. The separation of jet kerosene fuel consumption by domestic and international flights is discussed in Chapter 2.

Table 1.13. Oil Supply and Consumption

Year	Jet A-1 (kl)			Gasoline (kl)			DO (kl)			FO (kl)			Lubricant (kl)			LPG (t)		
	Import	Consumption	Balance	Import	Consumption	Balance	Import	Consumption	Balance	Import	Consumption	Balance	Import	Consumption	Balance	Import	Consumption	Balance
2000	45,730	54,420	(8,690)	101,676	100,476	1,200	214,461	201,569	12,892	3,875		3,875	260		260	1,801.32	1,510	291
2001	45,730	68,009	(22,279)	102,439	100,439	2,000	245,641	236,513	9,128	3,931		3,931	273		273	1,811.32	1,511	300
2002	45,730	69,154	(23,424)	108,002	107,002	1,000	247,574	238,059	9,515	4,392		4,392	349		349	1,892.45	1,568	324
2003	45,730	78,622	(32,892)	112,200	110,200	2,000	255,769	250,615	5,154	4,496		4,496	383		383	1,896.79	1,571	326
2004	45,730	81,992	(36,262)	119,879	117,879	2,000	262,904	257,323	5,581	4,505		4,505	433		433	1,926.42	1,592	334
2005	45,730	88,909	(43,179)	129,356	124,301	5,055	271,031	266,825	4,206	4,646		4,646	497		497	1,935.66	1,601	335
2006	45,730	89,908	(44,178)	143,473	134,654	8,820	375,295	282,850	92,445	4,682		4,682	588		588	2,132.08	1,739	393
2007	45,730	97,723	(51,993)	152,502	161,672	(9,170)	381,944	307,177	74,767	10,778		10,778	5,389		5,389	2,052.00	1,750	302
2008	45,730	45,730	-	159,455	165,401	(5,946)	457,327	365,013	92,314	9,812		9,812	4,038		4,038	2,151.00	1,837	314
2009	18,359	18,359	-	178,296	155,118	23,179	538,769	430,015	108,754	6,105		6,105	2,960		2,960	1,629.73	2,246	(616)
2010	13,359	13,359	-	178,296	152,885	25,411	538,769	436,034	102,735	6,130		6,130	2,960		2,960	1,510.00	2,314	(804)
2011	17,712	17,712	-	166,442	144,804	21,637	550,844	439,805	111,040	8,741		8,741	1,987		1,987	2,851.00	2,435	416
2012	29,256	29,256	-	159,627	139,559	20,067	601,588	510,293	91,295	8,459	7,459	1,000	1,900	1,840	60	2,954.00	2,523	431
2013	37,968	37,968	-	219,251	215,650	3,601	643,276	533,735	109,540	8,611	8,611	-	1,952	1,852	100	3,110.00	2,656	454
2014	47,866	42,603	5,263	212,950	210,416	2,534	688,907	654,122	34,786	10,067	9,717	350	1,594	1,919	(324)	3,510.00	2,998	512
2015	46,262	46,262	-	234,199	223,318	10,880	849,151	686,447	162,705	11,106	229	10,876	229	3,904	(3,675)	3,650.40	3,208	442

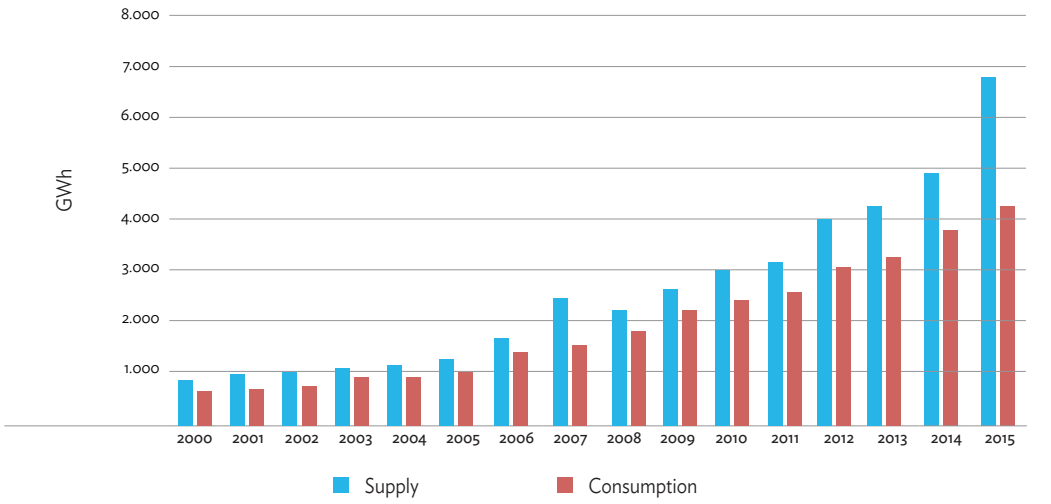
DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Authors' calculation.

Electricity Data

Electricity supply and demand in the Lao PDR is shown in Figure 1.2. Electricity supply to the domestic market is the sum of the production and import data minus the export data. The electricity demand data was only on the sectoral electricity consumption. No data was available on own use and transmission and distribution losses. Since the EBT includes own use and losses, it was necessary to estimate the missing data.

Figure 1.2. Lao PDR Electricity Data (GWh)



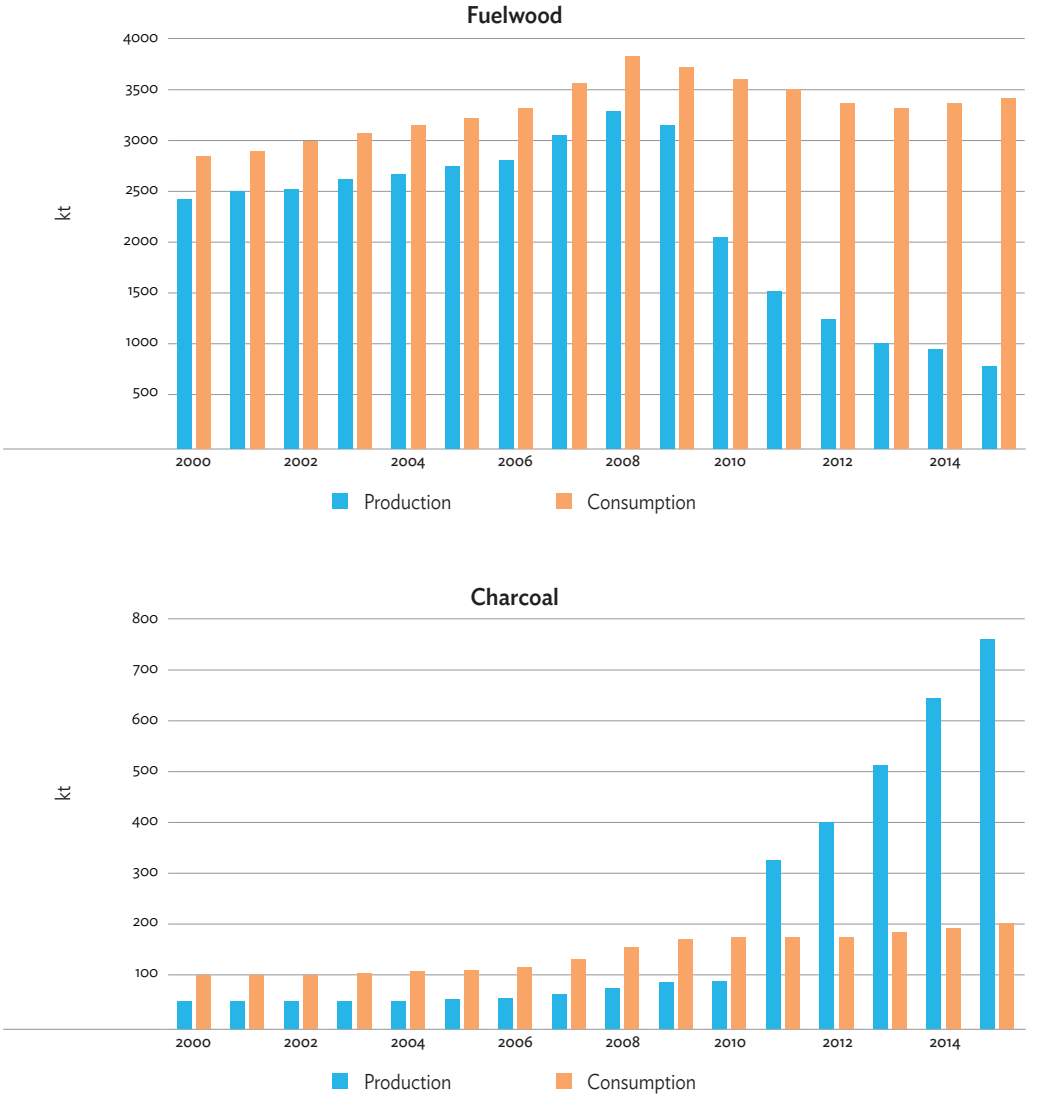
kt = kiloton.

Source: Authors' calculation.

Biomass Data

DEPP data on biomass referred only to the production of fuelwood and charcoal, and their consumption in the final sector. Figure 1.3 shows that production of fuelwood has always been lower than consumption. However, charcoal production increased rapidly after 2010.

Figure 1.3. Lao PDR Biomass Data



kt = kiloton.

Source: Authors' calculation.

DEPP's data excluded the amount of fuelwood used to produce charcoal. In addition, the electricity data showed that bagasse was consumed to produce electricity. The quantity of bagasse consumed by the biomass power plant was also unavailable. In both cases, the missing data needed to be estimated for the EBT.

Chapter 2
Energy Balance Table

The energy balance table (EBT) presents the supply-to-demand flow of all energy products – from production, importation, exportation, transformation, and consumption – within the national territory. It is widely used in estimating total energy supply, forecasting, and the study of substitution and conservation.

This chapter introduces the EBT of the Lao PDR. It also explains the estimation method for the missing data. Finally, it presents the country's EBT from 2000 to 2015.

Basic Concept of the Energy Balance Table

EBT is an accounting framework for the compilation and reconciliation of data on all energy products, from supply to demand, within the national territory of a given country during a reference period (usually a year). It expresses all forms of energy in a common accounting unit and shows the relationship between the inputs to and outputs from the energy transformation processes. It should be as complete as possible so that all of the energy flows are accounted for (United Nations, 2015).

The energy balance is a matrix showing the relationship between energy products (represented in columns) and energy flows (represented in rows). A column refers to a group of energy products in its primary or secondary form. Each cell in this column shows a flow of energy involving this group of products, as defined by the row name.

One of the main purposes of energy balance is to reflect the relationships between the primary production of energy (and other energy flows such as imports and exports in the national territory), its transformation, and final consumption. Therefore, the energy balance contains three main blocks of rows as follows:

1. Upper sector (Primary Energy Supply) – This sector intends to show flows representing indigenous energy production, imports, and exports in the national territory, as well as stock changes to provide information on the amount of energy available in the national territory during the reference period. The supply flows consist of production of primary energy products and imports of both primary and secondary energy products. The flows removing energy from the national territory are exports of primary and secondary energy products and international bunkers. The aggregate of the balance, which is the total energy supply, is computed as:[1]

Total Primary Energy Supply
= Indigenous Production + Imports + Exports + International Marine Bunkers
+ International Aviation Bunkers + Stock Changes

2. Middle sector (Energy Transfer and Transformation) – This sector intends to show flows of how energy is transformed, transferred, used by energy industries for their own use, and losses in distribution and transmission. Power generation and petroleum refinery processes are major activities in this sector.

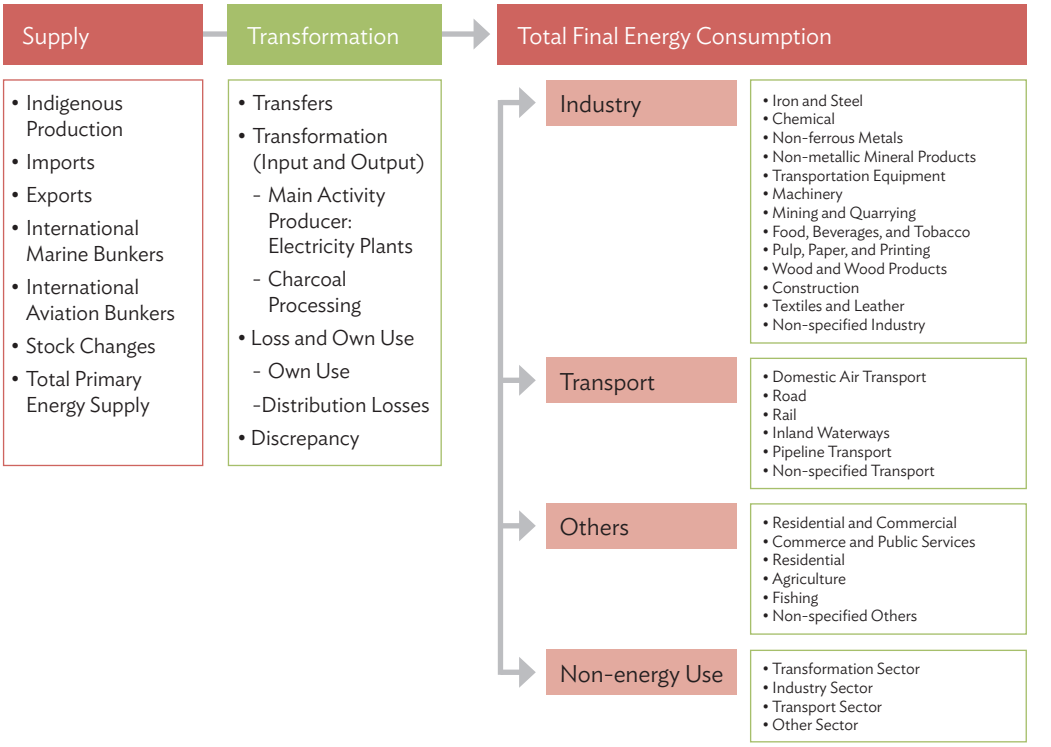
3. Lower sector (Final Energy Consumption) – This sector intends to show flows of how energy is being consumed by the final users. The flows reflect the final energy consumption and non-energy use of energy products. Thus, it excludes deliveries of fuel and other energy products for use in transformation processes and use of energy products for the energy needs of the energy industries (both covered in the middle block). Final energy consumers are grouped into three main categories:

(i) Manufacturing, construction, and non-fuel mining industries;
(ii) Transport; and
(iii) Others (agriculture, forestry and fishing, commerce and public services, households, and other consumers).

Figure 2.1 is a simplified diagram of the energy flow in an EBT.

[1] Because of the sign convention in energy balances, where quantities that contribute to the supply receive positive signs while those that are removed receive negative signs, these parts can be straightly added

Figure 2.1. Energy Flow in the Energy Balance



Source: IEA and IEEJ (2018), ' International Standard of Energy Demand and Supply',

A separate row is reserved for the statistical difference, which is defined as the difference between the total supply of energy products and its total use. The statistical difference occurs because of the discrepancy arising from various practical limitations and problems related to the collection of the data which make up supply and demand. These include sampling or other collection errors and/or data taken from different data sources which use different time periods, different spatial coverage, different fuel specifications, or different conversions from volume to mass or from mass to energy content in the supply and demand sides of the balance.

In general, the statistical difference is calculated by subtracting the supply with the demand as follows:

Statistical Difference = Total Primary Energy Supply + Transfers + Transformation + Energy Industries' Own Use + Losses - Final Consumption

EBT can be presented in both detailed and aggregated formats. The degree of detail depends on the policy concern, data and resource availability, and the underlying classifications used. Usually, a simplified format is used for small countries and/or for types of energy flows that are few and far between as the results can be summarised without much information loss. The detailed definitions of energy products and energy flows are shown in Annex 3, and the country's EBTs for 2000–2015 are provided in Annex 4. The structuring of an energy balance depends on the country's energy production and consumption patterns and the level of detail that the country requires.

Methodology

The definitions and groupings of energy products as well as statistical terminologies were harmonised with internationally established standards. The data for energy balances were based on the individual data collected for commodity (products) balances for coal, petroleum, gas, electricity, and renewables. The data are usually expressed in physical units of the products so that for each product, the completeness of the data can be observed from the commodity balance. The data in the commodity balance were combined to produce the energy balance.

Data Collection Format

The primary energy data required in the development of the Lao PDR 2000–2015 EBT was already discussed in Chapter 1. These data were entered in the reporting format for each energy product, which in the case of the Lao PDR consisted of coal; petroleum products; biomass (fuelwood, charcoal, bagasse); hydro; solar; and electricity (including imported electricity). The joint questionnaire used the format of the Asia-Pacific Economic Cooperation and the Association of Southeast Asian Nations (APEC–ASEAN) to build the main statistics on each product. This format checks the completeness of the data because the questionnaire balances the supply and use of the respective products. The APEC–ASEAN joint questionnaire consists of five questionnaires for coal, oil, gas, oil, electricity, and renewable energy products. The questionnaire basically consisted of the supply data, transformation, and energy industry own use and final consumption (including non-energy use).

After entering the data in the APEC–ASEAN joint format, which for the Lao PDR excludes the natural gas questionnaire, the researchers used the data to generate the EBT through

an interface programme provided by the Economic Research Institute of ASEAN and East Asia (ERIA) for the Lao PDR energy statistics project.

Unit and Conversion

All entries in the EBT are expressed as one energy unit: kilocalorie (kcal), gigajoule (GJ), thousand ton of oil equivalent (ktoe), etc. Net calorific values (NCV) are generally used in building energy balances since most current technologies are still not able to recover latent heat, which would thus not be treated as part of a fuel's energy-providing capability. However, providing both gross calorific value (GCV) and NCV while making clear which one is used in the balance is considered good practice. This allows the monitoring of technological advances in terms of recovering latent heat.[2]

The unit in the APEC–ASEAN joint questionnaire is the physical unit and it differs between the products. The unit in the oil questionnaire is in kiloton (kt) while the primary data unit is mainly in kilolitre (kl). Specific gravities data requirement is included in the oil questionnaire as well as the NCV to convert to the energy unit, kilocalories. If there is a refinery in the country, refinery intake data would also be requested in the questionnaire in kiloton.

The unit of coal in the questionnaire is also in kiloton, except for the gases produced from coal (coke oven gas, etc.) which are measured in gross kilocalories. For the other coal products, the calorific value data is also requested in the coal questionnaire. The unit of the new and renewable questionnaire is in kiloton for solid biomass (fuelwood, charcoal, and bagasse). The new and renewable energy is either in kilocalories or gigawatt-hour (GWh). The questionnaire also requests for the additional calorific value of the products.

The electricity questionnaire is in gigawatt-hour for production and consumption. For the fossil fuel input data, the unit is that of the products. A conversion data to kilocalorie is also requested in the questionnaire. The existing installed capacity is also included in the questionnaire in megawatt (MW).

The Lao PDR 2000–2015 EBT adopted the energy unit in ton of oil equivalent (toe). One unit of toe is defined as 10^7 kcal (41.868 GJ). There are two heat values: one is NCV and the other is GCV. The difference between NCV and GCV is:

- Coal/Oil: NCV is less than 5% of GCV; and
- Gas: NCV is around less than 10% of GCV.

[2] Department of Energy and Climate Change (DECC), United Kingdom. DECC Energy balance statistics methodology.

The calorific content of the different energy products in the Lao PDR is shown in Table 2.1. The conversion of the petroleum product's calorific value to the heat value uses the Thailand petroleum calorific value (assuming most petroleum products in the Lao PDR are imported from Thailand).

Also, the thermal efficiency of primary electricity such as hydropower generation is assumed as follows:

- Hydro: 100%
- Nuclear: 33%
- Geothermal: 10%
- Solar/Wind/Tide: 100%.

Table 2.1. Calorific Content of Energy Products in the Lao PDR

Energy Products	Original Unit	Calorific Content (Ton of oil equivalent)
Anthracite	Metric Ton	0.6000
Lignite	Metric Ton	0.3693
Motor Gasoline	Metric Ton	1.0450
Kerosene-Type Jet Fuel	Metric Ton	1.1675
Gas/Diesel Oil	Metric Ton	1.0236
Fuel Oil	Metric Ton	1.0105
Liquefied Petroleum Gas	Metric Ton	1.1777
Lubricants	Metric Ton	0.9928
Fuelwood and Wood Waste	Metric Ton	0.3820
Charcoal	Metric Ton	0.6900
Bagasse	Metric Ton	0.3000
Electricity	Megawatt-hour	0.0860

Source: Economic Research Institute for ASEAN and East Asia.

Treatment of Missing Data

Principles for Selecting the Source of Missing Data

In collecting data for the Lao PDR EBT, the research team classified data sources according to the following priorities:

- Priority 1: Direct owner of the data
- Priority 2: Official statistics
- Priority 3: Expert estimation.

Estimation Method for and Improvement of Missing Data

Chapter 1 on Lao PDR primary energy data identified the inconsistent data maintained by the Department of Energy, Policy and Planning (DEPP), Ministry of Energy and Mines. Such limitations of existing energy statistics result in unavailable information needed for the EBT and for estimation. The research team therefore applied estimation methods to the preliminary numbers of the existing energy statistics. These estimation methods are explained in this section.

Coal Data

The data for coal export in 2006 and 2007 had to be revised since only lignite coal was exported. Thus, the revised data in 2006 and 2007 applied only to lignite data. Lignite export in 2006 was increased so that production minus export would equal the consumption. In reverse, the 2007 lignite export was decreased so that production minus export would equal the consumption. After 2007, coal export data remained the same as collected by DEPP (Table 2.2).

Table 2.2. Export of Coal (kt)

Year	Export		
	Anthracite	Lignite	Total
2000		214	214
2001		227	227
2002		234	234
2003		253	253
2004		300	300
2005		320	320
2006		342	342
2007		382	382
2008		379	379
2009		400	400
2010		445	445
2011		465	465
2012	16	498	513
2013	45	200	245
2014	54	254	309
2015	0	0	0

kt = kiloton.

Source: Authors' calculation.

Data on domestic supply and consumption of coal in 2008–2015 were not balanced In this case, the existing DEPP data for industrial consumption were revised to equal the supply. In 2015, because the Hongsa coal power plant became operational, total consumption for power and industry was set equal to the supply. The revised coal consumption of industry by coal type is shown in Table 2.3.

Table 2.3. Coal Consumption in the Industry Sector (kt)

Year	Export		
	Anthracite	Lignite	Total
2000	15		15
2001	20		20
2002	31		31
2003	38		38
2004	46		46
2005	51		51
2006	62		62
2007	75		75
2008	105	20	125
2009	112	57	168
2010	212	77	288
2011	225	156	381
2012	217	211	428
2013	200	610	810
2014	203	657	859
2015	136	841	976

kt = kiloton.

Source: Authors' calculation.

Table 2.4 shows the revised coal balance of the Lao PDR.

Table 2.4. Revised Coal Balance (kt)

Year	Production	Export	Total Supply	Consumption		Total	Balance
				Power Plant	Industry	Consumption	
2000	229	214	15	0	15	15	0
2001	247	227	20	0	20	20	0
2002	265	234	31	0	31	31	0
2003	291	253	38	0	38	38	0
2004	346	300	46	0	46	46	0
2005	371	320	51	0	51	51	0
2006	404	342	62	0	62	62	0
2007	457	382	75	0	75	75	0
2008	504	379	125	0	125	125	0
2009	568	400	168	0	168	168	0
2010	733	445	288	0	288	288	0
2011	846	465	381	0	381	381	0
2012	941	513	428	0	428	428	0
2013	1,055	245	810	0	810	810	0
2014	1,168	309	859	0	859	859	0
2015	4,793	0	4,793	3,817	976	4,793	0

kt = kiloton.

Source: Authors' calculation.

Oil Data

As discussed in Chapter 1, the oil import data from the Department of Customs are inconsistent. The data on gasoline from 2010 to 2012, fuel oil in 2007 and 2008, Jet A-1 fuel from 2001 to 2013, and lubricant from 2006 to 2015 do not match the trend. Therefore, the import data on oil products were revised using a growth rate that was in line with the data trend. The 2009–2010 data on liquefied petroleum gas (LPG) were also revised by assuming that the import amount was equal to the total consumption of the household and commercial sectors. The import data on revised petroleum products are shown in Table 2.5.

Table 2.5. Import of Petroleum Products

Year	Jet A-1	Gasoline	DO	FO	Lubricant	LPG
	kl	kl	kl	kl	kl	ton
2000	45,730	101,676	214,461	3,875	260	1,801
2001	45,879	102,439	245,641	3,931	273	1,811
2002	46,029	108,002	247,574	4,392	349	1,892
2003	46,180	112,200	255,769	4,496	383	1,897
2004	46,330	119,879	262,904	4,505	433	1,926
2005	46,482	129,356	271,031	4,646	497	1,936
2006	46,634	143,473	375,295	4,682	605	2,132
2007	46,786	152,502	381,944	5,003	736	2,132
2008	46, 939	159,455	457,327	5,346	896	2,151
2009	47, 092	178,296	538,769	6,105	1,091	2,246
2010	47,246	187,755	538,769	6,130	1,521	2,314
2011	47,400	197,716	550,844	8,741	1,731	2,851
2012	47,555	208,205	601,588	8,459	1,970	2,954
2013	47,710	219,251	643,276	8,611	2,242	3,110
2014	47,866	212,950	688,907	10,067	2,552	3,510
2015	46,262	234,199	849,151	11,106	2,904	3,650

DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Authors' calculation.

Aside from the import data, the consumption data on petroleum products were also revised.

- The data on the consumption of gasoline for transportation were too high in 2007–2008 and too low in 2009–2012. These were revised with the assumption that import equals consumption.
- The data on kerosene type jet fuel were revised with the assumption that all imports were consumed by the airlines. Kerosene-type jet fuel was separated into domestic and international flights by using the calculated share of the domestic and international flights in the Lao PDR.
- The data on diesel oil consumption in the agriculture sector were assumed to be constant over the 2000–2015 period. Based on this, it was assumed that the remaining diesel oil were consumed by the industry sector. Thus, diesel oil consumption in the industry sector was calculated based on import minus the consumption of the transport and agriculture sectors.
- The data on fuel oil consumption of the industry sector from 2000 to 2011 were estimated based on the import data of fuel oil while data for 2015 were based on the trend consumption in 2014.

The revised petroleum product consumption data is shown in Table 2.6.

Table 2.6. Consumption of Petroleum Products

Year	Jet A-1	Gasoline	DO			FO	Lubricant	LPG	
	Transport	Transport	Transport	Industry	Agriculture	Transport	Transport	Commercial	Residential
	kl	kl	kl			kl	kl	ton	
2000	45,730	100,476	201,569	12,660	232	3,875	260	970	540
2001	45,879	100,439	236,513	8,896	232	3,931	273	970	541
2002	46,029	107,002	238,059	9,282	232	4,392	349	979	589
2003	46,180	110,200	250,615	4,921	232	4,496	383	981	590
2004	46,330	117,879	257,323	5,348	232	4,505	433	1,001	591
2005	46,482	124,301	266,825	3,974	232	4,646	497	1,001	600
2006	46,634	134,654	282,850	92,213	232	4,682	605	1,122	616
2007	46,786	152,502	307,177	74,535	232	5,003	736	1,130	620
2008	46,939	159,455	365,013	92,082	232	5,346	896	1,136	701
2009	47,092	178,296	430,015	108,522	232	6,105	1,091	1,389	857
2010	47,246	187,755	436,034	102,502	232	6,130	1,521	1,431	883
2011	47,400	197,716	439,805	110,807	232	8,741	1,731	1,506	929
2012	47,555	208,205	510,293	91,062	232	7,459	1,970	1,560	963
2013	47,710	215,650	533,735	109,308	232	8,611	2,242	1,642	1,014
2014	47,866	210,416	654,122	34,553	232	9,717	2,552	1,854	1,144
2015	46,262	223,318	686,447	162,472	232	10,719	2,904	1,944	1,264

DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Authors' calculation.

The data on petroleum product balance is shown in Table 2.7.

Table 2.7. Revised Petroleum Product Balance

Year	Jet A-1			Gasoline		DO				FO		Lubricant		LPG		
	kl			kl		kl				kl		kl		ton		
	Import	Domestic	International	Import	Transport	Import	Transport	Industry	Agriculture	Import	Consumption Transport	Import	Consumption Transport	Import	Consumption Commercial	Consumption Residential
2000	45,730	3,423	42,307	101,676	100,476	214,461	201,569	12,660	232	3,875	3,875	260	260	1,801	970	540
2001	45,879	3,434	42,446	102,439	100,439	245,641	236,513	8,896	232	3,931	3,931	273	273	1,811	970	541
2002	46,029	3,445	42,584	108,002	107,002	247,574	238,059	9,282	232	4,392	4,392	349	349	1,892	979	589
2003	46,180	3,456	42,723	112,200	110,200	255,769	250,615	4,921	232	4,496	4,496	383	383	1,897	981	590
2004	46,330	3,467	42,863	119,879	117,879	262,904	257,323	5,348	232	4,505	4,505	433	433	1,926	1,001	591
2005	46,482	3,479	43,003	129,356	124,301	271,031	266,825	3,974	232	4,646	4,646	497	497	1,936	1,001	600
2006	46,634	3,490	43,143	143,473	134,654	375,295	282,850	92,213	232	4,682	4,682	605	605	2,132	1,122	616
2007	46,786	3,502	43,284	152,502	152,502	381,944	307,177	74,535	232	5,003	5,003	736	736	2,052	1,130	620
2008	46,939	3,513	43,426	159,455	159,455	457,327	365,013	92,082	232	5,346	5,346	896	896	2,151	1,136	701
2009	47,092	3,524	43,567	178,296	155,118	538,769	430,015	108,522	232	6,105	6,105	1,091	1,091	2,246	1,389	857
2010	47,246	3,536	43,710	187,755	152,885	538,769	436,034	102,502	232	6,130	6,130	1,521	1,521	2,314	1,431	883
2011	47,400	3,548	43,853	197,716	144,804	550,844	439,805	110,807	232	8,741	8,741	1,731	1,731	2,851	1,506	929
2012	47,555	3,559	43,996	208,205	139,559	601,588	510,293	91,062	232	8,459	7,459	1,970	1,970	2,954	1,560	963
2013	47,710	3,571	44,139	219,251	215,650	643,276	533,735	109,308	232	8,611	8,611	2,242	2,242	3,110	1,642	1,014
2014	47,866	3,582	44,284	212,950	210,416	688,907	654,122	34,553	232	10,067	9,717	2,552	2,552	3,510	1,854	1,144
2015	46,262	3,462	42,800	234,199	223,318	849,151	686,447	162,472	232	11,106	10,719	2,904	2,904	3,650	1,944	1,264

DO = diesel oil, FO = fuel oil, kl = kilolitre, LPG = liquefied petroleum gas.

Source: Authors' calculation.

Electricity

The electricity production data contained in the Electricity Yearbook is the net production data. Therefore, the gross production of electricity in the APEC–ASEAN joint questionnaire was based on other sources. In the case of the transmission and distribution losses, total losses were calculated using the difference between the supply and demand (Table 2.8).

Table 2.8. Electricity Balance (GWh)

Year	Production	Export	Import	Consumption	Losses
2000	3,438	2,793	180	640	186
2001	3,654	2,871	184	710	256
2002	3,604	2,798	201	767	240
2003	3,178	2,285	229	884	239
2004	3,348	2,425	278	903	298
2005	3,509	2,506	330	1,011	323
2006	3,595	2,487	631	1,406	333
2007	3,374	1,741	793	1,616	810
2008	3,717	2,315	845	1,916	330
2009	3,366	1,921	1,175	2,258	362
2010	8,449	6,646	1,210	2,441	571
2011	12,969	10,669	904	2,556	649
2012	13,057	10,363	1,329	3,075	948
2013	15,510	12,494	1,272	3,381	907
2014	15,275	11,936	1,559	3,792	1,106
2015	16,302	11,549	2,050	4,239	2,565

GWh = gigawatt-hour.

Source: Authors' calculation.

Biomass

Data on biomass include fuelwood, charcoal, and bagasse, but DEPP manages only the production and consumption data for fuelwood and charcoal. As mentioned in Chapter 1, fuelwood production data is lower than consumption data. This trend is similar for charcoal until 2010. After 2010, charcoal production increased rapidly.

There were missing data on fuelwood consumption to produce charcoal, and on the biogas input to produce electricity in the biomass power plant. Thus, data on charcoal production was revised by assuming that production equals consumption. Based on the revised charcoal production data, the fuelwood requirement was estimated using the international efficiency standard of a fuelwood burner in a charcoal factory.

The total consumption of fuelwood now includes the consumption of the charcoal factory. Based on the revised fuelwood consumption data, fuelwood production is equal to consumption.

In the case of bagasse input to produce power, the efficiency assumption of the biomass power production is based on the international efficiency standard for biomass power production. The revised biomass data of the Lao PDR is shown in Table 2.9.

Lao PDR Energy Balance Table

The EBTs for 2000, 2005, 2010, and 2015 are shown in Tables 2.10 to 2.13. The complete EBTs from 2000 to 2015 are in Annex 4.

Table 2.9. Biomass Balance (kt)

Year	Fuelwood					Charcoal			Bagasse	
	Production	Consumption				Production	Consumption		Production	Consumption
		Commercial	Residential	Industry	Industry Charcoal		Commercial	Residential		
2000	3298	420	2346	123	410	102	53	50		
2001	3377	430	2402	126	419	105	54	51		
2002	3458	440	2459	129	429	107	55	52		
2003	3540	451	2518	133	439	110	56	53		
2004	3625	461	2579	136	449	112	58	55		
2005	3712	473	2641	139	459	115	59	56		
2006	3800	484	2704	142	470	117	60	57		
2007	4120	523	2922	154	522	130	67	64		
2008	4476	561	3135	165	616	154	79	75		
2009	4462	542	3028	159	732	183	94	89		
2010	4371	527	2946	155	743	186	95	91		
2011	4281	512	2864	151	754	189	97	92		
2012	4149	498	2781	104	765	191	98	93		
2013	4131	502	2699	156	774	193	103	90	5	8
2014	4181	508	2727	149	797	199	108	91	5	8
2015	4234	514	2754	146	820	205	113	92	4	5

kt = kiloton.

Source: Authors' calculation.

Table 2.10. Lao PDR's Energy Balance Table, 2000 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	88										1.260		1.650
2. Imports		312	78	44	184	3	2	0	296			15	328
3. Exports	-79											-240	-319
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	9	272	78	3	184	3	2	0	296		1.260	-225	1.618
8. Total Transformation Sector									-296		-86	302	-86
8.1 Main Activity Producer									-296			302	
8.8 Charcoal Processing											-86		-86
9. Loss and Own Use												-22	-22
10. Discrepancy		-1	-1	0	0		0					0	-1
11. Total Final Energy Consumption	9	270	77	3	184	3	2	0			1.174	55	1.509
12. Industry Sector	9	14			11	3					47	12	82
13. Transport Sector		254	77	3	173			0					254
13.2 Domestic Air Transport		3		3									3
13.3 Road		251	77		173			0					251
14. Other Sector		2			0		2				1.127	43	1.173
14.1 Residential and Commercial		2					2				1.127	41	1.169
14.1.1 Commerce and Public Services		1					1				197	13	210
14.1.2 Residential		1					1				930	28	959
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3.509				3.509

GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: This Working Group's own data source using international standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Table 2.11. Lao PDR's Energy Balance Table, 2005 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	148								308		1.418		1.874
2. Imports		384	100	44	233	4	2	0				28	412
3. Exports	-118											-216	-334
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	30	343	100	3	233	4	2	0	308		1.418	-187	1.912
8. Total Transformation Sector									-308		-96	308	-96
8.1 Main Activity Producer									-308			308	
8.8 Charcoal Processing											-96		-96
9. Loss and Own Use												-34	-34
10. Discrepancy		-4	-4	0	0		0				0	0	-4
11. Total Final Energy Consumption	30	338	96	3	233	4	2	0			1.322	87	1.777
12. Industry Sector	30	8			3	4					53	20	111
13. Transport Sector		329	96	3	229			0					329
13,2 Domestic Air Transport		3		3									3
13,3 Road		325	96		229			0					325
14. Other Sector		2			0		2				1.269	67	1.337
14.1 Residential and Commercial		2					2				1.269	64	1.334
14.1.1 Commerce and Public Services		1					1				221	20	242
14.1.2 Residential		1					1				1.047	44	1.092
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3.581				3.581

GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: This Working Group's own data source using international standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Table 2.12. Lao PDR's Energy Balance Table, 2010 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	320								741		1.670		2.731
2. Imports		662	145	45	463	6	3	1				104	766
3. Exports	-164											-572	-736
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	155	620	145	3	463	6	3	1	741		1.670	-468	2.719
8. Total Transformation Sector									-741		-156	741	-156
8.1 Main Activity Producer									-741			741	
8.8 Charcoal Processing											-156		-156
9. Loss and Own Use												-64	-64
10. Discrepancy	0	-27	-27		0		0				0	0	-27
11. Total Final Energy Consumption	155	593	118	3	463	6	2	1			1.514	210	2.472
12. Industry Sector	155	93			88	6					59	61	369
13. Transport Sector		497	118	3	374			1					497
13.2 Domestic Air Transport		3		3									3
13.3 Road		494	118		374			1					494
14. Other Sector		3			0		2				1.455	149	1.607
14.1 Residential and Commercial		2					2				1.455	145	1.603
14.1.1 Commerce and Public Services		1					1				267	64	333
14.1.2 Residential		1					1				1.188	81	1.270
14.2 Agriculture		0			0							4	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh									8.621				8.621

GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: This Working Group's own data source using international standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Table 2.13. Lao PDR's Energy Balance Table, 2015 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	1.801								1.232	0	1.619		4.652
2. Imports		971	180	44	729	10	4	2				176	1.147
3. Exports												-993	-993
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	1.801	930	180	3	729	10	4	2	1.232	0	1.619	-817	4.765
8. Total Transformation Sector	-1.410								-1.232	0	-173	1.453	-1.362
8.1 Main Activity Producer	-1.410								-1.232	0	-2	1.453	-1.190
8.8 Charcoal Processing											-172		-172
9. Loss and Own Use												-272	-272
10. Discrepancy	0	-9	-8	0		0	-1			0	0	0	-9
11. Total Final Energy Consumption	392	920	172	3	729	10	4	2			1.446	165	3.122
12. Industry Sector	392	46			37	10					56	150	644
13. Transport Sector		870	172	3	692			2					870
13.2 Domestic Air Transport		3		3									3
13.3 Road		867	172		692			2					867
14. Other Sector		4			0		4				1.390	214	1.608
14.1 Residential and Commercial		4					4				1.390	212	1.605
14.1.1 Commerce and Public Services		2					2				274	74	351
14.1.2 Residential		1					1				1.116	137	1.254
14.2 Agriculture		0			0							3	3
15. Non-energy Use		2						2					2
16. Electricity Output in GWh	2.567								14.326	0	4		16.896

GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: This Working Group's own data source using international standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Chapter 3
Energy Consumption Survey

Introduction

An energy consumption survey was conducted for the industry, road transport, residential, and commercial sectors. The objective of the survey was to collect the necessary consumption data for the estimation of the Lao PDR's energy consumption by sector and by type of energy source. The estimated unit consumption of the different types of fuel consumed by the sectors served as the basis to estimate the total fuel consumption of the country. The survey result was inflated by multiplying the specific energy consumption (intensity) of the respective sector's activity. In view of the voluntary nature of this survey, the limited time frame, and the relatively new experience of an energy consumption survey in the Lao PDR, the study team experienced constraints and difficulties due to the lack of full understanding of some of the questions and the lack of cooperation by the survey subjects. The overview of the data also appeared to lack consistency and some results were erratic. To eradicate the impact of outlier data, the study team made objective interpretation and judgement to achieve reasonable results in accordance with building practices in other countries of the Association of Southeast Asian Nations (ASEAN) with a similar climate. The assumptions and logic deployed in the analysis of data are discussed in the following sections.

Methodology

To achieve the consumption survey objective, the following methodologies were undertaken:

Preparation of Questionnaire

A questionnaire was prepared in close consultation with study team members consisting of a national consultant, an expert from the Economic Research Institute of ASEAN and East Asia (ERIA), staff from the Department of Energy Policy and Planning (DEPP) and other departments under the Ministry of Energy and Mines (MEM) of the Lao PDR, and representatives from the Lao State Fuel Company and the country's national electricity utility, Électricité du Laos (EDL).

The questionnaire consisted of two parts: general information and energy consumption. For the industry sector, general information on the manufacturing industry such as the name of the factory, major products, the International Standard Industrial Classification code, the yearly production amount of the major product, and the industry's annual gross revenue were collected.

The questionnaire was tested during the enumerator training and was adjusted and finalised with suggestions from experts.

Sampling and Sampling Size

The industry sector sampling consisted of six major industry sub-sectors: i) cement; ii) food, beverage, and tobacco; iii) wood and wood products; iv) construction; v) textile and leather; and vi) steel. At around 20 samples per sub-sector, the samples totalled 117.

The transport sector sampling used the parking lot survey. The types of vehicles sampled covered sedans, sport utility vehicles (SUVs), pickups, trucks, buses, motorcycles, private vehicles, taxis, and tuk-tuks. The sample size was 200 vehicles in 10 parking lot locations (around 20 samples per location). The buses in parking lots were not the big ones. For the big buses, the researchers approached a bus company in Vientiane.

The residential sector survey targeted urban and semi-urban areas. The sample totalled 200 residential dwellings.

The commercial sector survey consisted of four types of commercial buildings, namely: i) offices, ii) hotels, iii) malls/shops, and iv) hospital buildings. The sample totalled 200 commercial buildings.

All of the samples were located in Vientiane and its outer areas. The sample frame was based on the available list of establishments that the survey team sought from various sources (such as hotel and restaurant associations, chambers of commerce and industry, and garment associations). The sampling used both random and purposive techniques. For each sector and sub-sector, certain criteria were developed in consultation with the ERIA team members during the training workshop before researchers started the field survey.

Distribution and Collection of Survey Questionnaire

The researchers used questionnaires to collect data on the fuel consumption of the different sectors. The target respondents who were available during the survey were interviewed face-to-face. Those unavailable were requested to respond to the questionnaire at their convenience. In this case, the questionnaire was emailed or was left with administration officers. The enumerators went back to collect and check the questionnaire. The letter of introduction about the survey provided by MEM was attached to the questionnaire.

In addition to face-to-face interviews, information on actual figures of electricity consumption were collected from EDL.

The quality of information was key to this survey. The following steps were undertaken for quality assurance: i) checking by individual enumerators, ii) second checking by supervisors, and iii) call back or revisit (random and spot check) by the team leader/supervisor.

Industry Sector

The energy consumption survey in the industry sector was conducted to estimate the energy consumption of selected industry sub-sectors.

Survey Result

There were 117 establishments surveyed under the industry sector. Of these, 40 establishments came from the wood and wood products sub-sector; 30 from the food, beverage, and tobacco sub-sector; and 25 establishments from the textile and leather sub-sector (Table 3.1).

The survey collected the fuel consumption of the sub-sectors not only for the production process but also for other purposes such as lighting, transportation, stand-by power (auto generator/captive), feedstock, etc. Fuel consumption was estimated based on the fuel consumed for the production process.

Table 3.1. Overview Information on the Industry Sector

Sub-sector	Sample	Total Workers	Average Worker/ Factory	Main Products
i. Cement	14 (12%)	525	37.5	cement, ready-mixed concrete, concrete Pole, brick, CPAC roof
ii. Food, Beverage, and Tobacco	30 (26%)	1,815	60.5	beer, drinking water, whisky, tobacco, Pepsi, Coca-Cola, ice, noodles, meat ball
iii. Wood and Wood Products	40 (34%)	284	7.1	sawed timbre/lumber, furniture
iv. Construction	4 (3%)	52	13	building
v. Textile and Leather	25 (21%)	6,903	276.12	cloth, fabric, shoes
vi. Steel	4 (3%)	234	58.5	steel, nail, steel barbed wire, zinc/ steel roof
Total	**117**	**9,813**		

CPAC = Concrete Products and Aggregate Co., Ltd. (subsidiary of Thailand's Siam Cement Group).

Source: Industrial survey results for the Lao PDR.

The fuels consumed by the sub-sectors were recorded in their physical unit. For coal, it was in kilogram (kg); for petroleum products, except LPG, in kilolitre (kl), for liquefied petroleum gas (LPG), in ton; and for electricity, in kilowatt-hour (kWh). The fuels had to be converted to the energy unit before summation. Density and heating values of the different fuels are shown in Table 3.2.

Table 3.2. Density and Heating Values of Different Fuels

Type of Fuel	Density		Heating Value	
	Unit	Value	Unit	Value
Coal	-	-	kcal/kg	6,000
Wood/ Biomass	-	-	kcal/kg	3,820
Electricity	-	-	kcal/kWh	860
LPG	kg/l	0.510	kcal/kg	11,778
Diesel	kg/l	0.839	kcal/kg	10,236
Gasoline	kg/l	0.737	kcal/kg	10,450
Fuel Oil	kg/l	0.890	kcal/kg	10,105
Lubricant	kg/l	0.858	kcal/kg	9,929
OOP	kg/l	0.858	kcal/kg	9,929
Naphtha	kg/l	0.740	kcal/kg	10,750

kcal = kilocalorie, kg = kilogram, kWh = kilowatt-hour, LPG = liquefied petroleum gas, l = litre, OOP = other oil products.

Source: Association of Southeast Asian Nations/Asia-Pacific Economic Cooperation/International Energy Agency Joint Energy Format.

The activities of the sampled factories were represented by the sales revenue. Thus, the survey estimated the factory units' fuel consumption per sales revenue. Some of the sampled factories, however, considered sales revenue confidential. In these cases, the samples only provided their consumption data. In some cases, the samples had their sales revenue data, but their consumption data was only for purposes other than production. Note that it is necessary to have both the revenue and the fuel consumption data for the production process to estimate the average unit consumption per sales revenue.

The average fuel consumption and sales revenues of the sampled factories in each sub-sector are shown in Table 3.3. The sampled industry sub-sector included construction but it did not provide information on sales revenue. Therefore, the construction sector was excluded in the estimation of the unit fuel consumption per sales revenue.

Table 3.3. Average Sales Revenue and Fuel Consumption

Industry	Sales Revenue (Mil. US$)	Total Consumption (ktoe)	Ktoe/ Mil US$	Fuel Share (%)					
				Coal	Wood/ Biomass	Electricity	LPG	Diesel	Fuel Oil
Food Processing, Beverage, and Tobacco	23.2323	21.8436	0.9402	18.74	57.91	20.84	0.83	2.19	56.43
Textile	2.3263	0.2520	0.1083	2.88	91.91	5.17	0.00	0.04	0.00
Cement	0.6478	0.1856	0.2866	20.62	0.10	72.69	0.31	6.29	0.00
Wood	0.0118	0.0026	0.2200	0.00	28.28	70.96	0.76	0.00	0.00
Steel	0.5076	1.1908	2.3458	0.00	0.00	95.82	4.18	0.00	0.00

LPG = liquefied petroleum gas, ktoe = thousand ton of oil equivalent.

Source: Authors' calculation.

Inflation to National Total

In the industrial survey, the unit consumption for total fuel was calculated by dividing the total fuel consumption in each of the sub-sector by its sales revenue and adjusted by the value-added ratio. Multiplying the unit consumption with the sector's gross domestic product (GDP) will result in total fuel consumption of the industry sector for the whole country. Thus, total consumption is denoted as:

$$EC_i = \sum_{i=sector}^{n} IECi * (GDPi/VARi)$$

where:

ECi is the total energy consumption for sector i;
IECi is the energy consumption per revenue for sector i (intensity);
GDPi is the total GDP for sector i; and
VARi is the value-added ratio for sector i (assumed to be 0.5 for all sectors).

The Lao PDR GDP structure consists of the agriculture, industry, and service sectors (Table 3.4). Data were collected by DEPP from the Lao Statistics Bureau for 2012 to 2016.

The industry sector's contribution to total GDP reached around 34% in 2016, increasing from its 32% share in 2012. The manufacturing sector was separated into: i) food; ii) beverage and tobacco; iii) textile, cloth, shoes, and leather; and iv) other manufacturing. There was no further breakdown into the cement, wood, and steel sub-sectors.

Table 3.4. Lao PDR Gross Domestic Product
(KN billion, at 2012 constant price)

Main Activity	2012	2013	2014	2015	2016
Agriculture	**15,138**	**15,567**	**16,213**	**16,791**	**17,254**
Planting	9,423	9,770	10,485	10,946	11,289
Livestock	1,942	2,003	2,079	2,171	2,301
Forestry	1,748	1,668	1,420	1,314	1,229
Fishing	2,025	2,126	2,229	2,360	2,435
Industry	**26,471**	**28,509**	**30,594**	**32,738**	**36,667**
Mining and Quarrying	9,379	9,805	10,625	10,617	11,052
Food	1,368	1,462	1,545	1,620	1,645
Beverage and Tobacco	1,182	1,298	1,518	1,568	1,627
Textile, Cloth, Shoes, and Leather	1,300	1,311	1,348	1,357	1,368
Other Manufacturing	3,481	3,518	3,918	4,152	4,331
Electricity	5,265	6,185	6,160	6,856	9,539
Water and Waste Treatment	232	252	267	276	285
Construction	4,264	4,678	5,213	6,292	6,820
Sevice	**32,768**	**35,957**	**38,874**	**41,992**	**43,944**
Wholesale and Retail Trade, Repairs	9,759	10,860	12,393	13,622	14,516
Transport and Storage	1,148	1,253	1,334	1,482	1,606
Hotels and Restaurants	2,460	2,681	2,913	3,199	3,162
News and Communication	1,331	1,509	1,676	1,932	2,013
Financial and Insurance	1,496	1,995	2,154	2,288	2,466
Immovable Property	6,100	6,133	6,725	7,137	7,401
Colleges Service	1,071	1,170	1,258	1,417	1,518
Defence and National Protection	6,063	6,649	6,519	6,888	7,128
Education	1,432	1,677	1,794	1,852	1,892
Health Care and Welfare	421	486	499	516	519
Others Service	1,487	1,544	1,609	1,659	1,723
Gross Value Added	**74,377**	**80,033**	**85,681**	**91,521**	**97,865**
Tax on Product, Net	7,233	8,125	9,190	10,248	11,051
GDP at 2012 Constant Price	**81,610**	**88,158**	**94,871**	**101,769**	**108,916**

GDP = gross domestic product, KN = kip.

Source: Department of Energy, Policy and Planning, based on data from Lao Statistics Bureau.

To calculate the national energy consumption of the industry sector, the survey results for the cement, wood, and steel sub-sectors were combined as 'Other Manufacturing' sub-sector. The survey result was applied only for the 2015 values for comparison with the figures in the 2015 Lao PDR Energy Balance Table (EBT).

Table 3.5. Estimated Total Consumption of the Industry Sector

Industry	GDP 2015		Survey Result	Estimated Energy Consumption (ktoe)
	KN Billion	US$ Million	ktoe/US$ Million	
Manufacturing	**8,697**	**1,061**		**432.45**
Food, Beverage, and Tobacco	3,188	389	0.94022	182.77
Textile, Cloth, Shoes, and Leather	1,357	165	0.10835	8.97
Other Manufacturing	4,152	506	0.95079	240.71

GDP = gross domestic product, KN = kip, ktoe = thousand ton of oil equivalent.
Note: US$1.00 = KN8,200.
Source: Authors' calculation.

Using the fuel shares calculated from the survey as shown in Table 3.3, the estimated fuel energy consumption in 2015 shows that majority of the fuel consumed by the manufacturing sector is electricity followed by oil, which is mainly fuel oil (Table 3.6).

Table 3.6. Estimated Total Consumption by Fuel (ktoe)

Main Activity	Estimated Energy Consumption (ktoe)	Coal	Biomass	Electricity	Oil	LPG	Diesel	Fuel Oil
Industry	432.45	74.04	12.52	222.71	123.18	4.05	15.99	103.13
Food, Beverage, Tobacco	182.77	34.44	1.42	38.08	108.83	1.70	3.99	103.13
Textile, Cloth, Shoes,Leather	8.97	0.26	8.24	0.46	0.00	0.00	0.00	0.00
Other Manufacturing	240.71	39.34	2.86	184.17	14.35	2.35	11.99	0.00

LPG = liquefied petroleum gas, ktoe = thousand ton of oil equivalent.
Source: Authors' calculation.

The 2015 Lao PDR EBT shows that the total energy consumption of the total industry was around 644 ktoe (Table 3.7). Since no data was available for sub-sector consumption, total consumption was entered as non-specified industry consumption. The estimated energy consumption was just for the manufacturing industry consumption and should thus be smaller than that for the total industry. In this case, the difference is around 212 ktoe (almost one-third of the EBT value).

Table 3.7. Estimated Total Energy Consumption by Fuel (ktoe)

Sector	Coal	Petroleum Products	Gas/ Diesel Oil	Fuel Oil	LPG	Others	Electricity	TOTAL
Industry Sector	**392**	**46**	**37**	**10**		**56**	**150**	**644**
Iron and Steel								
Chemical (incl. Petrochemical)								
Non-ferrous Metals								
Non-metallic Mineral Products								
Transportation Equipment								
Machinery								
Mining and Quarrying								
Food, Beverages, and Tobacco								
Pulp, Paper, and Printing								
Wood and Wood Products								
Construction								
Textile and Leather								
Non-specified Industry	392	46	37	10		56	150	644

ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: 2015. Lao PDR Energy Balance Table.

The differences are due to the limitation of the GDP statistics. There was no breakdown of the GDP statistics for the cement, wood, and steel industries. In addition, some of the factories surveyed excluded their revenue data. This affected the estimation of the industry intensities.

This energy consumption survey of the industry sector is the first of its kind for DEPP. Therefore, there are differences in the estimated fuel consumption between the survey result and the DEPP data. In conclusion, there is plenty of room to improve the survey results in the future which will contribute to the breaking down of energy consumption in the industrial sub-sectors.

Future Improvements

The industrial survey was used to estimate the unit energy consumption of each sub-sector surveyed. The sales revenue of the sub-sector surveyed was used to represent the activity of the sub-sector. Thus, unit energy consumption was calculated per sales revenue.

Sales revenue was confidential in some of the surveyed factories so it was not possible to calculate the unit energy consumption of these factories. In addition, there were outliers

in the sample results of the unit energy consumption. These two factors reduced the accuracy of the average unit energy consumption of each sub-sector.

In the future, prior to conducting the survey, DEPP needs to collect the list of manufacturing industries operating in the Lao PDR to understand the population of the different sub-sectors. The number of samples should also be more than 200 since some factories have missing sales revenue data and some are outliers.

At the national level, the gross added value of the sub-sector is the indicator of sub-sector activity. Therefore, to inflate the industrial survey result of the estimated energy consumption to the national level, the researchers had to break down the surveyed sub-sector's GDP. The current GDP structure of the Lao PDR combines the gross added value of the cement, wood and wood products, and steel under the Other Manufacturing sub-sector.

For future surveys, DEPP should request the breakdown of the GDP of Other Manufacturing sub-sector from the Lao Statistics Bureau. This information should be available since the gross added value of an industry is usually calculated as the difference between the output and input values of the industry.

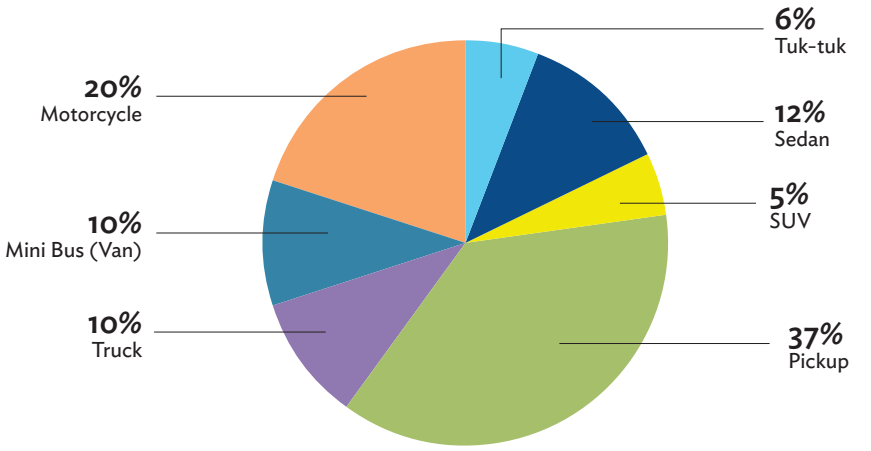
Another option to estimate the unit energy consumption is the production amount of each sub-sector surveyed. At the national level, this will also need the total production of the sub-sector. In conclusion, both the national production and gross added value of the sub-sectors surveyed are very important in estimating the total energy consumption of the Lao PDR from the demand side.

Road Transportation Sector

Survey Results

A parking lot survey was conducted in several locations in Vientiane (Anou Park, Aussie market, ITEC Shopping Mall, Khet Market, Kuadin Market, Nong Nieu Market, Sikhay Market, Victory Monument, View Mall, and VTE Center). The sample totalled 200 vehicles (Figure 3.1).

Figure 3.1. Types of Vehicles Sampled



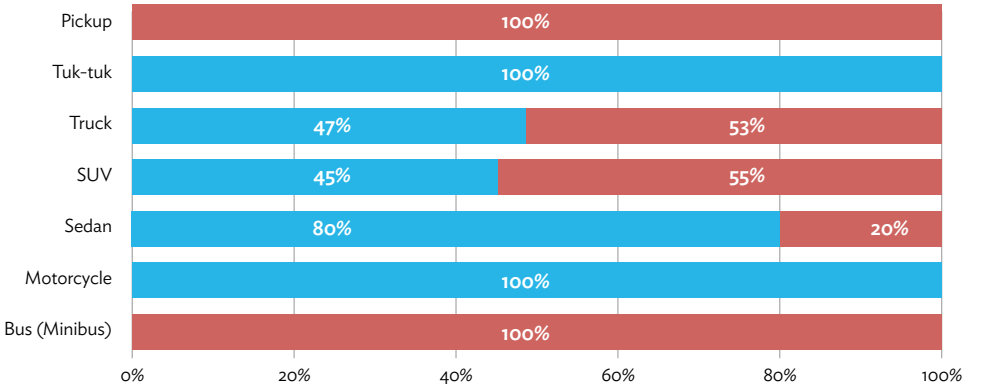
SUV = sport utility vehicle.

Source: Authors' calculation.

The pickup had the largest share of the vehicles sampled, followed by the motorcycle. All the pickups sampled consumed diesel oil while the motorcycles consumed gasoline. Figure 3.2 shows the fuel consumption of the sampled vehicles. Overall, 57% consumed diesel while 43% consumed gasoline. The share of the vehicles by type and their fuel share were the bases for estimating the national road transport consumption by vehicle type.

Based on the vehicle's weekly consumption and the distance travelled, it is possible to calculate the average fuel economy of the vehicle and its distance travelled over the year.

Figure 3.2. Breakdown of Vehicles by Fuel Consumed



	Bus (Minibus)	Motorcycle	Sedan	SUV	Truck	Tuk-tuk	Pickup
Gasoline		40	20	5	9	12	
Diesel	19		5	6	10		74

SUV = sport utility vehicle.

Source: Authors' calculation.

The fuel economy of the vehicle is the relationship between the distance travelled and the amount of fuel consumed by the vehicle. Consumption can be expressed in terms of volume of fuel to travel a distance, or the distance travelled per unit volume of fuel consumed. Outliers in the samples were removed from the data set. An outlier is an observation that has an abnormal distance from the other values in a random sample from a population. Table 3.8 shows the calculated average fuel economy and distance travelled for gasoline and diesel vehicles according to the type of vehicle

The large bus values were based on the interview of a bus company, which indicated that the large buses use diesel. The company provided the monthly fuel consumption and distance travelled of the operating buses. Not all of the company buses operate every month. On average, 29 buses operate per month. The fuel economy was calculated based on this number.

Table 3.8. Fuel Economy and Distance Travelled of Sampled Vehicles

Type of Vehicle	Average Km/Litre		Average Km/Year	
	Gasoline	Diesel	Gasoline	Diesel
Sedan/Car	9.6	9.5	15,236	16,276
SUV	9.9	9.3	16,006	16,995
Bus (minibus)		9.2	0	18,206
Pickup		9.1	0	16,712
Truck	9.8	9.8	31,633	14,080
Motorcycle	20.5		5,104	0
Tuk-tuk	10		15,974	0
Large Bus		3,4		4,990

km = kilometre, SUV= sport utility vehicle.

Source: Authors' calculation.

Inflation to National Total

Based on the unit fuel consumption of the different types of vehicles surveyed, the total oil consumption for road transport was estimated as follows:

$$OIL_i = \sum_{i=vehicle}^{n} (FEi * DISi * VEHi)$$

where:

OILi is the total gasoline/diesel consumption for vehicle type *i;*

FEi is the fuel economy of vehicle type *i;*

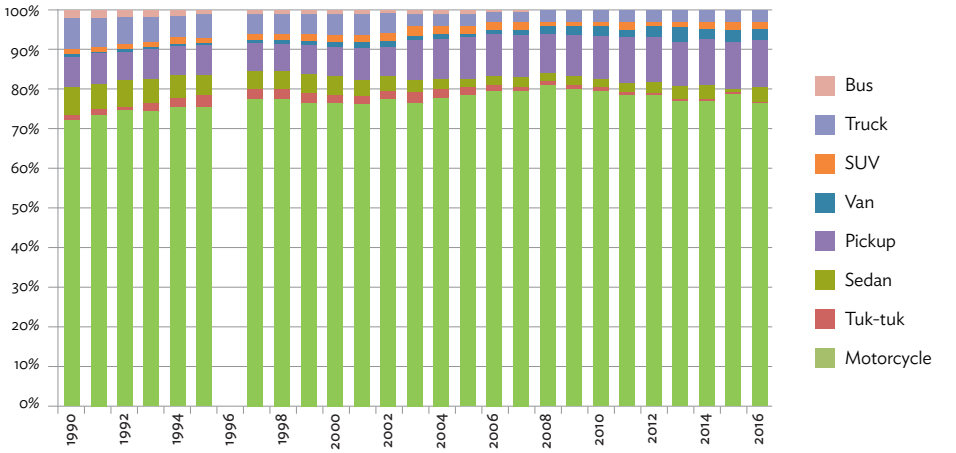
DISi is the distance travelled of vehicle type *i;* and

VEHi is the total number of gasoline/diesel vehicles for type *i*.

The unit fuel consumption or intensity is the consumption per vehicle over a year. This was calculated from the sample result as the product of the fuel economy (kilometre [km]/litre) and the distance travelled (km/year).

The total number of vehicles is the activity data for the road transport sector. The data was based on annual vehicle registrations. DEPP provided the vehicle population by type from 1990 to 2016 (Figure 3.3). Based on this data, total vehicle population in the Lao PDR increased by 13% per year, from around 80,000 in 1990 to almost 1.8 million in 2016. No data was available in 1996.

Figure 3.3. Vehicle Population in the Lao PDR, 1990–2016



SUV= sport utility vehicle.

Sources: Department of Energy, Policy and Planning Ministry of Energy and Mines, Lao PDR; Department of Transport, Ministry of Public Works and Transport, Lao PDR.

The majority of the vehicles surveyed were motorcycles. The shares of motorcycles in the total vehicle population were 72% in 1990 and 77% in 2016.

DEPP did not specify the vehicle type by fuel consumption in its vehicle population data. Hence, the breakdown of vehicles by type of fuel consumed was based on the survey conducted in 2017. Since no vehicle population data was available for 2017 and the latest DEPP petroleum product consumption data at the time of the survey was 2015, the number of vehicles by type in 2015 was used to estimate the total fuel consumption by type of vehicle using the vehicles' intensity (consumption per vehicle per year).

Table 3.9. Estimated Total Consumption on Road Transport

Vehicle Type	Number of Vehicles		Vehicle Intensity (l/vehicle)		Total Consumption (kl)		
	Gasoline-Fuelled Vehicle	Diesel-Fuelled Vehicle	Gasoline-Fuelled Vehicle	Diesel-Fuelled Vehicle	Gasoline-Fuelled Vehicle	Diesel-Fuelled Vehicle	Total Fuel
Sedan/Car	7,009	1,752	1,587	1,713	11,124	3,002	14,126
SUV	12,120	14,545	1,617	1,827	19,596	26,579	46,175
Minibus (Van)	-	47,553		1,979		94,103	94,103
Pickup	-	204,360		1,836		375,304	375,304
Truck	23,087	25,652	3,228	1,564	74,521	40,131	114,652
Motorcycle	1,318,107	-	249		328,176		328,176
Tuk-tuk	8,761	-	1,597		13,995		13,995
Buses	-	4,448		1,465		6,518	6,518
Total	**1,369.084**	**298,310**			**447,412**	**539,119**	**986,531**

kl = kilolitre, l = litre.

Source: Authors' calculation.

The result showed that the total consumption of petroleum products for road transport in the Lao PDR was 986,531 kl, consisting of 447,412 kl gasoline and 539,119 kl diesel fuel. However, the consumption of gasoline by fuel type was twofolds higher while that of diesel was lower. The DEPP consumption data was for total transport. In the case of gasoline, the DEPP data was only for road transport since gasoline was consumed only by road vehicles. Diesel fuel was consumed for road transport and water/river transport.

The estimated road energy consumption by fuel type was estimated based on the number of gasoline and diesel vehicles. The real share of these vehicles from the total vehicles in the country can be obtained by improving the transportation statistics to include the breakdown of the number of vehicles by the type of fuel consumed.

In terms of the total fuel consumption of the road sector, the difference was still statistically acceptable (below 10%). In this regard, the major study results (fuel economy and mileage) could be useful for the analysis of vehicles. The exception was the result of motorcycle consumption (328,000 kl), which was higher than the DEPP statistics on gasoline import for 2015 (234,000 kl).

Table 3.10. DEPP Statistics on Gasoline and Diesel Supply and Consumption

Year	Gasoline		Diesel Oil				
	Import	Consumption	Import	Consumption			
		Transport		Transport	Agriculture	Industry	Total
2000	101,676	100,476	214,461	201,569	232	12,660	214,461
2001	102,439	100,439	245,641	236,513	232	8,896	245,641
2002	108,002	107,002	247,574	238,059	232	9,282	247,574
2003	112,200	110,200	255,769	250,615	232	4,921	255,769
2004	119,879	117,879	262,904	257,323	232	5,348	262,904
2005	129,356	124,301	271,031	266,825	232	3,974	271,031
2006	143,473	134,654	375,295	282,850	232	92,213	375,295
2007	152,502	152,502	381,944	307,177	232	74,535	381,944
2008	159,455	159,455	457,327	365,013	232	92,082	457,327
2009	178,296	155,118	538,769	430,015	232	108,522	538,769
2010	187,755	152,885	538,769	436,034	232	102,502	538,769
2011	197,176	144,804	550,844	439,805	232	110,807	550,845
2012	208,205	139,559	601,588	510,293	232	91,062	601,588
2013	219,251	215,650	643,276	533,735	232	109,308	643,275
2014	212,950	210,416	688,907	654,122	232	34,553	688,908
2015	234,199	223,318	849,151	686,447	232	162,472	849,151

Source: Department of Energy Policy and Planning, Lao PDR.

Future Improvements

The parking lot survey and transport company interview provided bases for the estimation of oil consumption in the road transport sector. The result for total oil consumption was slightly higher than the DEPP data (less than 10%). The breakdown by diesel and gasoline fuel was significantly different.

The estimate of the fuel economy and distance travelled of the sampled vehicles was the basis for calculating the total road consumption at the national level. The survey resulted in an overestimation of gasoline consumption while diesel consumption was on the lower side compared to the DEPP data.

The issue was that the total number of vehicles by type was not broken down by type of fuel consumed. An estimation of the breakdown was made based on the sampled survey.

In the future, DEPP can approach the division that handles motor vehicle registrations. Usually, when a vehicle is registered, it includes information on the engine size and the type of fuel it consumes. Based on this information, it would be possible to break down the vehicle population by type and fuel consumed.

The statistics on the number of vehicles need to be clarified – whether it is all in operation or just a cumulative number from previous years. DEPP should also collect the number of newly registered vehicles in addition to those already in operation. This will make the estimation of the fuel consumption at the national level more accurate.

For buses or trucks not covered in the parking lot survey, the transport company interview was the best approach. For comparison purposes, at least two transport companies should be interviewed for each vehicle type (buses, trucks, and taxis).

Lastly, the estimate of the fuel consumed by the transport sector needs to be compared with the sales of the oil companies at the pump stations. At the moment, DEPP sources its data from the fuel import data of the customs office. There is no breakdown of, for example, of the imported diesel by road or inland waterways (river transport). By collecting the oil companies' sales at the pump stations, the diesel consumption used in the road transport sector can be obtained.

Commercial Sector

The commercial sector surveyed consisted of four types of buildings, namely, offices (100), hotels (50), shoping malls (35), and hospitals (15).

A useful method to evaluate the energy performance of commercial buildings is to derive a benchmark value in building energy intensity (BEI) from the survey data. BEI is expressed as kilowatt-hour per square meter (kWh/m^2) per year and can be determined by the following formula:

$$BEI = \frac{TBEC - CPEC - DCEC}{GFA - DCA - GLA \times FVR} \times \frac{52}{WOH}$$

where:

TBEC is the total building energy consumption (kWh/yr);
CPEC is the car park energy consumption (kWh/yr);
DCEC is the data centre energy consumption (kWh/yr);
GFA is the gross floor area (m^2);
DCA is the data centre area (m^2);
GLA is the gross lettable area (m^2);
FVR is the floor vacancy rate (%);
WOH is the weighted weekly operating hours (hr/week); and
BEI is the building energy intensity (kWh/m^2/yr).

Table 3.11 shows the typical benchmark values of BEI in Malaysia and the energy use intensity (EUI) in Singapore.

Table 3.11. Comparison of Building Energy Intensity Values

Building Type	EUI for Green Mark, Singapore (kWh/m^2/year)		BEI for GBI, Malaysia (kWh/m^2/year)	
	Conventional	Green Building Entry Level	Conventional	Green Building Entry Level
Office Buildings	246	200	250	• 150
Hotels	275	250	N/A	• 200 for 3-star hotels • below 290 for 4-star hotels and above
Retail Buildings	543	474	345	• 240 for malls consisting of general retail outlets and low-energy intensity outlets • 350 for malls consisting of at least 10% (of its NLA) high-energy intensity outlets such as F&B, supermarkets, and outlets operating long hours such as cinema, etc.
Hospitals	355	310	300	• 200 for hospitals providing limited clinical services such as day surgery, etc. • 290 for hospitals providing major clinical services (requiring high-energy intensity)

BEI = building energy intensity, EUI = energy use intensity, F&B = food and beverages, GBI = Green Building Index, kWh = kilowatt-hour, m^2 = square meter, N/A = not available, NLA = net lettable area.

Source: ASHRAE, Malaysia Chapter, 2018.

Office Buildings

The key data obtained in the survey were the following:

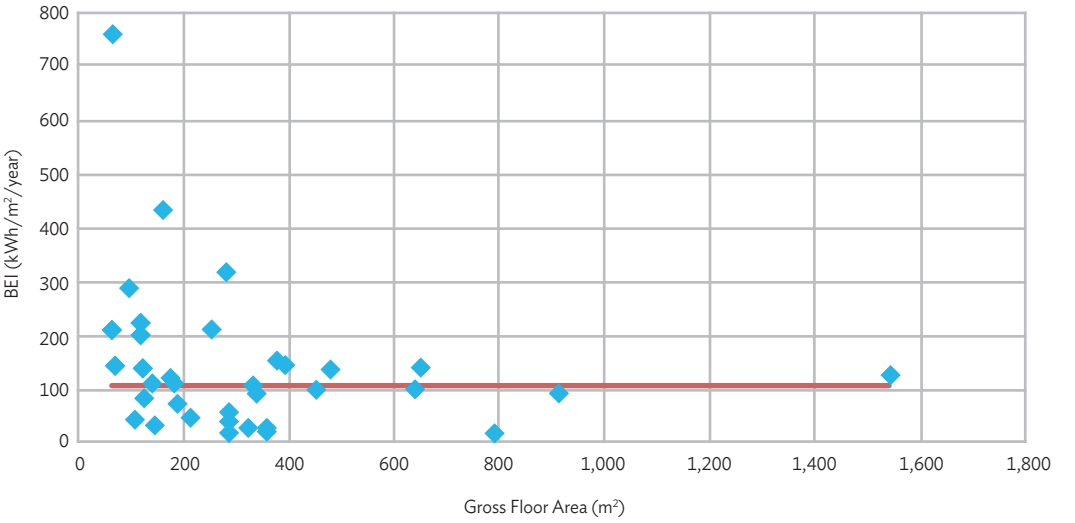
i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) daily operational hours;
v) total gross floor area (m^2 – excluding car park and data centre); and
vi) estimated percentage of air-conditioned area.

The maximum demand was supposed to be the highest load on the building's electrical system at a given time and was intended to be used to gauge the extent of electricity consumption in a building. The data obtained appeared to be the monthly electricity consumption of a building, which was not the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of the maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption in office buildings were not reflective of the actual yearly electricity consumption.

Operational hours of office buildings varied and that the average operational hours amongst the buildings surveyed was 2,160 hours per year. This value is lower than the 2,700 hours per year value adopted by the green building practices in Malaysia. The latter included working hours beyond the official operational hours in offices where air-conditioning systems were still operational. Nevertheless, based on this average value and after adding the consumption of other energy sources, the total energy consumption was adjusted to reflect the same operational hours of 2,160 per year to rationalise the energy consumption for comparison purposes.

The main energy source of office buildings was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey. Preliminary analysis showed exceptionally low BEI value compared with office buildings in Malaysia and Singapore, which have similar climatic conditions.

Figure 3.4. Preliminary BEI vs GFA Trend of Office Buildings



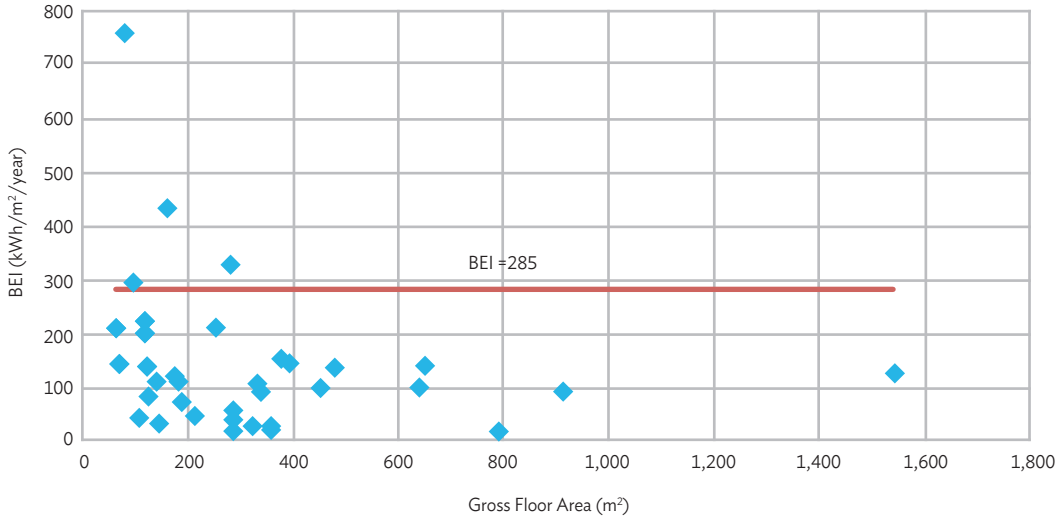
BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data 2017.

Figure 3.4 shows an average BEI value of about 106 kWh/m^2/year. This is good because the average conventional buildings without energy efficiency design and installations are in the range of 250 kWh/m^2/year in Malaysia and 246 kWh/m^2/year in Singapore. The discrepancies in the survey results could be due to the accuracy of the energy consumption values and the gross floor areas, and the average operational hours of office buildings. The average BEI in Figure 3.4 was derived from all the BEI values calculated from the survey data, except for BEI values exceeding 500 kWh/m^2/year.

Another analysis was conducted which invalidated BEI values below 200 kWh/m^2/year and only considered BEI values that fall between 200 kWh/m^2/year and 500 kWh/m^2/year. This assumption was made based on the established BEI and EUI values of office buildings in Malaysia and Singapore. The results are shown in Figure 3.5.

Figure 3.5. Final Analysis of BEI vs GFA of Office Buildings



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.
Source: The Working Group's calculation of BEI from 2017 survey data 2017.

Figure 3.5 shows an average BEI value of 284 kWh/m^2/year, which was rounded up to 285 kWh/m^2/year. For the purpose of this survey, the average benchmark value of energy consumption intensity in office buildings is 285 kWh/m^2/year.

Hotels

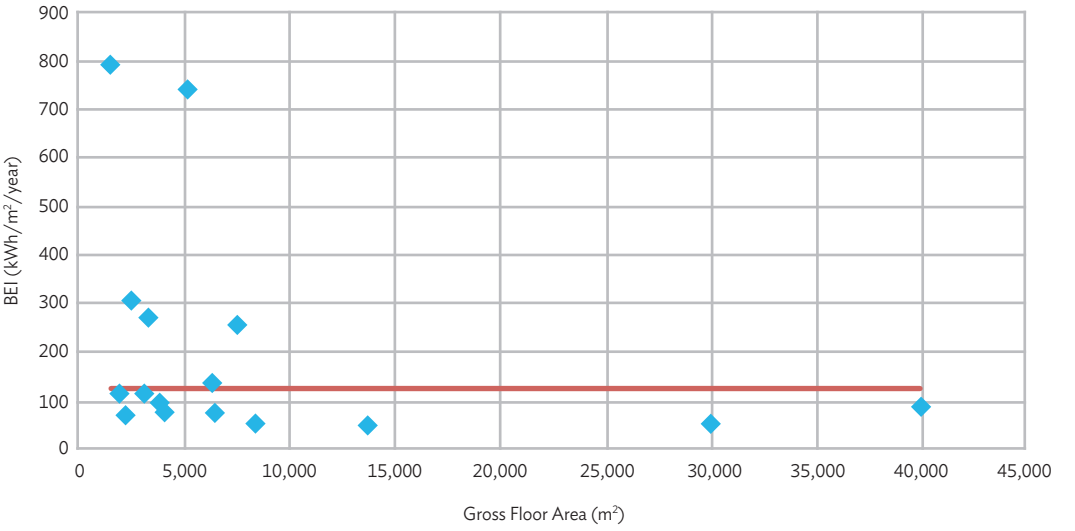
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) peak and off-peak periods;
v) star ratings of hotels;
vi) total gross floor area (m^2 – excluding car park and data centre); and
vii) estimated percentage of air-conditioned area.

Similar to office buildings, the maximum demand recorded appeared to be the monthly electricity consumption of the hotels, which was not in accordance with the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption of hotels were not reflective of their actual yearly electricity consumption. The maximum demand was meant to be the highest load on the building's electrical system at a given time and was intended to be used to gauge the extent of electricity consumption in a building.

The main energy source of hotels was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey. Preliminary analysis showed exceptionally low BEI value in compared with the BEI for hotels in Malaysia and Singapore.

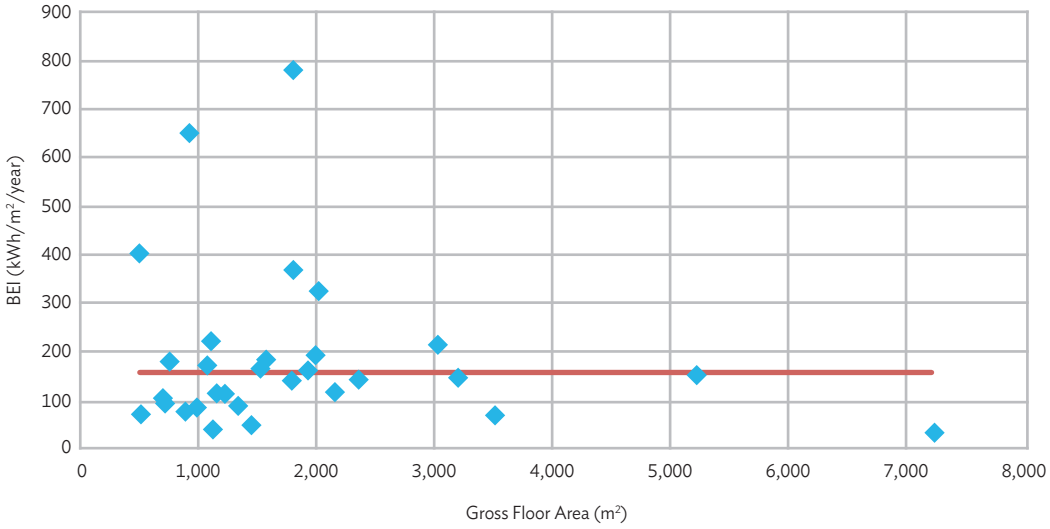
Figure 3.6. Preliminary BEI vs GFA Trend of 4- and 5-Star Hotels



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.7. Preliminary BEI vs GFA Trend of 1- to 3-Star Hotels

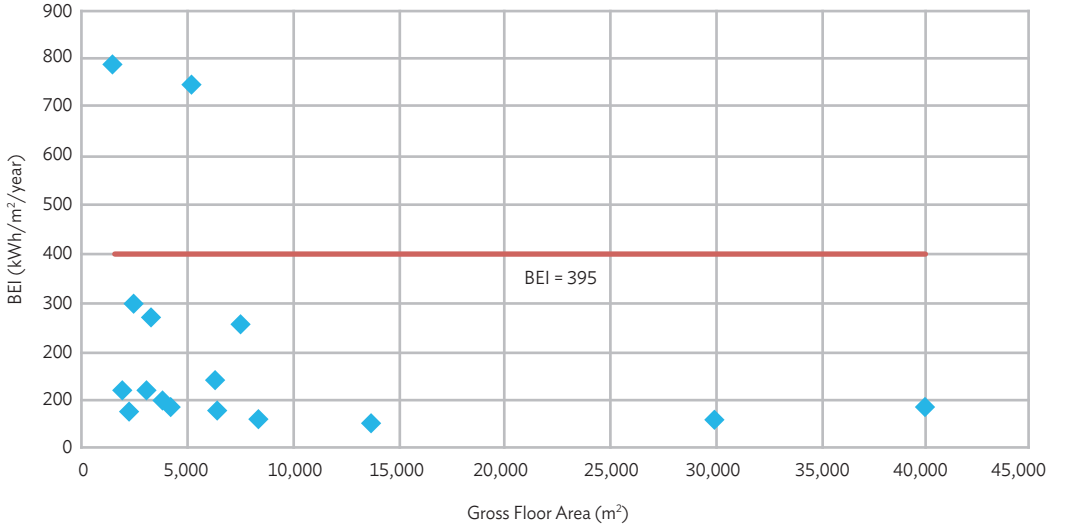


BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.
Source: The Working Group's calculation of BEI from 2017 survey data.

Preliminary analyses showed that the average BEI for 4- to 5-star hotels was about 126 kWh/m^2/year and about 159 kWh/m^2/year for 3-star hotels. These BEI values are rather low compared with the BEI values in Malaysia and Singapore. The BEI values of 4- to 5-star hotels are generally greater than those of 3-star hotels but the preliminary analyses showed the opposite.

In conducting further analyses, the same approach as that for office buildings was adopted. For 4- to 5-star hotels, the average BEI value was based on the 150 kWh/m^2/year to 750 kWh/m^2/year range. As shown in Figure 3.8, the average BEI value was 393 kWh/m^2/year, which was rounded to 395 kWh/m^2/year. Similarly, the BEI value for 3-star hotels was 262 kWh/m^2/year, which was rounded to 260 kWh/m^2/year.

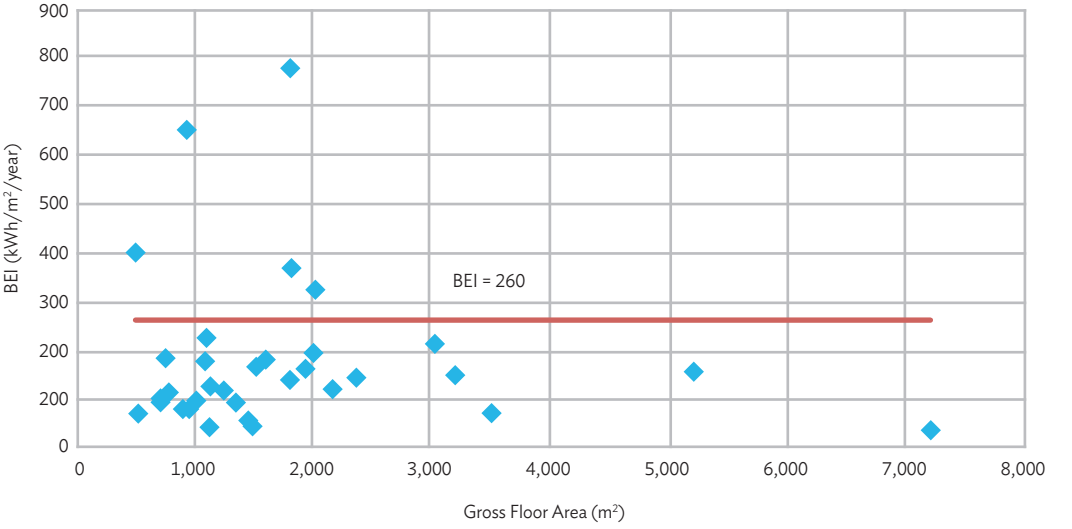
Figure 3.8. Final Analysis of BEI vs GFA for 4- to 5-Star Hotels



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.9. Final Analysis of BEI vs GFA for 3-Star Hotels



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

Retail Buildings

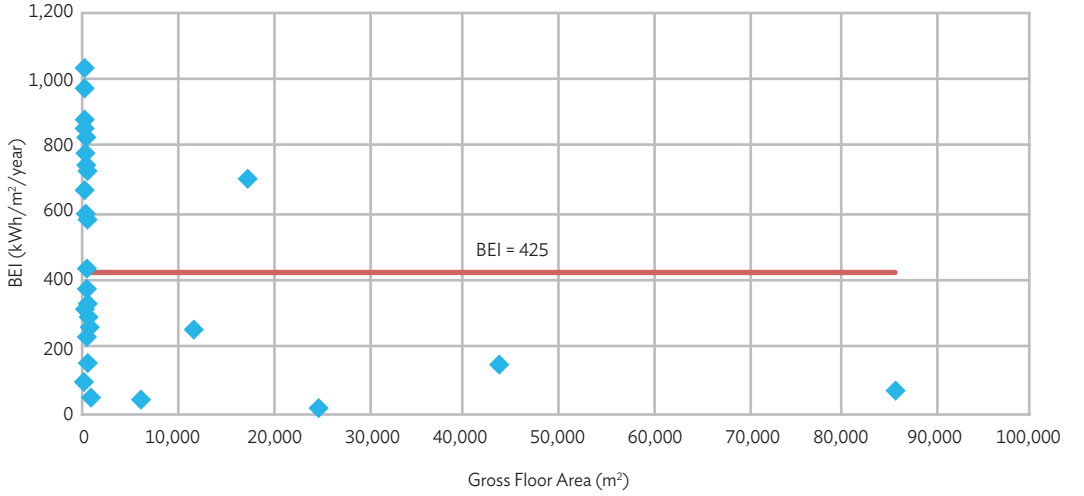
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) daily operational hours;
v) total gross floor area (m^2 – excluding car park and data centre); and
vi) estimated percentage of air-conditioned area.

Similar to office buildings, the operational hours of retail buildings varied. The average operational hour amongst the buildings surveyed was 6,068 hours per year, which was rounded up to 6,070 hours per year. This value is high compared with the 4,368 operational hours per year or 84 operational hours/week of green buildings in Malaysia. Based on this average value and after adding the consumption of other energy sources, the total energy consumption was adjusted to reflect the same operational hours of 6,070 per year to rationalise the energy consumption for comparison purposes.

Similar to other commercial buildings, the main energy source of retail buildings was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey.

Figure 3.10. Analysis of BEI vs GFA of Retail Buildings



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.10 shows the diverse range of BEI values of small retail buildings. Since the sampling size was small, the determination of the average value of BEI was based on all the values obtained in the survey. The average BEI value for retail buildings was 423 kWh/m^2/year, which was rounded up to 425 kWh/m^2/year.

Hospitals

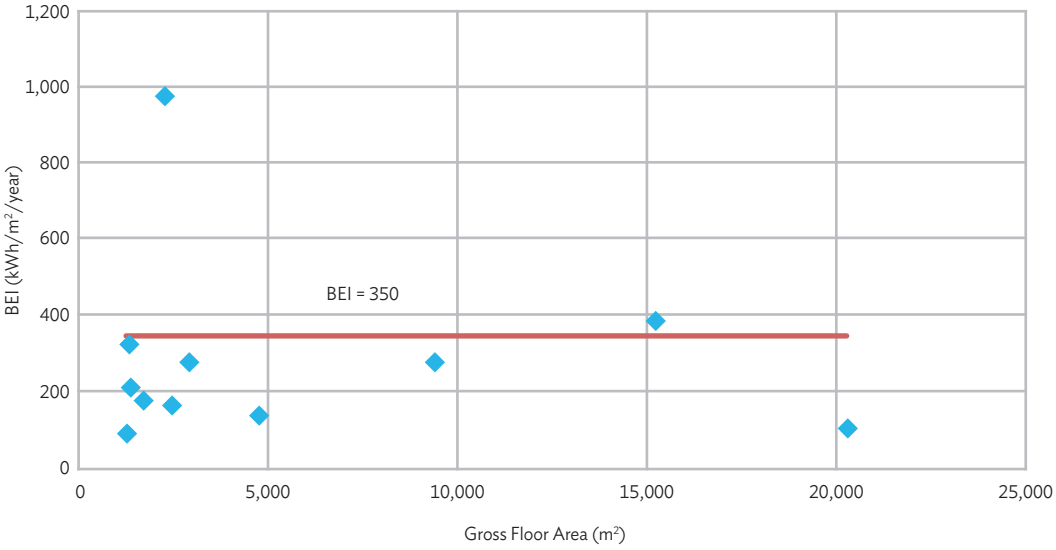
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) total gross floor area (m^2 – excluding car park and data centre); and
v) estimated percentage of air-conditioned area.

Similar to hotel buildings, the maximum demand recorded appeared to be the monthly electricity consumption of a building, which was not in accordance with the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption in office buildings were not reflective of the actual yearly electricity consumption in hotels. Nevertheless, the analysis of hospital energy consumption was based on the data obtained in the survey.

The hospitals were grouped according to size: i) large hospitals with gross floor area exceeding 2,000 m^2; ii) medium hospitals with gross floor area between 1,000 m^2 and 2,000 m^2; and iii) small hospitals with gross floor area less than 1,000 m^2. The BEI values for small hospitals appeared to be exceptionally low. The study group thinks that these buildings might be functioning as clinics rather than as hospitals. In view of this, the determination of the average value of BEI was based on the BEI values for large- and medium-sized hospital buildings. Figure 3.11 shows the average value of BEI for hospitals as 350 kWh/m^2/year.

Figure 3.11. Analysis of BEI vs GFA of Hospitals



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, m^2 = square meter.
Source: The Working Group's Calculation of BEI from 2017 survey data.

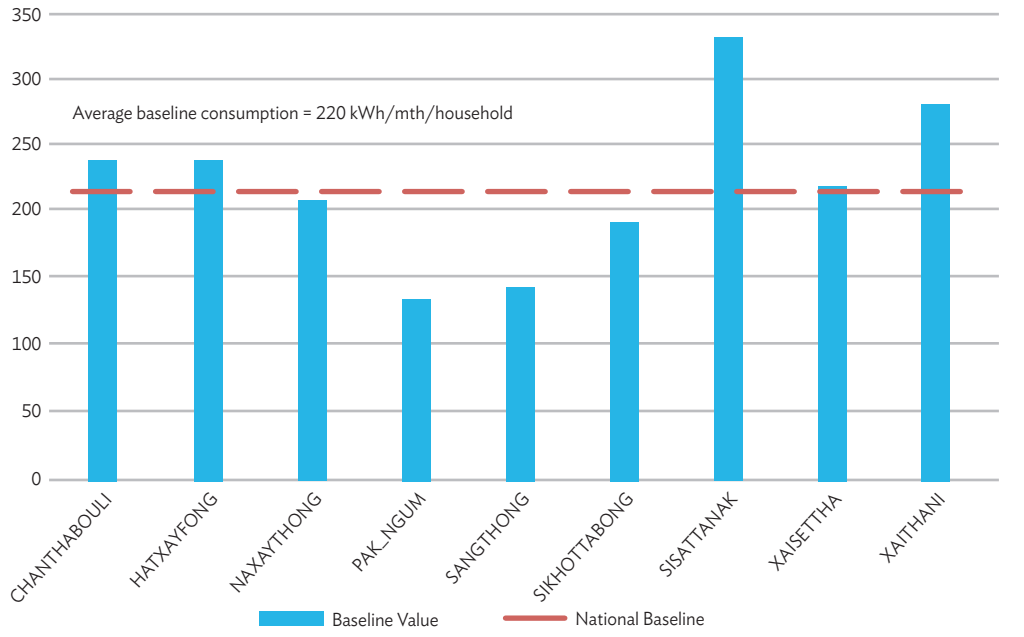
Residential Sector

The samples for the energy consumption survey in the residential sector consisted of 102 urban and 98 sub-urban dwellings. Of these, 170 were stand-alone houses and 30 were apartments.

The consumption survey data were grouped into districts. Figure 3.12 shows the average electricity consumption in each district surveyed. An average baseline electricity consumption of 220 kWh/month/household was determined from these average electricity consumption values in the respective districts.

Similarly, Figure 3.13 shows the average total energy consumption, including electricity, and the fossil fuel and biomass consumption in each district. The average baseline total energy consumption amongst the districts was 705 kWh/month/household, which is more than three times the average baseline electricity consumption. This may indicate that Lao households consume much more fossil fuels and biomass than electricity. Table 3.12 shows the breakdown of the shares of energy sources consumed in the residential sector; this is illustrated in Figure 3.14.

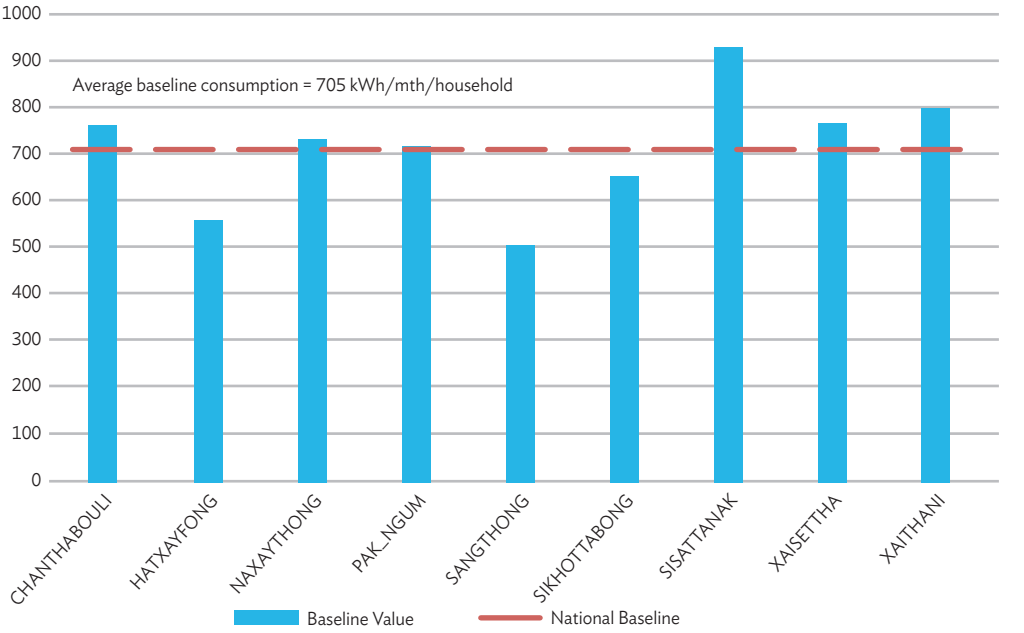
Figure 3.12. Average Electricity Consumption by District per Household



kWh = kilowatt-hour, mth = month.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.13. Total Energy Consumption (including Electricity) by District per Month per Household



kWh = kilowatt-hour, mth = month.

Source: The Working Group's calculation of BEI from 2017 survey data.

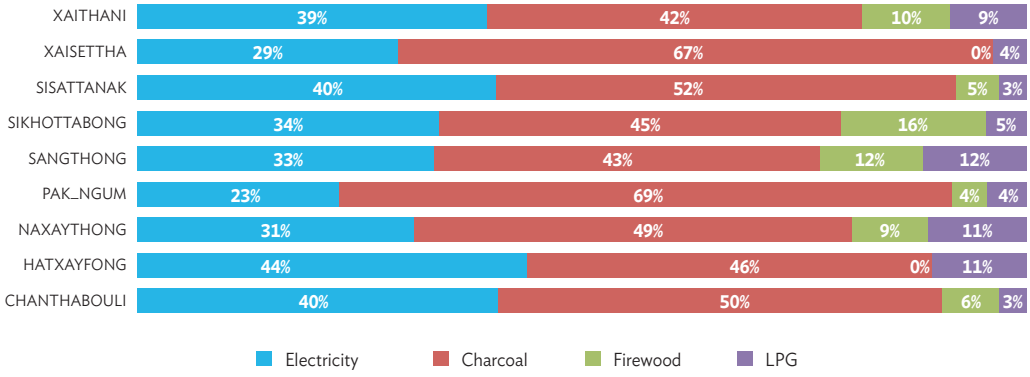
Table 3.12. Average Share of Energy Sources Consumed by Each District (%)

Districts	Category of Area	Electricity	Charcoal	Firewood	LPG
Chanthabouli	Urban/Inner City	40	50	6	3
Hatxayfong	Rural/Outer City	44	46	0	11
Naxaythong	Rural/Outer City	31	49	9	11
Pak_Ngum	Rural/Outer City	23	69	4	4
Sangthong	Rural/Outer City	33	43	12	12
Sikhottabong	Urban/Inner City	34	45	16	5
Sisattanak	Urban/Inner City	40	52	5	3
Xaisettha	Urban/Inner City	29	67	0	4
Xaithani	Rural/Outer City	39	42	10	9

LPG = liquefied petroleum gas.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.14. Average Share of Energy Sources Consumed by Each District



LPG = liquefied petroleum gas.

Source: The Working Group's calculation of BEI from 2017 survey data.

Table 3.12 shows the shares of electricity, charcoal, firewood, and LPG consumed by the residential sector in each of the districts where the pilot survey was conducted. The pilot survey was essentially conducted in Vientiane areas. The inner city was deemed to be an urban area while the outer city, a rural area. However, it is noted that some rural areas in the country do not have access to electricity supply, but all the 'so-called' rural areas in the survey had access to electricity supply as shown in Table 3.12 and Figure 3.14. The share of fossil fuel and biomass consumption was much more than the share of electricity consumption at an average proportion of about 65% (average ranging from 57% to 77%) of fossil fuels and biomass consumption, compared with about 35% (average ranging from 23% to 44%) of electricity consumption (Figure 3.14).

Based on Table 3.12 and Figure 3.14, we cannot conclusively state that rural areas consume more fossil fuels and biomass than urban areas, although rural areas were expected to consume much more of such fuels as some rural areas in the Lao PDR have no access to electricity supply. The lack of evidence to show such phenomenon could be because the rural areas in the pilot survey were not strictly rural compared with other rural areas in the country. Therefore, the sampling of the energy consumption survey in the outer city (deemed as rural) in Vientiane was not truly representative of the rural areas and affected the projected national energy consumption estimates for the residential sector of the country.

Estimates of National Energy Consumption in Commercial and Residential Sectors

Commercial Sector

Based on the analyses on the road transportation sector (p. 47), the projected national energy consumption in the commercial sector can be derived (Table 3.13). The projected estimates were based on the BEI, which were derived from the analysis of the survey data, the total floor area obtained in the survey, and the national statistics on the number of respective buildings in the Lao PDR. However, statistics for office and shopping mall buildings were not available at the time of the analysis. In view of this, the study team assumed that the office and shopping mall buildings constituted about 30% each of the national energy consumption of the office and shopping mall buildings. The other assumption was that the projected estimates of energy consumption from the survey data constitute about 80% of the national energy consumption in the commercial sector. Therefore, the energy consumption of other commercial buildings not accounted for in the pilot survey was assumed to be 20% of the projected estimates derived from the survey data.

Table 3.13. Projected National Energy Consumption of the Commercial Sector

	Hotels 1–3 Stars	Hotels 4–5 Stars	Hospitals	Office	Malls	Miscellaneous Commercial Buildings *Assumed 20% of survey projection	Projected Commercial Sector Energy Consumption
BEI (kWh/m²/year)	260	395	350	285	425		
No. of Samples	51	17	15	101	35		
Average BEI (kWh/m²/year) *Estimated considering the respective floor areas	327		NA	NA	NA		
Total Floor Area from Survey Data (m²)	200,093		65,914	154,807	199,939		
Estimated Yearly Consumption from Survey Data (MWh) *based on floor area and BEI	65,430		23,070	44,120	84,974		
National Statistics (No. of buildings)	2,527		162	Not available	Not available		
Total Yearly Consumption (MWh)	**2,431,510**		**249,155**	**147,067**	**283,247**	**622,196**	**3,733,174**
Total Yearly Consumption (ktoe)	**209.07**		**21.42**	**12.65**	**24.35**	**53.50**	**321.00**

BEI = building energy intensity, kWh = kilowatt-hour, ktoe = thousand ton of oil equivalent, MWh = megawatt-hour, m^2 = square meter.

Source: The Working Group's Calculation of BEI from 2017 survey data.

Table 3.13 shows that the total energy consumption for the commercial sector projected from the survey data is 321 ktoe. Table 2.13 on the 2015 Lao PDR EBT shows that the total energy consumption for the commercial and public services sector was 351 ktoe. The projected estimates show that the total energy consumption derived from the survey data for the commercial sector was in the same order of magnitude as the corresponding EBT value. Therefore, the pilot survey demonstrates that it is possible to derive energy consumption for the commercial sector from the BEI. The accuracy can be improved if national statistics, such as number of buildings and total floor area for the various building categories, are available. The BEI values from the survey should be presented and deliberated on by the respective stakeholders in the commercial sector. If these BEI values could be accepted as the indicative benchmark values, then the energy efficiency roadmap and policy could be established to drive the energy efficiency agenda in the commercial sector.

Residential Sector

Based on the analyses made on page 63, the projected national energy consumption can be derived as given in Table 3.14. The projected estimates were based on the average national baseline energy consumption for households, which were derived from the analysis of the survey data and the national statistics on the number of households in 2016.

Table 3.14. Projected National Energy Consumption of the Residential Sector

	Projected National Electricity Consumption	Projected National Total Energy Consumption	Values based on 2015 Energy Balance Table (refer to Table 2.13)
Number of Samples	200	200	
National Statistics, 2016 (Number of households)	1,203,000	1,203,000	
Average Baseline Energy Consumption per Household (kWh/month/household)	220	705	
Yearly Average Energy Consumption per Household (kWh/year/household)	2,640	8,460	
Projected Yearly Average Energy Consumption (GWh/year)	3,176	10,177	
Projected Yearly Average Energy Consumption (ktoe/year)	**273.08** (overestimated due to survey sampling c.f. EBT)	**875.10** (underestimated due to survey sampling c.f. EBT)	• 137 for electricity • 1,254 for total consumption

c.f. = compared with, EBT = energy balance table, GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, kWh = kilowatt-hour.

Source: The Working Group's calculation of BEI from 2017 survey data.

Table 3.14 shows that the projected electricity consumption and the total energy consumption for the residential sector are 273.08 ktoe/year and 875.10 ktoe/year, respectively. In comparison, Table 2.13 on the 2015 Lao PDR EBT shows the electricity consumption and total energy consumption for the residential sector as 137 ktoe. It can be seen that the projected electricity consumption of 273.08 ktoe/year, based on the pilot survey, was higher than the electricity consumption in the 2015 Lao PDR EBT. As mentioned on page 53 (Commercial Sector), this could be due to the pilot survey sampling, which was mainly conducted in the urban and outer city areas of Vientiane where electricity is available and consumed much more than most rural areas in the country.

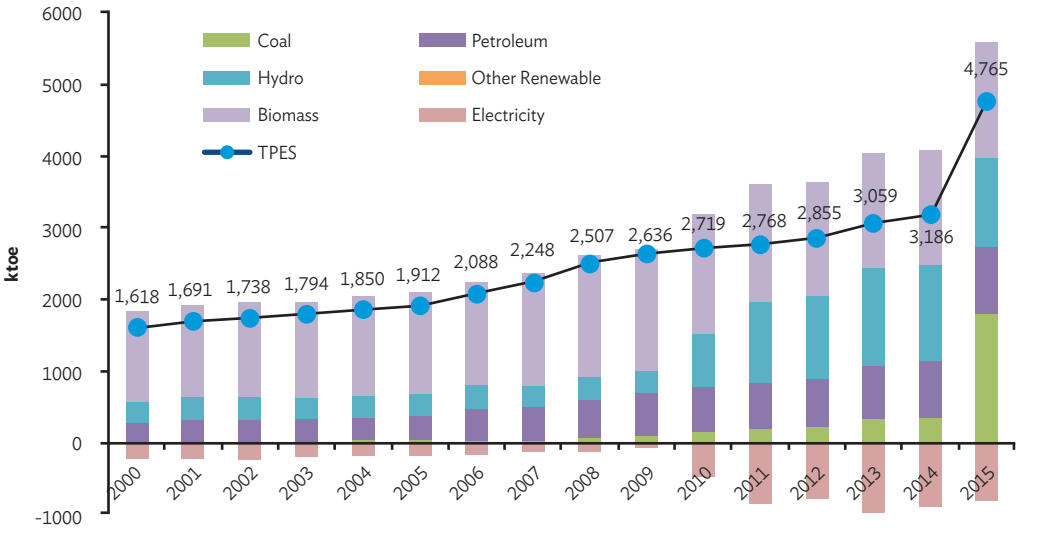
On the other hand, the projected total energy consumption of 875.1 ktoe in Table 3.14 above is much less than the 1,254 ktoe given in Table 2.13 on the 2015 Lao PDR EBT. This suggests that the pilot survey might not have captured fully the other fuels used. As already mentioned, this was probably due to the survey sampling coverage being confined to urban and outer city areas of Vientiane, which was not reflective of the actual scenario that rural areas consume much more biomass fuels. The consumption of other fuels recorded in the survey was much less, which resulted in lower average total energy consumption baseline values. The projected estimates of total energy consumption based on the pilot survey for the total national residential consumption was grossly underestimated compared with the corresponding EBT value. The projected estimates of total energy consumption for the residential sector can be improved if the survey coverage could be extended nationwide.

Chapter 4
Analysis of Energy Demand–Supply Situation

Primary Energy Supply

The total primary energy supply (TPES) of the Lao PDR increased from 1,618 thousand ton of oil equivalent (ktoe) in 2000 to 4,765 ktoe in 2015 at an average annual growth rate of 7.5% (Figure 4.1). Coal had the highest increase over the 2000–2015 period at an average of 42.2% per year. This is because the Hongsa power plant started its full production in 2015, resulting in a significant increase in coal supply that year. The Hongsa power plant was constructed only for export purposes to Thailand.

Figure 4.1. Total Primary Energy Supply



ktoe = thousand ton of oil equivalent, TPES = total primary energy supply.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the Lao PDR EBT 2000–2015.

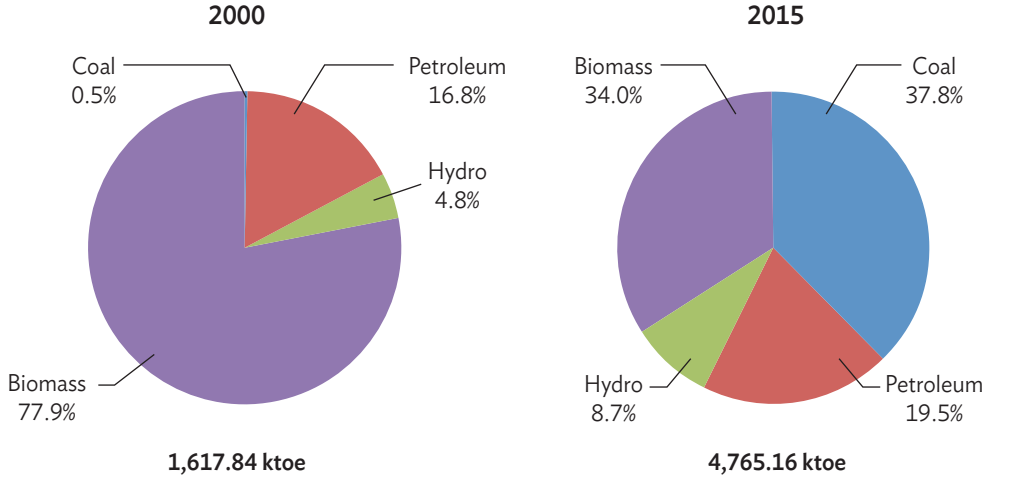
The second-highest growth during the period was hydro at 9.8% per year. Hydro is the major energy source for electricity production in the Lao PDR. Petroleum supply also increased rapidly at an average of 8.5% a year. Since the power sector does not use oil products, most of the increased demand came from the transport sector.

The Lao PDR exports most of its electricity products to Thailand. However, it also imports from neighbouring countries to meet demand during the dry season and at the border areas not connected to the grid. Lao's TPES, which reflects the net trade of electricity (import minus export), shows a negative value, making the Lao PDR a net electricity exporting country. Its electricity supply grew from -225 ktoe in 2000 to -817 ktoe in 2015, reflecting an almost fourfold increase in electricity export over the 15-year period.

In 2000, biomass had the largest share in the TPES at 78%, followed by petroleum (15%), hydro (5%), and coal (0.5%). Coal grew very rapidly, increasing its share in the TPES to 33% by 2015. The share of biomass, on the other hand, declined to 34% by 2015. The slower growth of biomass supply indicates that there was a substitution in the use of biomass for cooking in the residential sector.

The shares of the other supplies increased but not as drastically as that of coal. Hydro's share increased to around 9% by 2015, while the share of petroleum products reached 20%. Figure 4.2 shows the energy mix in the TPES of the Lao PDR in 2000 and 2015.

Figure 4.2. Energy Mix of the Total Primary Energy Supply



ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

The Lao PDR imports all of its petroleum products. Imports of petroleum products increased at an average rate of 7.9% per year during the 2000–2015 period (Table 4.1). Apart from petroleum products, the country also imports electricity and at the same time exports it. Its electricity imports increased at an average rate of 17.6% per year. Total energy imports increased from 328 ktoe to 1,147 ktoe over the 2000–2015 period at an average rate of 8.7% per year.

Compared to energy imports, the total indigenous production of energy (coal, hydro, biomass, and other renewables) grew at a lower rate of 7.2% per year in 2014 and 2015. Biomass has always been the main energy supply in indigenous production. Biomass supply slightly increased from 1,260 ktoe in 2000 to 1,619 ktoe in 2015, resulting in an average growth rate of 1.7% annually. On the other hand, coal production had been the lowest up to 2014. In 2015, because of the operation of the Hongsa power plant, coal production increased significantly, resulting in an average coal production growth of 22.3% per year over the 2000–2015 period.

Hydropower production also increased from 302 ktoe in 2000 to 1,232 ktoe in 2015. The Lao PDR started generating electricity from solar energy in 2014, but the amount remained very small.

Table 4.1. Indigenous Production and Energy Imports (ktoe)

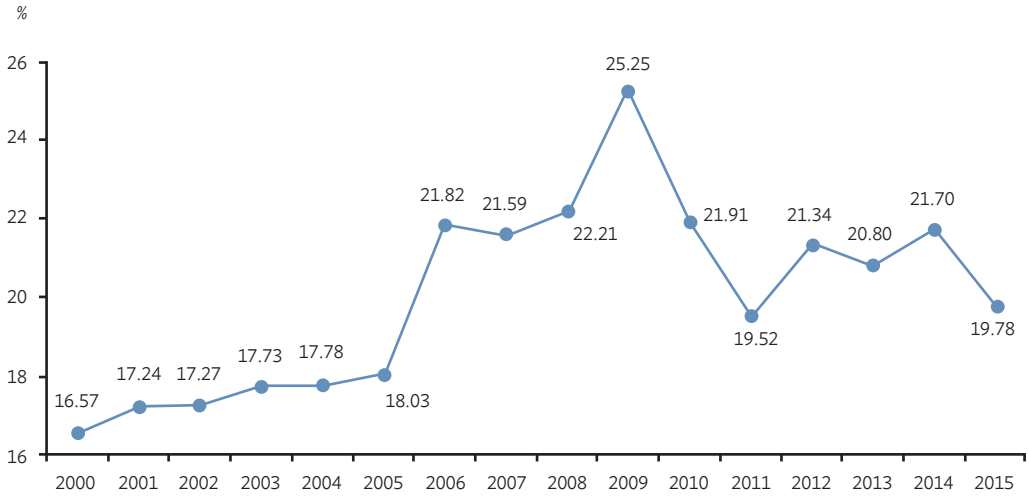
Year	Indigenous	Hydro	Biomass	Coal	Other Renewables	Imports	Petroleum	Electricity	Dependence on Imported Energy
2000	1,649.99	301.74	1,260.02	88.24	0.00	327.60	312.10	15.49	16.57
2001	1,706.51	320.63	1,290.10	95.78	0.00	355.49	339.69	15.81	17.24
2002	1,742.42	316.28	1,320.91	105.24	0.00	363.62	346.35	17.27	17.27
2003	1,747.70	278.90	1,352.44	116.35	0.00	376.62	356.89	19.72	17.73
20t04	1,817.18	293.77	1,384.74	138.67	0.00	393.04	369.16	23.87	17.78
2005	1,874.24	307.97	1,417.80	148.48	0.00	412.17	383.78	28.39	18.03
2006	1,930.78	315.48	1,451.65	163.66	0.00	538.97	484.70	54.28	21.82
2007	2,055.74	296.05	1,573.72	185.97	0.00	566.15	497.91	68.24	21.59
2008	2,246.32	326.19	1,709.82	210.32	0.00	641.25	568.62	72.63	22.21
2009	2,235.26	295.36	1,704.30	235.6	0.00	755.24	654.18	101.06	25.25
2010	2,730.99	741.44	1,669.87	319.67	0.00	766.12	662.08	104.03	21.91
2011	3,137.71	1,138.09	1,635.45	364.17	0.00	761.20	683.43	77.77	19.52
2012	3,131.89	1,145.80	1,584.75	401.33	0.00	849.61	735.31	114.30	21.34
2013	3,387.17	1,360.64	1,580.39	446.13	0.00	889.68	780.32	109.36	20.80
2014	3,430.25	1,340.02	1,599.44	490.78	0.00	950.94	816.85	134.09	21.70
2015	4,652.34	1,232.04	1,618.91	1,801.39	0.00	1,146.98	970.70	176.29	19.78
AAGR	**7.16**	**9.83**	**1.68**	**22.27**	**-**	**8.71**	**7.86**	**17.60**	**-**

AAGR = average annual growth rate , ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Dependence on imported energy was about 17% in 2000 and 20% in 2015. In 2009, Lao PDR's import dependence reached its highest level at 25% (Figure 4.3).

Figure 4.3. Dependence on Imported Energy

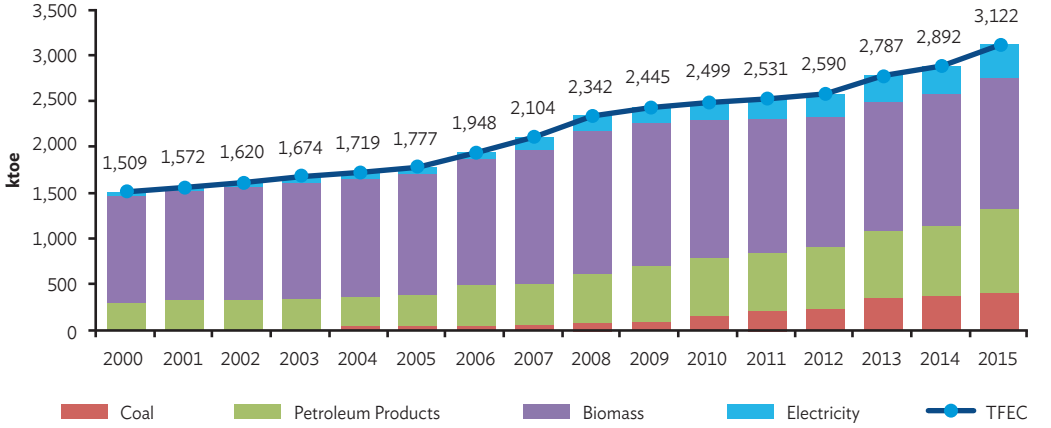


Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Total Final Energy Consumption

The total final energy consumption (TFEC) of the Lao PDR increased at an average annual growth rate of 5% – from 1,509 ktoe in 2000 to 3,122 ktoe in 2015 (Figure 4.4). By type of fuel, coal grew the fastest at 28.4% per year, followed by electricity at 13.4% per year. Petroleum products and biomass consumption, which are the most used types of fuel in the country, grew at a slower rate than coal and electricity. The average annual growth rate of consumption of petroleum products was 8.5% while biomass consumption grew only 1.4% per year over 2000–2015.

Figure 4.4. Total Final Energy Consumption by Fuel

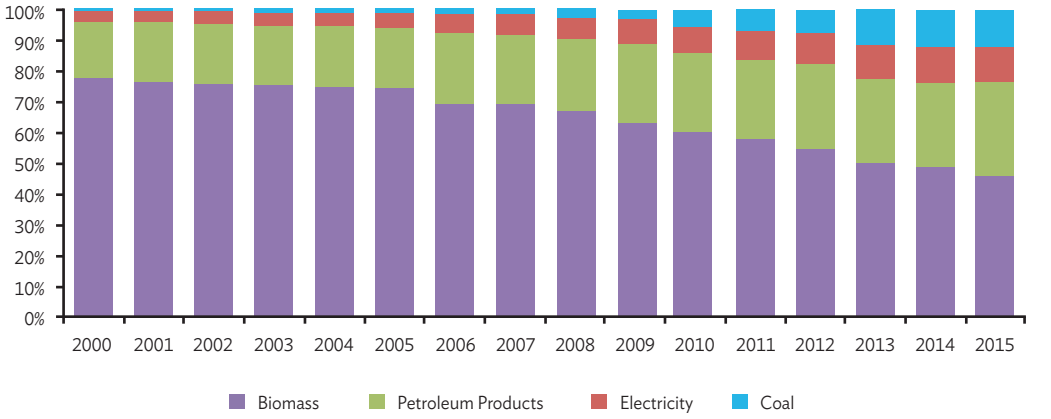


ktoe = thousand ton of oil equivalent, TFEC = total final energy consumption.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Despite the high average annual growth rate of consumption in 2000–2015, coal's share in the TFEC was only 13% in 2015. Electricity's share in the TFEC was the lowest in 2015 at 12%. Petroleum products and biomass had a total share of more than 76% in 2000–2015 (Figure 4.5). Although the largest, biomass share in the TFEC decreased from 78% in 2000 to 46% in 2015.

Figure 4.5. Fuel Mix in Total Final Energy Consumption



Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Table 4.2 shows Lao PDR's TFEC from 2000 to 2015 by industry, transport, and other sectors covering residential, services (commercial), agriculture, and others. The non-energy use in the Lao PDR refers to lubricants, which are mainly used in the road transport sector.

Table 4.2. Total Final Energy Consumption by Sector (ktoe)

Year	Consumption	Industry	Transport	Other					Non-energy Use
					Service	Residential	Agriculture	Others	
2000	1,508.72	82.21	254.00	1,172.52	210.36	958.99	3.17	0.00	0.22
2001	1,572.43	82.90	284.00	1,205.53	216.45	985.30	3.78	0.00	0.23
2002	1,620.28	94.24	290.46	1,235.57	222.13	1,010.18	3.27	0.00	0.30
2003	1,673.59	99.31	303.75	1,270.53	228.82	1,038.71	3.01	0.00	0.33
2004	1,719.10	107.10	312.16	1,299.85	233.46	1,062.71	3.67	0.00	0.37
2005	1,777.18	111.25	328.65	1,337.29	241.98	1,092.00	3.32	0.00	0.42
2006	1,947.51	222.14	350.49	1,374.88	249.21	1,121.98	3.69	0.00	0.52
2007	2,104.44	226.02	385.25	1,493.16	273.00	1,215.86	4.30	0.00	0.63
2008	2,342.41	277.56	440.29	1,624.56	309.74	1,310.73	4.09	0.00	0.76
2009	2,445.18	312.91	510.94	1,621.33	328.62	1,289.08	3.64	0.00	0.93
2010	2,499.20	368.81	523.77	1,606.62	332.94	1,269.74	3.94	0.00	1.30
2011	2,530.58	416.63	534.87	1,579.09	330.06	1,244.77	4.25	0.00	1.48
2012	2,589.55	409.46	603.70	1,576.39	345.03	1,227.69	3.67	0.00	1.68
2013	2,786.73	602.42	629.81	1,554.50	346.46	1,204.74	3.31	0.00	1.91
2014	2,892.08	594.01	729.44	1,568.62	336.66	1,228.62	3.34	0.00	2.17
2015	3,122.30	643.79	870.23	1,608.28	350.77	1,254.43	3.08	0.00	2.47
AAGR	**4.97**	**14.71**	**8.56**	**2.13**	**3.47**	**1.81**	**-0.19**	**-**	**17.47**

AAGR = average annual growth rate, ktoe = thousand ton of oil equivalent.

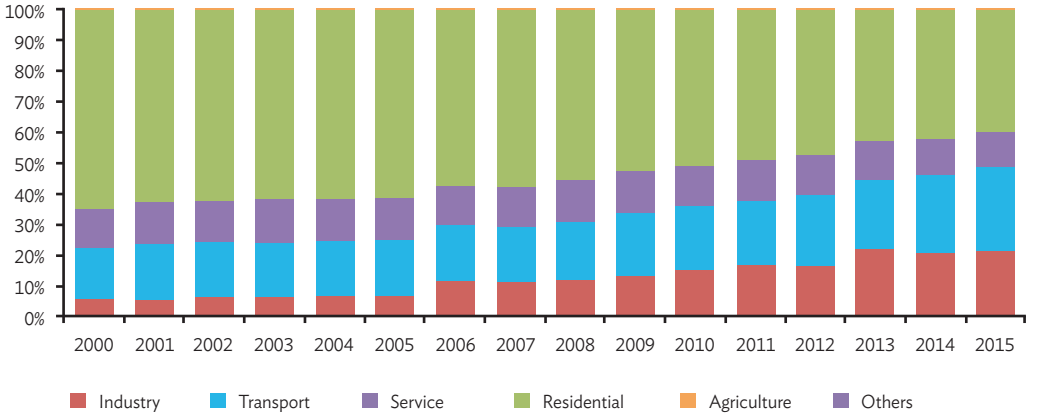
Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

The residential sector was the highest contributor to the TFEC because it is the major consumer of fuelwood (biomass). Lao PDR's energy consumption in the residential sector increased from 959 ktoe in 2000 to 1,254 ktoe in 2015 at an average rate of 1.8% per year. Its share in the TFEC declined, however, from 64% in 2000 to 40% in 2015 (Figure 4.6).

The transport sector had the second-highest share of energy consumption in 2000 at 17%; the share increased to around 28% in 2015. Energy consumption in the transport sector grew at an average annual growth rate of 8.6% over the 2000–2015 period, increasing from 254 ktoe in 2000 to 870 ktoe in 2015. The industry sector had fastest growth in energy consumption during the same period at an average rate of 14.7% per year. Consequently, the share of the industry sector in the TFEC increased from 5% in 2000 to 21% in 2015.

The total consumption of the remaining sectors (service, agriculture, and others) contributed around 14% to Lao PDR's TFEC in 2000. The growth in the total consumption of the sectors was around 3.4% per year, resulting in a fall of the share of its contribution to the TFEC to 11% in 2015.

Figure 4.6. Total Final Energy Consumption by Sector



Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Supply and Consumption by Energy Product

Coal

Table 4.3 shows Lao PDR's coal supply and consumption. Coal production is for export and domestic consumption. Increasing coal consumption domestically, particularly for the power plants and some industries, will affect the total coal export.

Table 4.3. Coal Supply and Consumption (ktoe)

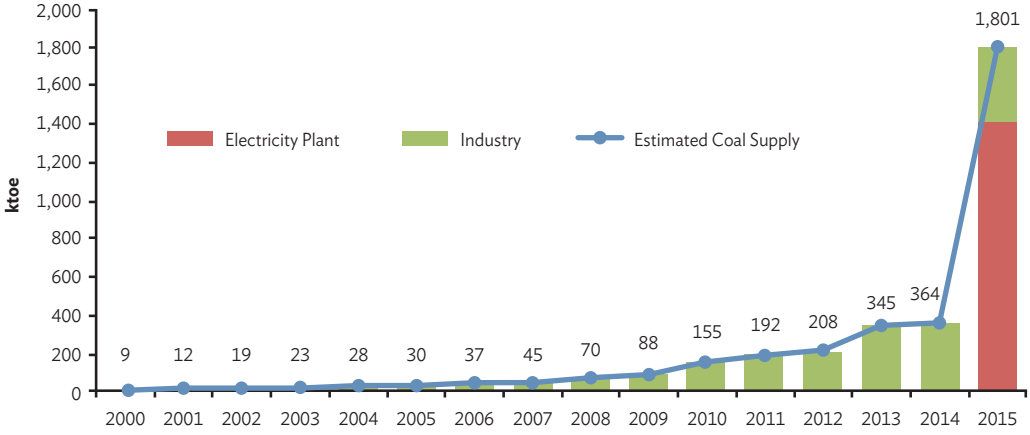
Year	Estimated Coal Supply	Coal Consumption		
			Electricity Plant	Industry
2000	9.17	9.17	0.00	9.17
2001	11.91	11.91	0.00	11.91
2002	18.85	18.85	0.00	18.85
2003	22.99	22.99	0.00	22.99
2004	27.88	27.88	0.00	27.88
2005	30.30	30.30	0.00	30.30
2006	37.20	37.20	0.00	37.20
2007	45.00	45.00	0.00	45.00
2008	70.25	70.25	0.00	70.25
2009	88.04	88.04	0.00	88.04
2010	155.32	155.32	0.00	155.32
2011	192.43	192.43	0.00	192.43
2012	208.21	208.21	0.00	208.21
2013	345.27	345.27	0.00	345.27
2014	364.19	364.19	0.00	364.19
2015	1,801.39	1,801.39	1,409.62	391.77
AAGR	**42.19**	**42.19**	**-**	**28.44**

AAGR = average annual growth rate, ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

From 2000–2014, domestic coal consumption in the Lao PDR had been entirely for the industry sector. In 2015, when the Hongsa coal power plant started full operation, the power generation sector started to utilise coal. As a result, coal consumption increased significantly from 9 ktoe in 2000 to 1,801 ktoe in 2015 at an average rate of 42.2% per year (Figure 4.7).

Figure 4.7. Coal Consumption (ktoe)



ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Petroleum Products

The Lao PDR imported all its petroleum products requirement. Some petroleum products were used to supply the need of the international aviation sector and these were deducted to derive the domestic oil supply of the country. The total domestic oil supply was 272 ktoe in 2000 and increased to 929 ktoe in 2015 (Table 4.4). As shown in the table, supply was higher than consumption, indicating an excess in the supply of petroleum products. Usually, importers of petroleum products reserve some stock. Since no information was available, this was considered a discrepancy in the country's energy balance table (EBT).

Petroleum products are usually consumed by the final sector (industry, transport, service, residential, and others) as well as for power generation and own use. In the case of the Lao PDR, no diesel or fuel oil is consumed by the power sector.

Table 4.4. Supply and Consumption of Petroleum Products (ktoe)

Year	Petroleum Supply	Consumption	Total Final Energy Consumption							Non-energy Use
			Industry	Transport	Other	Service	Residen-tial	Agricul-ture	Others	
2000	271.60	270.35	14.28	254.00	2.07	1.14	0.64	0.29	0.00	0.22
2001	299.05	297.16	11.10	284.00	2.06	1.14	0.64	0.28	0.00	0.23
2002	305.58	304.43	11.84	290.46	2.12	1.15	0.69	0.28	0.00	0.30
2003	315.99	314.07	8.19	303.75	2.13	1.16	0.70	0.28	0.00	0.33
2004	328.13	322.88	8.57	312.16	2.15	1.18	0.70	0.28	0.00	0.37
2005	342.61	338.32	7.51	328.65	2.16	1.18	0.71	0.28	0.00	0.42
2006	443.40	436.14	83.33	350.49	2.33	1.32	0.73	0.28	0.00	0.52
2007	456.47	456.02	68.43	385.25	2.34	1.33	0.73	0.28	0.00	0.63
2008	527.04	526.54	83.81	440.29	2.44	1.34	0.83	0.28	0.00	0.76
2009	612.47	612.07	98.61	510.94	2.53	1.39	0.86	0.28	0.00	0.93
2010	620.24	619.83	93.46	523.77	2.59	1.43	0.88	0.28	0.00	1.30
2011	641.45	640.96	102.94	534.87	3.15	1.77	1.09	0.28	0.00	1.48
2012	693.19	692.46	85.51	603.70	3.25	1.84	1.13	0.28	0.00	1.68
2013	738.06	734.76	101.54	629.81	3.41	1.93	1.19	0.28	0.00	1.91
2014	774.45	771.58	38.34	729.44	3.81	2.18	1.35	0.28	0.00	2.17
2015	929.72	920.47	46.19	870.23	4.06	2.29	1.49	0.28	0.00	2.47
AAGR	**8.55**	**8.51**	**8.14**	**8.56**	**4.58**	**4.74**	**5.83**	**-0.39**	**-**	**17.47**

AAGR = average annual growth rate, ktoe = thousand ton of oil equivalent.

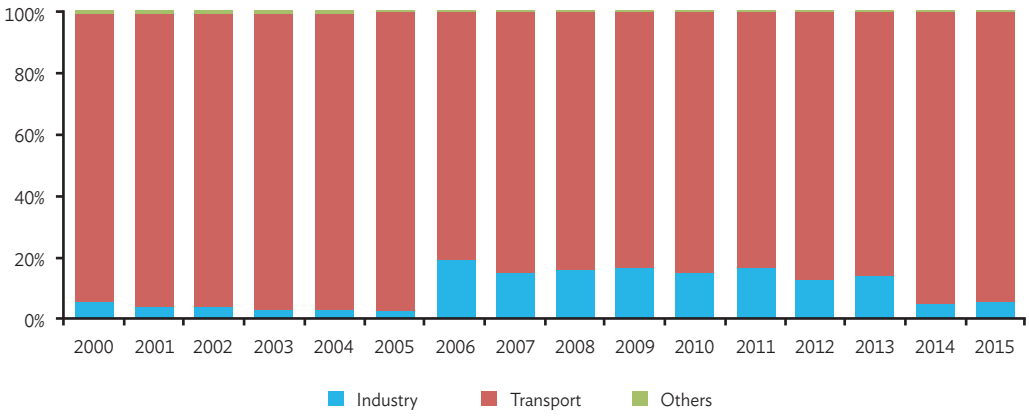
Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

The transport sector is the major consumer of petroleum products, growing on average by 8.6% per year over the 2000–2015 period. The total share of the transport sector consumption in the total petroleum products consumption of the Lao PDR was around 94% in both 2000 and 2015 (Figure 4.8).

In the industry sector, the consumption of petroleum products increased at an average rate of 8.1% per year. This rate is still lower than that of the transport sector. As a result, the share of the industry sector in the total consumption declined from 5.3% in 2000 to 5.0% in 2015. The industry sector usually has self-generating systems that use diesel when blackout occurs. Since the public electricity supply is very stable, petroleum consumption by the industry sector showed a downward trend.

The consumption of the service, residential, agriculture, and other sectors increased at an average rate of 4.6% per year in 2000–2015. Most of the consumption was in the residential and service sectors, with a total share of 86% in 2000, which increased to 93% in 2015. These two sectors consumed liquefied petroleum gas (LPG), which is used as cooking fuel in households or restaurants in major cities.

Figure 4.8. Consumption of Petroleum Products by Sector



Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

In terms of type of petroleum products, diesel is the main fuel consumed by the sectors. Total diesel consumption increased at an average rate of 9.6% per year, from 184 ktoe in 2000 to 729 ktoe in 2015 (Table 4.5). The share of diesel in the total petroleum products reached 68% in 2000 and increased to around 79% in 2015. Motor gasoline accounted for about 19% of the total consumption in 2015, down from 29% in 2000. This implies that motor gasoline consumption also increased over the 2010–2015 period, but at a slower

rate than diesel which is widely used across the sectors. The average growth rate for motor gasoline was 5.5% per year.

Table 4.5. Consumption of Petroleum Products by Product (ktoe)

Year	Petroleum Products	Motor Gasoline	Jet Fuel	Gas/Diesel Oil	Fuel Oil	LPG	Other Petroleum Products
2000	270.35	77.39	3.28	184.20	3.48	1.78	0.22
2001	297.16	77.37	3.29	210.96	3.54	1.78	0.23
2002	304.43	82.42	3.30	212.62	3.95	1.85	0.30
2003	314.07	84.88	3.31	219.65	4.04	1.85	0.33
2004	322.88	90.80	0.00	225.78	4.05	1.87	0.37
2005	338.32	95.74	3.33	232.76	4.18	1.89	0.42
2006	436.14	103.72	3.34	322.30	4.21	2.05	0.52
2007	456.02	117.47	3.35	328.01	4.50	2.06	0.63
2008	526.54	122.82	3.36	392.75	4.81	2.16	0.63
2009	612.07	137.34	3.37	462.69	5.49	2.25	0.93
2010	619.83	144.62	3.39	462.69	5.51	2.32	1.30
2011	640.96	152.29	3.40	473.07	7.86	2.87	1.48
2012	692.46	160.37	3.41	516.64	7.38	2.97	1.68
2013	734.76	166.11	3.42	552.45	7.74	3.13	1.91
2014	771.58	162.08	3.43	591.63	8.74	3.53	2.17
2015	920.47	172.02	3.31	729.25	9.64	3.78	2.47
AAGR	**8.51**	**5.47**	**0.08**	**9.61**	**7.02**	**5.15**	**17.47**

AAGR = average annual growth rate, ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.
Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Fuel oil consumption grew at an average rate of 7% per year during 2000–2015. Although the growth was faster than gasoline consumption, its share in the total petroleum products consumption remained at around 1% over the period (Figure 4.9.). Fuel oil is consumed only in the industry sector and usually as fuel in an industrial boiler.

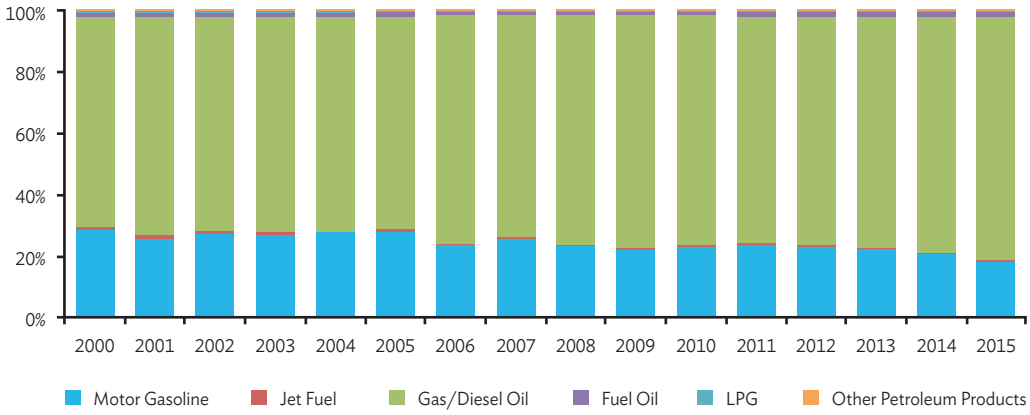
LPG's share in the consumption of total petroleum products was less than 1% since LPG is consumed only for cooking in the residential and service sectors (restaurants, cafeterias, and the like). Although the share of LPG was small, consumption showed an increasing trend over the 2010–2015 period, i.e. on average, at 5.2% per year. Increasing consumption of LPG indicates a substitution in the fuelwood used for cooking, particularly in the residential sector.

Domestic jet fuel consumption was only 3 ktoe in 2000 and it remained almost the same in 2015. This indicates that domestic flights in the Lao PDR have not changed drastically over 2000–2015.

Consumption of other petroleum products in the Lao PDR was very small and covered mainly lubricants. Although small, consumption increased significantly from 0.2 ktoe in

2000 to 2.5 ktoe in 2015 at an average rate of 17.5% per year due to the increase in the number of vehicles.

Figure 4.9. Consumption of Petroleum Products, by Product



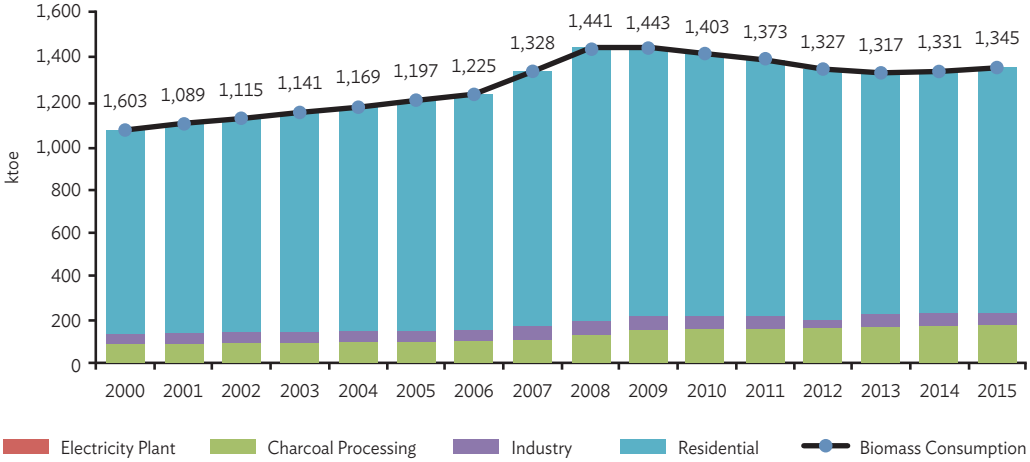
LPG = liquefied petroleum gas.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Biomass

Biomass is the major energy source consumed in the Lao PDR. The total biomass consumption increased from 1,063 ktoe in 2000 to 1,345 ktoe in 2015 at an average rate of 1.6% per year. The residential sector is the largest consumer of biomass, followed by charcoal processing, industry, and electricity generation (Figure 4.10).

Figure 4.10. Biomass Consumption (ktoe)



ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Biomass consumed by the residential sector was mainly fuelwood, although a small amount of charcoal was consumed. Total biomass consumption in the residential sector increased at an average rate of 1.2% per year, from 930 ktoe in 2000 to 1,116 ktoe in 2015. This growth is slower than the growth of total biomass consumption, resulting in a decreasing share of biomass used in the residential sector. This slower growth indicates substitution from biomass to LPG.

Biomass consumption in the industry sector also experienced a declining share from 4.4% in 2000 to 4.1% in 2015. The average annual growth rate of the biomass consumption in the industry sector was 1.1 %, increasing from 47 ktoe in 2000 to 56 ktoe in 2015.

For charcoal production, the amount of biomass (fuelwood) consumed increased from 86 ktoe in 2000 to 172 ktoe in 2015. The average annual growth rate was 4.7% over the period, higher than the 1.6% annual growth rate of the total biomass consumption. As a result, the share of biomass used for charcoal production increased from 8.1% in 2000 to 12.8% in 2015.

The biomass consumed to produce electricity is mainly bagasse. The consumption of bagasse for electricity production started in 2013 at 2 ktoe. This amount was only 0.2% of the total biomass consumption. The share remained almost the same in 2015.

Electricity

Lao PDR's hydro resources had been the only sources of power generation until several biomass and solar power plants started operating in 2013 and 2014, and the Hongsa coal power plant started operating in 2015. Total electricity produced in 2000 was 3,509 gigawatt-hours (GWh) and this increased to 14,326 GWh in 2015, resulting in an average annual growth of 9.8% per year (Table 4.6).

Some of the electricity generated is used internally by the power plant (own use). The electricity generated for own use by the power plant is assumed by applying an appropriate rate for the existing power plants. The exception is for the Hongsa power plant whose own use is the result of the difference between gross production and net production. The remaining generated electricity (net production) is available to the market.

Table 4.6. Electricity Supply (GWh)

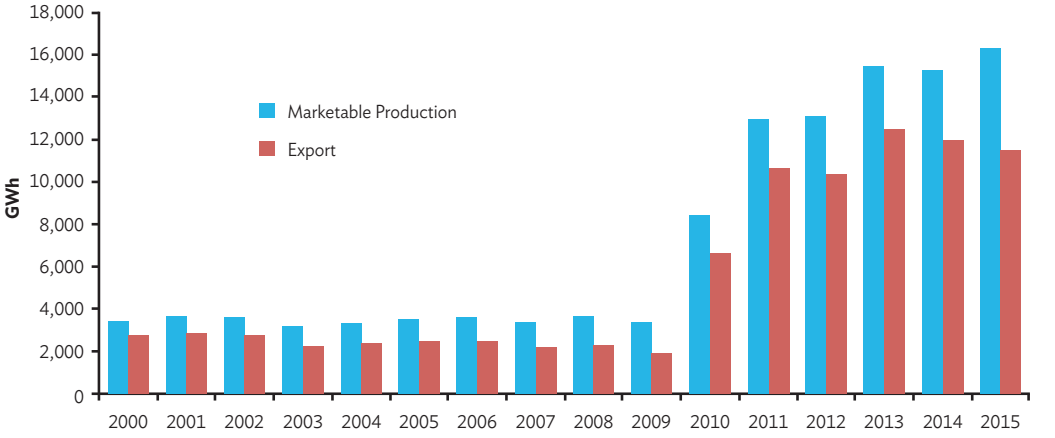
Year	Electricity Supply	Net Production (Marketable)	Esti-mated Own Use	Gross Production	Hydro	Coal	Wood and Biomass	Others	Export	Import
2000	825.71	3,438.38	-70.17	3,508.55	3,508.55	0.00	0.00	0.00	-2,792.84	180.17
2001	966.05	3,653.66	-74.56	3,728.22	3,728.22	0.00	0.00	0.00	-2,871.41	183.80
2002	1,006.56	3,604.11	-73.55	3,677.66	3,677.66	0.00	0.00	0.00	-2,798.34	200.80
2003	1,122.91	3,178.20	-64.86	3,243.06	3,243.06	0.00	0.00	0.00	-2,284.64	229.34
2004	1,200.52	3,347.62	-68.32	3,415.94	3,415.94	0.00	0.00	0.00	-2,424.69	277.59
2005	1,333.58	3,509.41	-71.62	3,581.03	3,581.03	0.00	0.00	0.00	-2,505.99	330.16
2006	1,738.69	3,594.97	-73.37	3,668.34	3,668.34	0.00	0.00	0.00	-2,487.40	631.12
2007	1,936.65	3,373.60	-68.85	3,442.45	3,442.45	0.00	0.00	0.00	-2,230.40	793.45
2008	2,246.11	3,717.00	-75.86	3,792.86	3,792.86	0.00	0.00	0.00	-2,315.40	844.51
2009	2,620.06	3,365.74	-68.69	3,434.43	3,434.43	0.00	0.00	0.00	-1,920.82	1,175.14
2010	3,012.22	8,449.01	-172.43	8,621.44	8,621.44	0.00	0.00	0.00	-6,646.49	1,209.70
2011	3,204.80	12,968.90	-264.67	13,233.57	13,233.57	0.00	0.00	0.00	-10,668.40	904.30
2012	4,022.84	13,056.83	-266.47	13,323.30	13,323.30	0.00	0.00	0.00	-10,363.08	1,329.09
2013	4,288.04	15,510.40	-316.54	15,826.94	15,821.43	0.00	5.51	0.00	-12,494.02	1,271.65
2014	4,898.14	15,275.20	-311.74	15,586.94	15,581.63	0.00	5.31	0.00	-11,936.20	1,559.14
2015	6,803.27	16,302.14	-594.08	16,896.22	14,325.89	2,566.70	3.63	0.00	-11,548.70	2,049.83
AAGR	**15.10**	**10.93**	**15.30**	**11.05**	**9.83**	**-**	**-**	**-**	**9.93**	**17.60**

AAGR = average annual growth rate, GWh = gigawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

A major portion of the marketable electricity in the Lao PDR is exported to neighbouring countries, above all to Thailand. The electricity export amounted to 80% of the total production in 2000, but it declined to 68% in 2015 (Figure 4.11).

Figure 4.11. Electricity Production vs Electricity Export



GWh = gigawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

The Lao PDR also imports electricity to meet shortages during the dry season and to meet demand in areas near the border that are not connected to the grid. Total supply of electricity (sales to final users) is the amount of electricity available for domestic use, i.e. the difference between marketable production and export, plus import. Table 4.7 shows the electricity supply and demand of the country. The electricity supply increased on average by 15.1% per year from 826 GWh in 2000 to 6,803 GWh in 2015.

The amount of total electricity at the end user point is equal to total supply of electricity minus transmission and distribution loss. Transmission and distribution losses are estimated as the difference between the electricity supply and the consumption. The estimated transmission and distribution loss is around 5% of the total electricity produced in 2000 and it increased to 15% in 2015.

The total electricity consumption was 640 GWh in 2000. Of this, the industry sector's electricity consumption accounted for 21%, whereas the residential sector's share was 51%. The remaining 28% was the share of the service sector and other sectors.

Table 4.7. Electricity Consumption (GWh)

Year	Electricity Consumption	Industry	Service	Residential	Other	Estimated Distribution Loss	Electricity Supply
2000	639.86	134.83	146.93	324.69	33.41	185.85	825.71
2001	710.33	134.88	163.29	371.41	40.75	255.72	966.05
2002	766.74	163.97	173.41	394.56	34.80	239.83	1,006.56
2003	883.74	203.42	194.09	454.48	31.75	239.17	1,122.91
2004	902.76	218.64	189.44	455.26	39.42	297.76	1,200.52
2005	1,011.06	236.54	228.60	510.60	35.33	322.52	1,333.58
2006	1,406.07	549.42	249.80	567.17	39.68	332.62	1,738.69
2007	1,615.79	626.20	300.30	642.49	46.80	320.86	1,936.65
2008	1,915.69	703.20	461.38	706.74	44.37	330.42	2,246.11
2009	2,257.65	760.21	644.93	813.47	39.04	362.41	2,620.06
2010	2,440.73	707.02	748.60	942.55	42.56	571.48	3,012.22
2011	2,555.72	740.39	765.07	1,004.07	46.19	649.08	3,204.80
2012	3,074.96	882.62	992.90	1,159.99	39.45	947.88	4,022.84
2013	3,380.96	1,118.21	949.11	1,278.42	35.22	907.08	4,288.04
2014	3,791.69	1,563.61	768.32	1,424.15	35.61	1,106.45	4,898.14
2015	4,238.60	1,745.32	866.04	1,594.65	32.59	2,564.67	6,803.27
AAGR	**13.43**	**18.62**	**12.55**	**11.19**	**-0.17**	**19.12**	**15.10**

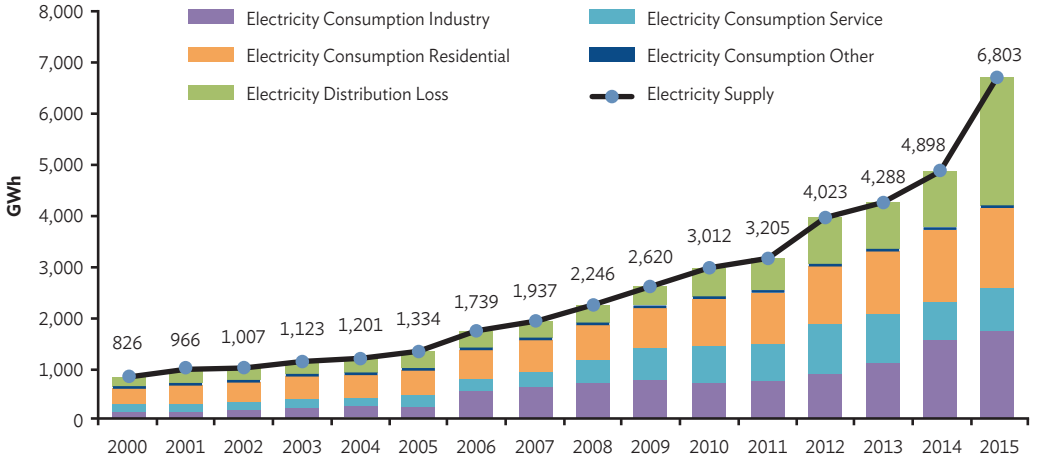
AAGR = average annual growth rate, GWH = gigawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

By 2015, total electricity consumption increased to 4,239 GWh at an average rate of 13.4% per year. The industry sector's consumption increased at a faster rate of 18.6% per year, reaching almost 13 times its consumption in 2000 as more industries were being constructed and more reliable supply from Electricité du Laos became available, reducing the auto-generation (genset) usage. The residential sector's electricity consumption increased at an annual average rate 11.2% per year while the service and other sectors increased at 11.3% per year.

The industry sector increased faster than the residential and service sectors. Its share to total electricity consumption increased to 41% while the residential sector's share declined to 38% and that of the service and other sectors also declined to 21% (Figure 4.12).

Figure 4.12. Electricity Consumption



GWh = gigawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Energy Indicators

Energy consumption is the result of human activities. Therefore, analysing human activities and energy consumption makes sense. The activities analysed included:

- production of primary and secondary products;
- transport of persons or cargo from point A to point B;
- service activities;
- household activities; and
- agriculture, forestry, and fishery.

This chapter focuses on the overall activities, such as population and gross domestic product (GDP), and analyses the relationship between macro indicators and the following energy consumptions:

- TPES/GDP;
- factor analysis of TPES/GDP; and
- carbon dioxide (CO_2)/GDP and CO_2/TPES.

These are known as energy indicators. Energy indicators describe the link between energy consumption and human activity. It usually refers to a ratio between energy consumption divided by 'human activities', such as energy consumption per capita and energy consumption per unit of GDP (Trudeu, 2012).

Energy intensity TPES/GDP is a measure of the amount of energy it takes to produce a dollar's worth of economic output or, conversely, the amount of economic output that can be generated by one standardised unit of energy. The value varies widely between countries, depending on the country's level of industrialisation, the mix of services and manufacturing in the economies, and the efforts made to increase energy efficiency.

GDP is a popular index reflecting a country's economy. It is easily found in national accounts and statistics. GDP may be expressed in United States dollars, in international dollars using purchasing power parity (PPP) conversions, or other common currencies. The PPP conversion factor for GDP is the number of units of a country's currency required to buy the same amount of goods and services in the domestic market as US dollars would buy in the United States.

Energy and Economics

Lao PDR's real GDP increased at an average rate of 7.3% per year from 2000 to 2015. GDP measured in PPP at constant 2011 international dollars increased from around US$12 billion in 2000 to US$36 billion in 2015. The service sector, mainly the wholesale and retail trade, mining and quarrying, agriculture (planting), and electricity have driven Lao PDR's growth. The population grew by 1.5% per year on average, from 5.3 million to 6.7 million over the same period. The TPES/capita indicator increased at an average annual growth rate of 5.9%, from 0.3 to 0.72 ton of oil equivalent (toe) per person, while the TPES/GDP remained around 0.1 toe/thousand $ (at constant 2011 PPP) over the 2000–2015 period (Table 4.8).

Table 4.8. Energy and Economic Indicators

Year	Total Primary Energy Supply	GDP	Population	TPES/GDP	TPES/Population
	ktoe	million $ (constant 2011 PPP)	thousand persons	toe/thousand $ (constant 2011 PPP)	toe/capita
2000	1,617.84	12,504.87	5,329.30	0.13	0.30
2001	1,690.56	13,224.08	5,414.57	0.13	0.31
2002	1,738.23	14,006.78	5,497.27	0.12	0.32
2003	1,793.57	14,856.57	5,579.66	0.12	0.32
2004	1,849.87	15,801.11	5,664.61	0.12	0.33
2005	1,911.56	16,924.18	5,754.03	0.11	0.33
2006	2,088.08	18,382.92	5,849.36	0.11	0.36
2007	2,247.66	19,779.44	5,949.79	0.11	0.38
2008	2,506.80	21,327.16	6,052.19	0.12	0.41
2009	2,636.04	22,927.08	6,152.04	0.11	0.43
2010	2,719.31	24,882.05	6,246.27	0.11	0.44
2011	2,767.71	26,882.23	6,333.49	0.10	0.44
2012	2,855.03	29,039.87	6,415.17	0.10	0.45
2013	3,059.25	31,370.25	6,494.56	0.10	0.47
2014	3,185.68	33,758.63	6,576.40	0.09	0.48
2015	4,765.16	36,213.19	6,663.97	0.13	0.72
AAGR	**7.47**	**7.35**	**1.50**	**0.11**	**5.88**

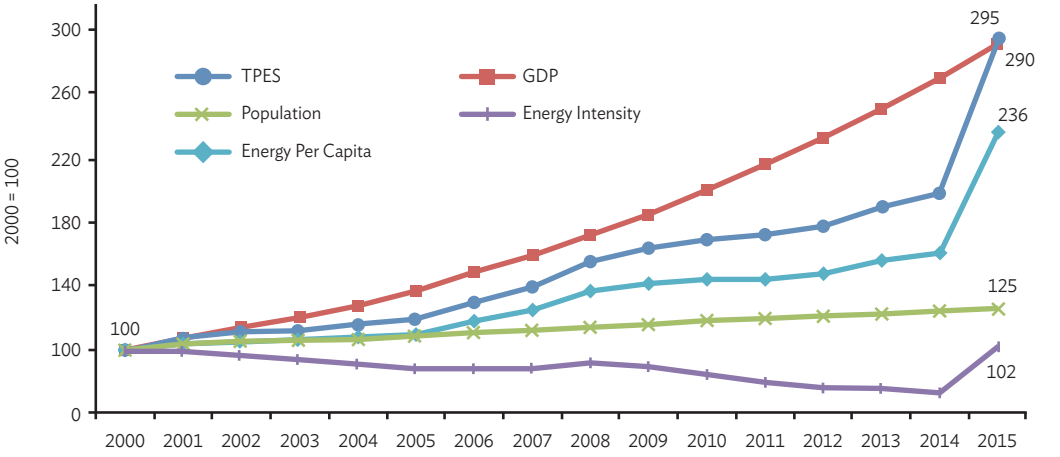
AAGR = average annual growth rate, GDP = gross domestic product, ktoe = thousand ton of oil equivalent, PPP = purchasing power parity, TPES = total primary energy supply.

Source: National Statistics Office, World Economic Outlook Database 2017.

Figure 4.13 shows the relative changes of GDP, population, TPES, and energy indicators (TPES/GDP and TPES/capita), with the year 2000 as baseline (2000=100). The energy per capita changed in the same way as the TPES but at a slower rate of growth. The increase in the energy consumption per capita is common for emerging economies, in line with the growth in GDP/capita, electrification, and similar development programmes.

There was a relatively small improvement in energy intensity (TPES/GDP) from 2000 to 2015. The intensity showed a declining trend from 2000 to 2014, with a slight increase in 2008. The increase in 2015 indicates a faster growth of TPES compared to GDP as a result of the drastic increase in coal consumption.

Figure 4.13. TPES and Energy Intensity



GDP = gross domestic product, TPES = total primary energy supply.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Energy intensity and GDP growth have separate effects on the change of energy consumption. As shown in Table 4.9 and Figure 4.14, improvement in energy intensity (intensity effect) made the TPES decrease in 2000–2015. GDP growth (production effect), on the other hand, made the TPES increase.

Table 4.9. Factor Analysis of Energy Consumption (ktoe)

Year	Change in TPES	Intensity Effect	Production Effect	Cross Term
2001	72.72	-20.33	91.94	1.11
2002	47.67	-52.39	97.13	2.93
2003	55.34	-50.12	102.59	2.87
2004	56.30	-57.73	110.58	3.45
2005	61.69	-69.79	126.85	4.63
2006	176.52	11.76	165.70	-0.93
2007	159.58	0.95	158.70	-0.07
2008	259.14	83.27	181.92	-6.04
2009	129.24	-58.82	183.95	4.10
2010	83.27	-141.51	213.65	11.12
2011	48.40	-170.19	205.93	12.66
2012	87.32	-134.83	212.13	10.02
2013	204.22	-24.89	227.26	1.85
2014	126.43	-106.48	225.38	7.53
2015	1,579.48	1,347.85	322.99	-91.36
2001–2015	**3,147.32**	**80.01**	**3,119.69**	**-52.38**

ktoe = thousand ton of oil equivalent, TPES = total primary energy supply.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

TPES is measured as the energy intensity times GDP, i.e.:

$$TPES = TPES/GDP * GDP$$

The intensity effect is estimated using the following formula:

$$\triangle (TPES/GDP) * GDP$$

The production effect is estimated as:

$$(TPES/GDP) * \triangle GDP$$

Thus, the impact of the effects to the TPES can be estimated as follows:

$$\triangle TPES = \triangle (TPES/GDP) * GDP + Intensity\ Effect$$
$$(TPES/GDP) * \triangle GDP + Production\ Effect$$
$$Cross\text{-}over\ Term$$

The cross-over term is just a term for the difference between the impacts of both effects with the changes in the TPES.

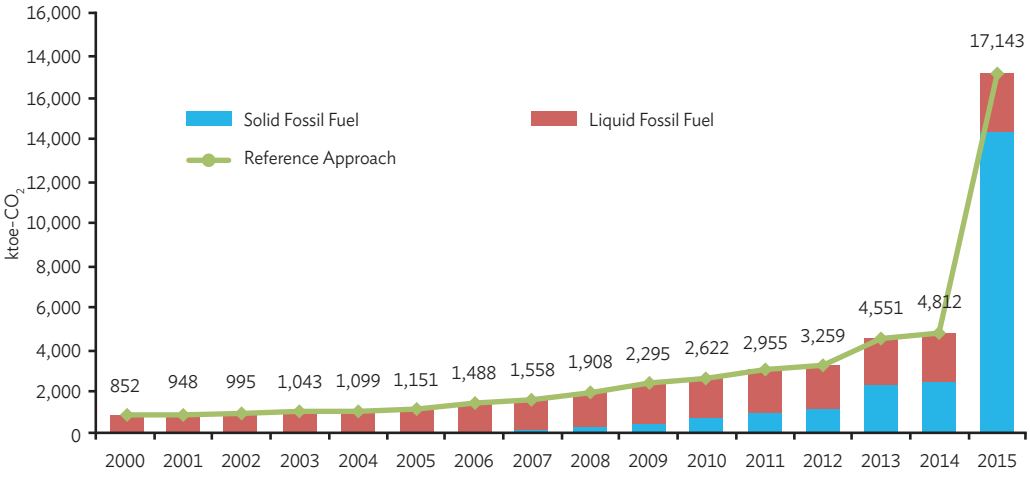
Energy and CO_2 Emissions

CO_2 emissions from fuel combustion can be calculated using the reference and the sectoral approaches as suggested in the 2006 Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change. The reference approach provides simple estimates for CO_2 emissions from all fuel combustion and some fugitive emissions. The sectoral approach provides estimates of CO_2 emissions from the main groups of fuel-using activities and, as such, information is essential for monitoring and abatement of emissions.

The reference approach is often applied in countries that have insufficient data for the sectoral approach. National fuel supply statistics are used to calculate the carbon flows. The sectoral approach uses the deliveries or consumption of fuels to each of the main source categories, together with their carbon content, to estimate the emissions of CO_2 (Simmons, n.d.).

The reference approach was used to estimate the CO_2 emission of the Lao PDR based on its 2000–2015 EBT. The result of the calculation showed that CO_2 emission increased in 2000–2015 at an average rate of 22.1% per year. The major sources of CO_2 emission from fuel combustion were solid fossil fuel (coal) and liquid fossil fuel (oil). The CO_2 emission from coal combustion was 4% in 2000 because the use of coal constituted less than 1% of the total primary energy consumption. Oil consumption, on the other hand, accounted for 17% of the country's total fuel use. Therefore, most of the CO_2 emission came from burning oil at that time (Figure 4.14).

Figure 4.14. CO_2 Emissions from Fuel Combustion by Sector



CO_2 = carbon dioxide, ktoe = thousand ton of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Since the transport sector consumed most of the oil, the burning of gasoline and diesel fuel contributed the highest, particularly from the use of motor vehicles in Vientiane. Total CO_2 emission from oil combustion was 814 kiloton (kt)-CO_2 in 2000.

By 2015, CO_2 emission from oil increased to 2,813 kt-CO_2 as the number of vehicles continued to increase and as the residential sector shifted to biomass. Emission of CO_2 from coal combustion also increased significantly. As a result, emission from coal grew faster than that of oil. The commission of the Hongsa coal power plant contributed to this increase because coal consumption increased by 196 times as compared to 2000.

Table 4.10 shows the energy and CO_2 emission indicators. The CO_2 intensity measures the impact of an increase in GDP or TPES to the absolute emission of CO_2. The intensities (CO_2/GDP and CO_2/TPES) increased from 2000 to 2015 but at a different average annual growth rate. For the CO_2/GDP intensity, the increase was 9.8% per year, from 68 kt CO_2/thousand PPP $ to 278 ton CO_2/thousand PPP $. The CO_2/TPES intensity increased at a slower rate of 9.7 % per year, from 527 ton CO_2/toe in 2000 to 2,112 ton CO_2/toe in 2015.

Table 4.10. Energy and CO_2 Emission Indicators

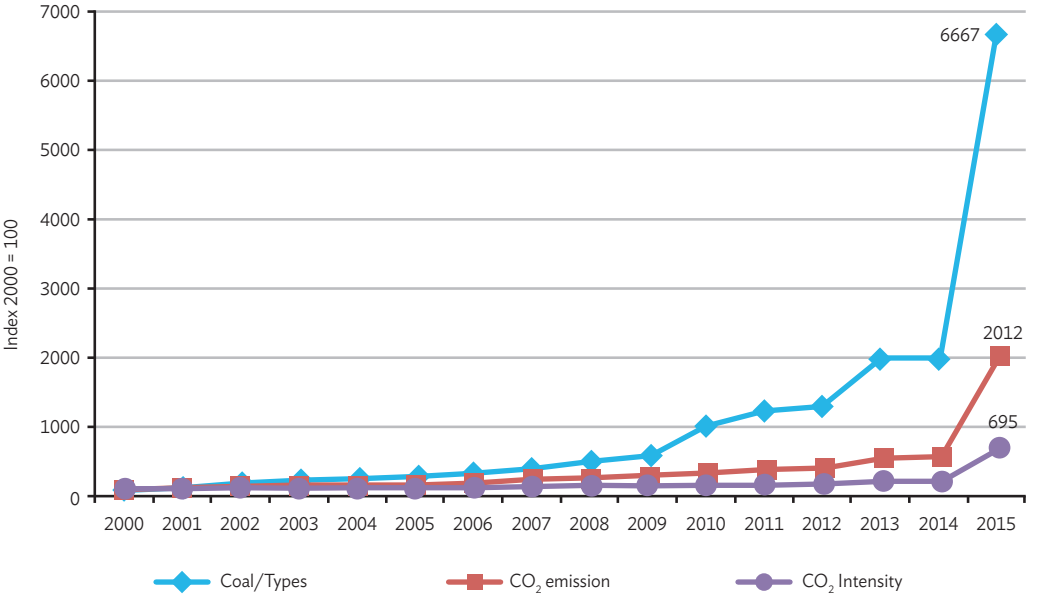
Year	Total Primary Energy Supply	GDP	CO_2 Emissions	CO_2/GDP	CO_2/TPES
	ktoe	10^6 US$ in PPP	kt CO_2	ton CO_2/thousand $ PPP	ton CO_2/toe
2000	1,617.84	12,504.87	852.00	0.07	0.53
2001	1,690.56	13,224.08	948.15	0.07	0.56
2002	1,738.23	14,006.78	995.32	0.07	0.57
2003	1,793.57	14,856.57	1,043.44	0.07	0.58
2004	1,849.87	15,801.11	1,099.08	0.07	0.59
2005	1,911.56	16,924.18	1,151.32	0.07	0.60
2006	2,088.08	18,382.92	1,488.17	0.08	0.71
2007	2,247.66	19,779.44	1,558.16	0.08	0.69
2008	2,506.80	21,327.16	1,908.41	0.09	0.76
2009	2,636.04	22,927.08	2,295.38	0.10	0.87
2010	2,719.31	24,882.05	2,622.41	0.11	0.96
2011	2,767.71	26,882.23	2,955.03	0.11	1.07
2012	2,855.03	29,039.87	3,259.23	0.11	1.14
2013	3,059.25	31,370.25	4,551.41	0.15	1.49
2014	3,185.68	33,758.63	4,812.25	0.14	1.51
2015	4,765.16	36,213.19	17,143.22	0.47	3.60
AAGR	**7.47**	**7.35**	**22.15**	**13.80**	**13.67**

AAGR = average annual growth rate, CO_2 = carbon dioxide, GDP = gross domestic product, kt = kiloton, ktoe = thousand ton of oil equivalent, TPES = total primary energy supply.

Source : National Statistics Office; International Monetary Fund (2016), World Economic Outlook Database; Economic Research Institute for ASEAN and East Asia.

Combustion of fossil fuels, particularly coal, is the main contributing factor in the increased CO_2 emission in the Lao PDR. In 2000, the share of coal in the fuel mix was very small, lower than petroleum products. As coal use in the country increased faster than other fuels, the share of coal also increased. In 2015, the power sector started to consume oil. Consequently, the CO_2 emission of the country sharply increased in 2015. The relationship between changes of coal share in the TPES, CO_2 emission, and CO_2 intensity (CO_2/GDP) is shown in Figure 4.15. The index (2000=100) is used to describe these relationships.

Figure 4.15. Coal Share in TPES, CO_2 Emissions, and CO_2 Intensity



CO_2 = carbon dioxide, TPES = total primary energy supply.

Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

Chapter 5
Conclusion

This 2018 National Energy Statistics of the Lao PDR is the first-ever published comprehensive energy statistics in the country. The statistics in this book contain primary energy data, energy balance tables (EBTs), energy consumption surveys, and analyses of energy demand and supply situations. Since the research team encountered missing data during primary and secondary data collection, they used techniques to correct or fill in these missing data, to ensure data quality in line with the view of experts from the Ministry of Energy and Mines, the Lao State Fuel Company, and other ministries and agencies involved.

Primary energy data were mainly collected from the Department of Energy Policy and Planning (DEPP), Ministry of Energy and Mines, Lao PDR. The petroleum sales data were collected from oil companies in the country; the petroleum products import data, from the Department of Customs of the Ministry of Industry and Commerce; and energy consumption data, through surveys of industry, road transport, commercial, and residential sectors. Based on these collected data, EBTs for the Lao PDR were produced historically from 2000 to 2015. Finally, these statistics provide rich information for policy implications on energy policies and planning.

Primary energy data in the Lao PDR consists of coal, oil, hydro, and biomass. The country imports oil products to meet its domestic demand. Its coal resources are used domestically and exported at the same time. It exports electricity to Thailand and Cambodia, and but also imports electricity from Thailand, China, and Viet Nam. Hydro has been the primary source of electricity generation. Since 2015, coal has also been consumed to generate electricity only for export purposes. Other renewable energies consumed consist of biomass and, recently, solar energy. The Lao PDR classifies its coal resources as anthracite and lignite. Most of the lignite produced is exported. Some anthracite was exported from 2012. In 2015, the government stopped the country's coal export to prioritise the use of coal to meet domestic demand, which comes from the industry sector. In the same year, the Lao PDR opened the Hongsa Mine Mouth power plant to meet electricity demand in Thailand. Therefore, all of the electricity produced from this power plant is exported to Thailand. Based on DEPP data, the capacity of the Hongsa power plant is 1,878

megawatts and its coal consumption was 3,817 kiloton (kt) lignite in 2015. Except for power generation, the coal consumption data is only for the industry sector. This data is not broken down to the sub-sectors of the industry such as cement, textile, etc. Only data on coal consumption in total industry was available.

Oil data consists of import and consumption data from DEPP and sales survey data from some petroleum companies. The type of petroleum products consumed in the Lao PDR includes Jet A-1 (kerosene-type jet fuel), gasoline (motor gasoline), gas/diesel oil, fuel oil or residual oil, lubricant, and liquid petroleum gas (LPG). DEPP collected petroleum sales data from the survey of private petroleum companies in the Lao PDR in 2015. The survey involved 24 private oil companies under the Lao State Fuel Company. DEPP maintains electricity data in the Electricity Yearbook published by the Electricité du Laos, a public generation company that collects power generation data from its stakeholders. Power generation is broken down into hydropower, coal power, solar power, and biomass power. Electricity had been produced solely by hydro plants until 2013, from which time a small fraction was also generated by biomass plants. Some small solar power generation plants started operation in 2014. In 2015, the country started producing electricity from coal for export purposes. It is a net electricity exporting country since its electricity export is larger than its import.

DEPP data on biomass was available only for the production of fuelwood and charcoal and their consumption by the final sector. Production of fuelwood has always been lower than consumption while charcoal production increased rapidly after 2010. DEPP data excluded the amount of fuelwood used to produce charcoal. In addition, based on electricity data, bagasse was consumed to produce electricity. The quantity of bagasse consumed by the biomass power plant was also not available. In both cases, the missing data needed to be estimated to create the Lao PDR EBT.

This Lao PDR National Energy Statistics used an energy consumption survey that covered the industry, road transport, residential, and commercial sectors. Since this is the first energy consumption survey in the country, many improvements are needed. However, several remarkable information were extracted as follows:

i) Meaningful transport information such as fuel economy and mileage of selected types of vehicles
ii) Biomass use in the residential sector is lower than DEPP data (It is suggested that DEPP change the unit consumption of biomass in residential sector and apply it in a new survey)
iii) Reasonable building energy intensity by each building type.

The team from the Economic Research Institute for ASEAN and East Asia (ERIA) and experts from the Ministry of Energy and Mines of the Lao PDR and other agencies worked together to correct and fill in those data. ERIA used a critical technique to separate jet fuel consumption for domestic use from international consumption since no aviation data or other information was available. The ERIA team estimated this information by separating domestic aviation jet fuel use in reference to other sources. Likewise, only two-thirds of private oil companies provided data and information on petroleum sales. The ERIA team deployed some techniques to extrapolate the data to national data. This was successfully conducted for the energy consumption survey. However, extrapolation of the national data was constrained due to lack of macro statistics for extrapolation. Detailed methodologies were discussed in each section of this book as each section had its own technique and methodology to interpret and extrapolate data. However, the historical data could provide some analysis using the EBTs.

The following are the key findings and policy implications:

1. Total Final Energy Consumption by energy and sector – Elasticity was less than 1 but commercial energy increased by more than 10%.

2. Total Primary Energy Supply (TPES) by energy – Biomass was dominant but its share sharply declined. Hydro share followed biomass but electricity generated was mainly exported to neighbouring countries.

3. The TPES/capita indicator increased at an average annual growth rate of 5.9% from 0.3 to 0.72 ton of oil equivalent (toe)/person while the TPES per gross domestic product (GDP) remained at around 0.1 toe thousand $ (at constant 2011 PPP) over 2000–2015. Energy intensity (TPES/GDP) showed small improvement from 2000 to 2015. The intensity showed a declining trend from 2000 to 2014, with a slight increase in 2008. The increase in 2015 indicates a faster growth of TPES compared to GDP due to the drastic increase in coal consumption for power generation.

4. Combustion of fossil fuels, particularly coal, was the main contributing factor in the increased carbon dioxide (CO_2) emission in the Lao PDR. In 2000, the share of coal in the fuel mix was very small, lower than that of petroleum products. As coal use in the country increased faster than other fuels, the share of coal also increased. In 2015, coal started to be consumed by the power sector. Consequently, the CO_2 emission of the country increased very sharply in 2015. Due to changes of coal share in the TPES, CO_2 emission increased by 18% per year from 852 kt CO_2 in 2000 to 10,066 kt CO_2 in 2015. The CO_2 intensity (CO_2/GDP) increased at 9.8% per year, from 68 kg CO_2/thousand PPP $ to 278 kg CO_2/thousand PPP $.

References

Simmons, Tim (n.d.), 'CO_2 Emissions from Stationary Combustion of Fossil Fuels' http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_1_CO2_Stationary_Combustion.pdf

Trudeu, Nathalie (2012), 'Energy Efficiency Indicators Overview', Paris: International Energy Agency.

United Nations (2015), 'Concepts and Definition', *2013 Energy Balances*. New York: UN Department of Economics and Social Affairs. https://unstats.un.org/unsd/energy/balance/2013/03.pdf

Annex 1
Definition of Lao PDR's Energy Products and Flows

The definition of energy products and flows below explains the flow of energy balance table in Annex 4.

1. Energy Products

Energy Products	Definition
1. Coal	This includes all coal, i.e. solid fossil fuel consisting of carbonized vegetal matter such as hard coal (cooking coal, other bituminous coal, sub-bituminous coal), anthracite, lignite, and peat.
4. Petroleum Products	These comprise motor gasoline, aviation gasoline, naphtha, jet fuel, kerosene, gas/diesel oil, fuel oil, LPG, refinery gas, ethane, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke, and other petroleum products.
4.1 Motor Gasoline	This is a mixture of some aromatics (e.g. benzene and toluene) and aliphatic hydrocarbons in the C5 to C12 range. The distillation range is 25°C to 220°C. Motor gasoline may also contain bio-gasoline products.
4.3 Jet Fuel	This is a blend of kerosene suited to flight conditions, with specifications such as freezing point. The specifications are set down by a small number of national standards committees, most notably ASTM International (USA), Ministry of Defence UK (MOD UK), and GOST (Russia).
4.5 Gas/Diesel Oil	Diesel oils are middle distillates, predominantly of carbon range C11 to C25 and with a distillation range of 160°C to 420°C. These products comprise of road diesel and heating or other gas oils.
4.6 Fuel Oil	This comprises residual fuel oils and heavy fuel oils which are usually blended products based on residues from various refinery, distillation, and cracking processes. Residual fuel oil A-5 has a distillation range of 350°C to 650°C and a kinematic viscosity in the range 6 to 55 centistokes (cSt) at 100°C. Their flash point is always above 60°C and their specific gravity is above 0.95.

Energy Products	Definition
4.7 LPG	LPG refers to liquefied propane (C_3H_8) and butane (C_4H_{10}) or mixtures of both. Commercial grades are usually mixtures of the gases with small amounts of propylene, butylene, isobutane, and isobutylene stored under pressure in containers.
4.10 Other Petroleum Products	These comprise lubricants, bitumen, white spirits and special boiling points industry spirits, paraffin wax, petroleum coke, and other products.
6. Hydro	This refers to the energy content of the electricity produced in hydro power plants. Hydro output excludes output from pumped storage plants.
8. Geothermal, Solar, etc.	Electricity from solar photovoltaics refers to electricity produced by the direct conversion of solar radiation through photovoltaic processes in semiconductor devices (solar cells), including concentrating photovoltaic systems. Heat from concentrating solar thermal refers to high temperature heat produced from solar radiation captured by concentrating solar thermal systems. The high temperature heat can be transformed to generate electricity or drive chemical reactions, or it can be used directly in industrial processes. Heat from non-concentrating solar thermal refers to low-temperature heat produced from solar radiation captured by non-concentrating solar thermal systems.
9. Others (Combustible Renewables and Waste)	These are composed of solid biomass, liquid biomass, biogas, industrial waste, and municipal waste. Biomass is defined as any plant matter used directly as fuel or converted into fuels (e.g. charcoal) or electricity and/or heat. These include fuelwood, wood waste, bagasse, charcoal, other biomass, and biogas. Municipal waste comprises wastes produced by the residential, commercial, and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power. Hospital waste is included in this category.
10. Electricity	This shows final consumption and trade in electricity, which is accounted at the same heat value as electricity in final consumption (i.e. 1 MWh = 0. 086 toe).
12. Total	Defined as 1+3+4+6+9+10

LPG = liquefied petroleum gas, MWh = megawatt hour, toe = ton of oil equivalent, UK = United Kingdom, USA = United States of America.

Source: International Standard of Energy Balance Table Format. IEA, IEEJ, 2018.

2. Energy Flows

Energy Flows	Definition
1. Indigenous Production	This refers to the production of primary energy, i.e. hard coal, lignite/brown coal, peat, crude oil, NGL, natural gas, combustible renewables and waste, nuclear, hydro, geothermal, solar, and heat from heat pumps, that is extracted from the ambient environment. Indigenous production is calculated after the removal of impurities (e.g. sulphur from natural gas).
2. Imports and 3. Exports	These comprise amounts that have crossed the national territorial boundaries of the country, whether or not customs clearance has taken place. • For coal: Composed of the amounts of fuels obtained from or supplied to other countries, whether or not there is an economic or customs union between the relevant countries. Coal in transit should not be included. • For oil and gas: Composed of quantities of crude oil and oil products imported or exported under processing agreements (e.g. refining on account). Quantities of oil in transit are excluded. Crude oil, NGL, and natural gas are reported as coming from the country of origin; refinery feedstock and oil products are reported as coming from the country of last consignment. Re-exports of oil imported for processing within bonded areas are shown as exports of product from the processing country to the final destination. • For electricity: Amounts are considered imported or exported when they have crossed the national territorial boundaries of the country. If electricity is 'wheeled' or transited through a country, the amount is shown as both an import and an export.
4. International Marine Bunkers	These refer to the quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is based on the port of departure and port of arrival, and not on the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded.
13.1 International Aviation Bunkers	These include deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split is based on the departure and landing locations and not on the nationality of the airline. For many countries, this incorrectly excludes fuel used by domestically owned carriers for their international departures.

Energy Flows	Definition
5. Stock Changes	These reflect the differences between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on the national territory held by producers, importers, energy transformation industries, and large consumers. A stock build is shown as a negative number, and a stock draw is shown as a positive number.
6. Total Primary Energy Supply (TPES)	This is equal to indigenous production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes.
8. Total Transformation Sector	Transformation is the process where a part or all of the energy content of a product enters a process to become one or more different product (e.g. coking coal to coke, crude oil to petroleum products, and heavy fuel oil to electricity). The total transformation sector is the sum of transformation input (negative number) and transformation output (positive number) of various energy industries.
8.1 Main Activity Producer	This refers to the generators of electricity and/or heat for sale to third parties as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid. Columns 1 to 9 show the use of primary and secondary fuels for the production of electricity and/or heat as negative entries. Gross electricity and/or heat produced (including power stations' own consumption) appears as a positive quantity in the electricity and heat column. Transformation losses appear in the total column as negative.
8.8 Charcoal Processing	This refers to the recording of the transformation of fuelwood or other vegetal matter to produce charcoal. The quantity of fuelwood or other vegetal matter input is recorded as negative, while the output of charcoal is recorded as positive.
9. Loss and Own Use	Losses include distribution and transmission losses in gas distribution, electricity transmission, and coal transport. Own use contains the primary and secondary energy consumed by transformation industries for heating, pumping, traction, and lighting purposes [ISIC4 Divisions 10–12, 23, and 40]. These quantities are shown as negative figures. Included here, for example, are own use of energy in coal mines, own consumption in power plants (which includes net electricity consumed for pumped storage), and energy used for oil and gas extraction.
10. Discrepancy	This includes the sum of the unexplained statistical differences for individual fuels as they appear in the basic energy statistics. It also includes the statistical differences that arise because of the variety of conversion factors in the coal and oil columns.
11. Total Final Energy Consumption (TFEC)	This refers to the sum of consumption by the different end-use sectors. Backflows from the petrochemical industry are not included in final consumption.

Energy Flows	Definition
12. Industry Sector	This sector includes the following sub-sectors (energy used for transport by industry is not included here but is reported under transport): • Iron and steel industry [ISIC Group 271 and Class 2731]; • Chemical (including petrochemical) industry [ISIC Division 24] excluding petrochemical feedstock; • Non-ferrous metals basic industries [ISIC Group 272 and Class 2732]; • Non-metallic minerals such as glass, ceramic, cement, etc. [ISIC Division 26]; • Transport equipment [ISIC Divisions 34 and 35]; • Machinery comprises fabricated metal products, and machinery and equipment other than transport equipment [ISIC Divisions 28 to 32]; • Mining (excluding fuels) and quarrying [ISIC Divisions 13 and 14]; • Food, beverages, and tobacco [ISIC Divisions 15 and 16]; • Paper, pulp, and printing [ISIC Divisions 21 and 22]; • Wood and wood products (other than pulp and paper) [ISIC Division 20]; • Construction [ISIC Division 45]; • Textile and leather [ISIC Divisions 17 to 19]; • Other industry (any manufacturing industry not included above) [ISIC Divisions 25, 33, 36, and 37]. Note: The other industry row is also used when there is difficulty in breaking down the industrial sub-sectors. This number should be treated with caution.

Energy Flows	Definition
13. Transport Sector	This includes all fuels used for transport [ISIC Divisions 60 to 62], except international marine bunkers and international aviation bunkers. It also includes transport in the industry sector and covers domestic aviation, road, rail, pipeline transport, domestic navigation, and non-specified transport. Domestic aviation includes deliveries of aviation fuels to aircraft for domestic aviation – commercial, private, agriculture, and the like. It includes use for purposes other than flying, e.g. bench testing of engines, but not airline use of fuel for road transport. The domestic/international split should be based on the departure and landing locations and not by the nationality of the airline. Fuels used for ocean, coastal and inland fishing (included under fishing), and military consumption (see not elsewhere specified – Other sectors) are excluded from the transport sector.
13.2 Domestic Air Transport	This reports on quantities of aviation fuels delivered to aircraft for domestic aviation – commercial, private, agricultural, etc. It includes fuel used for purposes other than flying, e.g. bench testing of engines. The domestic/international split should be based on the departure and landing locations and not on the nationality of the airline. Note that this may include journeys of considerable length between two airports in an economy (e.g. San Francisco to Honolulu). This excludes fuels used by airlines for their road vehicles (see not elsewhere specified – Transport sector) and military use of aviation fuels (see not elsewhere specified – Other sectors).
13.3 Road	This reports on oil used on road vehicles. It includes fuel used on agricultural vehicles on highways and lubricants used on road vehicles. It excludes motor gasoline and diesel used on stationary engines (see not elsewhere specified – Oher sectors), diesel oil for non-highway used on tractors (see Agriculture/Forestry – Other sectors), military use (see not elsewhere specified – Other sectors) and gasoline used on engines at construction sites (see Construction – Industry sector).
14. Other Sector	This covers residential, commercial, and public services [ISIC Divisions 41, 50-52, 55, 63-67, 70-75, 80, 85, 90-93, 95, and 99], agriculture [ISIC Divisions 01 and 02], fishing [ISIC Division 05] and others. Others include military fuel used for all mobile and stationary consumption (e.g. ships, aircraft, road, and energy used in living quarters), regardless of whether the fuel delivered is for the military of that country or the military of another country.
14.1 Residential and Commercial	Defined as 15.1.1 + 15.1.2

Energy Flows	Definition
14.1.1 Commercial and Public Services	ISIC Divisions and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84 (excluding Class 8422), 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96, and 99. These refer to oils consumed by businesses and offices in the public and private sectors. Note that oil used at railways, bus stations, shipping piers, and airports should be reported in this category and not shown in the Transport sector.
14.1.2 Residential	This reports on fuels consumed by all households, including households with employed persons (ISIC and NACE Divisions 97 and 98).
14.2 Agriculture	ISIC Divisions 01 and 02 (NACE Divisions 01 and 02). This reports on oil consumption by users classified as agriculture, hunting, and forestry.
15. Non-energy Use	This covers fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Non-energy use is shown separately in final consumption under the heading Non-energy Use.
16. Electricity Output in GWh	This refers to the power generation amount by each power source.

GWh = gigawatt-hour, ISIC = International Standard Industrial Classification, NACE = Nomenclature générale des activités économiques dans les Communautés Européennes, NGL = natural gas liquids.

Source: International standard of Energy Balance Table Format. IEA, IEEJ, 2018.

Annex 2
Petroleum Products Sales Questionnaire Definitions

Definitions of Fuels

1. Liquefied Petroleum Gas (LPG)
   LPG refers to liquefied propane (C3H8) and butane (C4Hl0) or mixtures of both. Commercial grades are usually mixtures of gases with small amounts of propylene, butylene, isobutane, and isobutylene stored under pressure in containers.

2. Naphtha
   Naphtha refers to light or medium oils distilling between 30°C and 210°C which do not meet the specification for motor gasoline. Naphtha is mainly used as feedstock for high-octane gasolines and the manufacture of olefins in the petrochemical industry.

3. Motor Gasoline
   Motor gasoline is a mixture of some aromatics (for example, benzene and toluene) and aliphatic hydrocarbons in the C5 to C12 range. Its distillation range is 25°C to 220°C. Motor gasoline may also contain biogasoline products.

4. Kerosene-Type Jet Fuel
   This is a blend of kerosene suited to flight conditions, with particular specifications such as freezing point. The specifications are set down by a small number of national standards committees, most notably, ASTM (United States of America), MOD (United Kingdom), GOST (Russia).

5. Other Kerosene
   Kerosene is used for heating, cooking, lighting, solvents, and internal combustion engines. Other names of this product are burning oil, vaporising oil, power kerosene, and illuminating oil.

6. Diesel Oil
   Diesel oils are middle distillates, predominantly of carbon range C11 to C25 and with a distillation range of 160°C to 420°C. These products comprise road diesel and heating or other gas oils.

7. Fuel Oil
   This comprises residual fuel oils and heavy fuel oils which are usually blended products based on residues from various refinery, distillation, and cracking processes. Residual fuel oil A-5 has a distillation range of 350°C to 650°C and a kinematic viscosity in the range 6 to 55 centistokes (cSt) at 100°C. Their flash point is always above 60°C and their specific gravity is above 0.95.

8. Lubricants
   Lubricants are oils, produced from crude oil, for which the principal use is to reduce friction between sliding surfaces and during metal-cutting operations.

9. Bitumen
   Bitumen is a solid, semi-solid, or viscous hydrocarbon with a colloidal structure that is brown to black in color. It is obtained as a residue in the distillation of crude oil and by vacuum distillation of oil residues from atmospheric distillation. It should not be confused with the non-conventional primary extra heavy oils which may also be referred to as bitumen.

10. Other Products
    Other products comprise white spirits and special boiling points industry spirits, paraffin wax, petroleum coke, and other products.

Definitions of Flows

1. Import
   Data should reflect amounts/quantities that have crossed the national territorial boundaries, whether customs clearance has taken place or not. Quantities of crude oil and products imported or exported under processing agreements (e.g. refining on account) should be included.

2. Blending
   Petroleum companies blend several petroleum products and create a petroleum product. So, there are + (create) – (blended) and total should be zero.

3. Own use
   Own use by petroleum import companies.

4. Stock (at the end of the year)
   All stocks on national territory, including stocks held by governments, by major consumers, or by stockholding organisations; stocks held on board incoming ocean vessels; stocks held in bonded areas; and stocks held for others, whether under bilateral government agreement or not.

5. Total Sales
   = 1 ± 2 – 3

6. Sale to power producers
   = 6 + 7

7. Electricité du Laos (EDL)
   Sales of diesel or fuel oil to EDL

8. Independent power producer (IPP), off-grid factory (OGF), etc.
   Sales of diesel oil and fuel oil to other power producers

9. Sale to large-scale industrial users (13 subsectors)
   =10+11+12+13+14+15+16+17+18+19+20+21+22

10. Iron and Steel
    ISIC Group 241 and Class 2431 (NACE) Groups 24.1, 24.2, 24.3; and Classes 24.51 and 24.52)

    To avoid double counting, oil used in blast furnaces should be reported in the Energy or Transformation sector.

11. Chemical (including Petrochemical)
    ISIC Division 20 and 21 (NACE Division 20 and 21)
    Note: This heading includes petroleum products used as fuel and as feedstock (non-energy use). However, consumption should be net, after deduction of backflows. The breakdown of net consumption by product should be calculated applying the same proportion of product split for gross deliveries.

12. Non-ferrous Metals
    ISIC Group 242 and Class 2432 (NACE Group 24.4 and Classes 24.53 and 24.54)

13. Transportation Equipment
    ISIC Divisions 29 and 30 (NACE Divisions 29 and 30)

14. Machinery
    ISIC Divisions 25, 26, 27, and 28 (NACE Divisions 25, 26, 27, and 28)
    Report fabricated metal products, machinery, and equipment other than transport equipment.

15. Mining and Quarrying
    ISIC Divisions 07 and 08 and Group 099 (NACE Divisions 07 and 08 and Group 09.9)

16. Food, Beverage, and Tobacco
    ISIC Divisions 10, 11, and 12 (NACE Divisions 10, 11, and 12)

17. Pulp, Paper, and Printing
    ISIC Divisions 17 and 18 (NACE Divisions 17 and 18)
    This category includes reproduction of recorded media.

18. Wood and Wood Products
    ISIC Division 16 (NACE Division 16)

19. Construction
    ISIC Divisions 41, 42, and 43 (NACE Division 41, 42, and 43).

20. Textile and Leather
    ISIC Divisions 13, 14, and 15 (NACE Divisions 13, 14, and 15).

21. Not Elsewhere Specified (Industry)
    If an economy's industrial classification of oil consumption does not correspond to the above ISIC (or NACE) codes, it must estimate the breakdown by industry and include in 'not elsewhere specified' consumptions in sectors that are not covered above.

    ISIC Divisions 22, 31, and 32. For NACE, it covers Divisions 22, 31, and 32 (Industry).

22. Sale to Large-Scale Transport Users
    =23+24+25+26+27

23. Taxi, Bus, Road Freight, etc.
    Report oil used on road vehicles. Include fuel used by agricultural vehicles on highways and lubricants used on road vehicles. Exclude motor gasoline and diesel used on stationary engines (see not elsewhere specified – Other sectors), diesel oil for non-highway used on tractors (see Agriculture/Forestry – Other sectors), military use (see not elsewhere specified – Other sectors), and gasoline used on engines at construction sites (see Construction – Industry sector).

24. International Civil Aviation
    Report quantities of aviation fuels delivered to aircraft for international aviation bunkers (also known as International Aviation Bunkers). The domestic/international split should be based on departure and landing locations and not by the nationality of the airline. Exclude fuels used by airlines for their road vehicles (see not elsewhere specified – Transport sector) and military use of aviation fuels (see not elsewhere specified – Other sectors).

25. Domestic Air Transport
    Report quantities of aviation fuels delivered to aircraft for domestic aviation – commercial, private, agricultural, etc. Include fuel used for purposes other than flying, e.g. bench testing of engines. The domestic/international split should be based on the departure and landing locations and not on the nationality of the airline. Note that this may include journeys of considerable length between two airports in an economy (e.g. San Francisco to Honolulu). Exclude fuels used by airlines for their road vehicles (see not elsewhere specified – Transport sector) and military use of aviation fuels (see not elsewhere specified – Other sectors).

26. Inland Waterways
    Report fuels delivered to vessels of all flags not engaged in international navigation (see international marine bunkers). The domestic/international split should be based on the port of departure and port of arrival and not on the flag or nationality of the ship. Note that this may include journeys of considerable length between two ports in an economy (e.g. San Francisco to Honolulu).

27. International Marine Bunkers
    Bunkers cover the quantities of fuels delivered to sea-going ships of all flags. Consumption of warships should be included in final consumption under other sector, not elsewhere specified. Consumption by ships engaged in fishing and in transport in inland and coastal waters are not included.

28. Sale to Other Large-Scale Users
    =29+30+31+32+33+34

29. Commercial Services such as Mall, Hotel, School, Hospital, Office Building
    ISIC Divisions and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84 (excluding Class 8422), 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96, and 99

    Oil consumed by businesses and offices in the public and private sectors. Note that oil use at railways, bus stations, shipping piers, and airports should be reported in this category and not shown in the Transport sector.

30. Public Services such as Central and Local Governments
    Sales of petroleum products to Central and Local Governments.

31. Residential
    ISIC and NACE Divisions 97 and 98
    Report fuels consumed by all households including households with employed persons.

32. Agriculture
    ISIC Divisions 01 and 02 (NACE Divisions 01 and 02)
    Report oil consumption by users classified as agriculture, hunting, and forestry.

33. Fishing
    Report fuels used for inland, coastal, and deep-sea fishing. Fishing should cover fuels delivered to ships of all flags that have refuelled in the economy (include international fishing). Also include energy used in the fishing industry as specified in ISIC Division 03 and NACE Division 03.

34. Petroleum Wholesaler
    Sales of petroleum products to petroleum wholesalers.

35. Sale to Gas Stations
    = 36 + 37

36. Company-Owned Stations
    Delivery of petroleum products to company-owned service stations.

37. Company Franchises
    Delivery of petroleum products to franchised service stations.

Petroleum Product Sales Questionnaire

Quantity Descriptions	LPG	Naphtha	Motor Gasoline	Kerosene-Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products (Specify)
	Ton	KL	KL	KL	KL	KL	KL	KL	Specify	Specify
Import										
Blending										
Own Use										
Stock (at the end of the year)										
Total Sales										
Sell to Power Producers										
EDL										
IPP, Rural, etc.										
Sell to Large-Scale Industrial Users										
Iron and Steel										
Chemical (includin Petrochemical)										
Non-ferrous Metals										
Transportation Equipment										
Machinery										
Mining and Quarrying										
Food, Beverages, and Tobacco										
Pulp, Paper, and Printing										
Wood and Wood Products										
Construction										
Textiles and Leather										
Not Elsewhere Specified (Industry)										
Sell to Large-Scale Transport Users										
Taxi, Bus, Road Freight, etc.										
International Civil Aviation										
Domestic Air Transport										
Inland Waterways										
International Marine Bunkers										
Sell to Other Large-Scale Users										
Commercial Services such as Mall, Hotel, School, Hospital, Office Building										
Public Services such as Central and Local Governments										
Residential										
Agriculture										
Fishing										
Petroleum Wholesaler										
Sell to Gas Station										
Company-Owned Stations										
Company Franchises										

EDL = Electricité du Laos , IPP = independent power producer, KL = kilolitre, LPG= liquefied petroleum gas,

Annex 3
Enabling Policy and Institutional Support for a Functioning Lao PDR Energy Statistics

1. Introduction

As the Lao PDR has been moving up in terms of gross domestic product (GDP) per capita due to stable economic growth, its energy consumption is also expected to continue to grow. This requires appropriate and effective energy policies for now and into the future.

The Ministry of Energy and Mines (MEM), Lao PDR, has been working hard to improve the country's energy policies – in line with the Power Sector Strategy and the Energy Efficiency and Conservation Goals – to ensure a stable and affordable supply of primary energy and thus attain sustainable economic development.

MEM recognises that Lao PDR's energy data and statistics require strengthening in terms of procedure, analytical tools, and systematic data collection by concerned agencies and ministries. MEM believes that improving Lao PDR's energy data and statistics will not only serve its policy purpose but will also enhance its energy cooperation with the Association of Southeast Asian Nations (ASEAN) and other regional and international bodies such as the ASEAN Centre for Energy and the International Energy Agency that require data from time to time for policy and analyses.

The Department of Energy Policy and Planning (DEPP) under MEM approached the Economic Research Institute for ASEAN and East Asia (ERIA) for support in the preparation of the 'Lao PDR National Energy Statistics', including the construction of the energy balance table. This national energy statistics will provide a good baseline for the preparation and planning of Lao PDR's energy policy.

MEM wants to see a continued and functioning Lao PDR energy data and statistics, even after ERIA's support for the project has been completed. To achieve this, the goal, objective, structure, and policy support required by an energy statistics unit need to be clarified. Therefore, the Lao Energy Data and Statistics Unit must take on forward-looking roles as follows:

- Lead the development and maintenance of a comprehensive national and sectoral statistics for energy production, transformation, and end use.
- Produce data to advise policymakers and inform investment decisions.
- Share data as a vital input to meeting regional and international reporting obligations.
- Also collect, process, and publish energy statistics to support policy analysis; conduct statistical and economic analyses of energy services sectors and sustainable energy options; and contribute to the development and promulgation of appropriate sustainability indicators and timely and reliable statistics to monitor the energy situation.

2. Review of the Legal Framework for Supporting Energy Data and Statistics

Lao PDR's Statistical Law No. 03/NA dated 30 June 2010 provides the legal framework on all matters relating to the collection, processing, compilation, analysis, publication, and dissemination of the statistical data of the Lao PDR. By law, there are four types of statistics for the Lao Statistics Bureau (LSB) to work with relevant line agencies, ministries, provinces, and districts. These are (i) economic statistics, (ii) social statistics, (iii) environment and natural resources statistics, and (iv) security and stability statistics.

Article 18 of Lao PDR's Statistical Law stipulates that the Prime Minister shall approve the conduct of a census upon the request of the Ministry of Planning and Investment. After approval, the Minister of Planning and Investment shall approve the national sample survey upon the request of LSB, after consultation with line ministries, ministry-equivalent agencies, or sectors concerned. The minister or head of agency, provincial and capital city governor shall approve the sub-national sample survey in their own sector and province upon the request of their respective sectors through the certification and technical approval of the LSB.

Article 19 stipulates that LSB shall execute censuses, national sample surveys, and other specific surveys that are defined in the Strategic Development of National Statistical System. However, the statistics centres based at line ministries, ministry-equivalent agencies, provinces, municipalities, districts, and sub-districts execute the sample surveys and specific surveys/case studies for their respective sectors and local needs through the certification and technical approval of LSB. The economic units from concerned ministries can carry out sample surveys or case studies to produce statistics data for their own need but these are not considered official statistics. International organisations and non-government organisations can carry out statistical surveys but they are required to get approval from line ministries, ministry-equivalent agencies, or local authorities as defined in Article 18 of the Statistical Law.

However, amongst the four types of statistical data defined by the Statistical Law, only economic statistics and environmental and natural resources statistics are relevant to energy data and statistics. Article 10 on 'socio statistics' refers to data on population, ethnicity, education, public health, labour, social welfare, information and culture, administrative unit registration, poverty, gender, social security, housing, sports and recreation, social organisation, accident, crime, and other socio-related statistics. Article 11 on 'environment and natural resources statistics' refers to data on the country's geography, mine, hydrology, topology, disaster, pollution, waste and waste management to balance the environment, natural resources, human and human development, and other environment-related statistics.

Therefore, Lao PDR's Statistical Law provides ample room for line ministries to carry out surveys to get the needed data and information to serve the purposes of their ministries. However, the lack of data coordination and data centre for each ministry and agency has led to inconsistencies in data and data gaps at various levels. Thus, improving data collection and empowering data and statistical centres at each ministry and agency is important for the country.

3. Proposed Actions and Collaboration for Data Collection and Acquisition

There are members in the Asia-Pacific Economic Cooperation (APEC) that perform energy data collection, analysis, and dissemination that is worth exploring. Some of these countries such as Japan, Indonesia, Thailand, the United States, etc. collect their energy data through their Ministry of Energy. Other APEC economies such as Canada, China, Russia, etc. use their National Statistical Office to collect their energy data.

The Lao PDR Statistical Law provides the legal framework for MEM to have full functioning sectoral statistical units to collect, compile, analyse, publish, and disseminate data and information such as the 'energy statistics and mineral resources statistics' to the public in coordination with LSB. However, the current statistical unit within MEM needs support to make it a full-functioning unit. The Lao Energy Data and Statistics Unit within DEPP needs to be empowered with effective coordination, policy, and institutional support including:

- **Institutional and Data Collection Coordination**
  - Work with LSB to issue sub-decrees on regular energy data consumption surveys in household/residential, transportation, industrial, and commercial/building sectors.
  - Collaborate with LSB as it has a well-established structure of administrative data collection with line agencies. The first step is to set up an official meeting with LSB to see how 'energy data statistics' can be collected from line agencies. It is very important to define clear and simple types of energy data to be collected. The next step is to have a well-designed energy data collection format for discussion with LSB, together with relevant agencies such as the Ministry of Public Works and Transport, Ministry of Industry and Commerce, Ministry of Finance, Lao State Fuel Company, Electricité du Laos, etc.
  - Empower the DEPP-designated staff at statistical centres to collect data regularly, and to involve a data supplier. DEPP will need to work with the LSB to acquire data from all involved stakeholders, including the state-owned petroleum import companies and other agencies/sectors using intensive energy.
  - DEPP, in collaboration with the LSB, may work with statistical units in other ministries or any newly established statistical units from related agencies which are also in charge of collecting and publishing energy and mines data.

- **Technical Capacity Building and Budgets**
  - Once data collection has been done, there are capacity constraints to process, analyse, and publish the data to the public. Therefore, there is a need to have capacity building to train staff to handle the energy data and statistics.
  - DEPP may continue to seek support from the Economic Research Institute for ASEAN and East Asia (ERIA) to further strengthen the design of the petroleum product specifications and the downstream legal framework, regulation, policy, and procedures.
  - DEPP may continue to seek ERIA's technical advice and lead a regular technical and high-level working group on energy statistics.
  - Provide clear financial support and budget for the Energy Statistical Unit for its daily core functions (including surveys, data collection and coordination, and capacity building).
  - Maintain staff and update knowledge and analytical skills. The Energy Statistical Unit may aim for a series of publications (monthly, quarterly, yearly statistics). Furthermore, the unit may aim to produce a Lao PDR energy outlook and other energy-specific papers to support policy formulation.

- **Lao Energy Data and Statistics Unit**
  - DEPP may act as the energy data centre by linking all concerned stakeholders for data sharing as well as data collection and updating.
  - DEPP as an energy data centre would have to be equipped with both hardware and software (computer, software, staff).

Annex 4
Lao PDR's Energy Balance Tables, 2000–2015

Lao PDR Energy Balance Table, 2000 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	88								296		1.260		1.650
2. Imports		312	78	44	184	3	2	0				15	328
3. Exports	-79											-240	-319
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	9	272	78	3	184	3	2	0	296		1.260	-225	1.618
8. Total Transformation Sector									-296		-86	302	-86
8.1 Main Activity Producer									-296			302	
8.8 Charcoal Processing											-86		-86
9. Loss and Own Use												-22	-22
10. Discrepancy		-1	-1	0	0		0					0	-1
11. Total Final Energy Consumption	9	270	77	3	184	3	2	0			1.174	55	1.509
12. Industry Sector	9	14			11	3					47	12	82
13. Transport Sector		254	77	3	173			0					254
13.2 Domestic Air Transport		3		3									3
13.3 Road		251	77		173			0					251
14. Other Sector		2			0		2				1.127	43	1.173
14.1 Residential and Commercial		2					2				1.127	41	1.169
14.1.1 Commerce and Public Services		1					1				197	13	210
14.1.2 Residential		1					1				930	28	959
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3.509				3.509

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2001 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	96								321		1,290		1,707
2. Imports		340	79	44	211	4	2	0				16	355
3. Exports	-84											-247	-331
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	12	299	79	3	211	4	2	0	321		1,290	-231	1,691
8. Total Transformation Sector									-321		-88	321	-88
8.1 Main Activity Producer									-321			321	
8.8 Charcoal Processing											-88		-88
9. Loss and Own Use												-28	-28
10. Discrepancy		-2	-2	0	0		0				0	0	-2
11. Total Final Energy Consumption	12	297	77	3	211	4	2	0			1,202	61	1,572
12. Industry Sector	12	11			8	4					48	12	83
13. Transport Sector		284	77	3	203			0					284
13.2 Domestic Air Transport		3		3									3
13.3 Road		281	77		203			0					281
14. Other Sector		2			0		2				1,154	49	1,206
14.1 Residential and Commercial		2					2				1,154	46	1,202
14.1.1 Commerce and Public Services		1					1				201	14	216
14.1.2 Residential		1					1				953	32	985
14.2 Agriculture		0			0							4	4
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3,728	0	0		3,728

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2002 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12. Total
1. Indigenous Production	105								316		1,321		1,742
2. Imports		346	83	44	213	4	2	0				17	364
3. Exports	-86											-241	-327
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	19	306	83	3	213	4	2	0	316		1,321	-223	1,738
8. Total Transformation Sector									-316		-90	316	-90
8.1 Main Activity Producer									-316			316	
8.8 Charcoal Processing											-90		-90
9. Loss and Own Use												-27	-27
10. Discrepancy		-1	-1	0	0		0				0	0	-1
11. Total Final Energy Consumption	19	304	82	3	213	4	2	0			1,231	66	1,620
12. Industry Sector	19	12			8	4					49	14	94
13. Transport Sector		290	82	3	204			0					290
13.2 Domestic Air Transport		3		3									3
13.3 Road		287	82		204			0					287
14. Other Sector		2			0		2				1,182	52	1,236
14.1 Residential and Commercial		2					2				1,182	49	1,232
14.1.1 Commerce and Public Services		1					1				2016	15	222
14.1.2 Residential		1					1				976	34	1,010
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3,678	0	0		3,678

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2003 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	116								279		1,352		1,748
2. Imports		357	86	44	220	4	2	0				20	377
3. Exports	-93											-196	-290
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	23	316	86	3	220	4	2	0	279		1,352	-177	1,794
8. Total Transformation Sector									-279		-92	279	-92
8.1 Main Activity Producer									-279			279	
8.8 Charcoal Processing											-92		-92
9. Loss and Own Use												-26	-26
10. Discrepancy		-2	-2	0			0				0	0	-2
11. Total Final Energy Consumption	23	314	85	3	220	4	2	0			1,261	76	1,674
12. Industry Sector	23	8			4	4					51	17	99
13. Transport Sector		304	85	3	215			0					304
13.2 Domestic Air Transport		3		3									3
13.3 Road		300	85		215			0					300
14. Other Sector		2			0		2				1,210	59	1,271
14.1 Residential and Commercial		2					2				1,210	56	1,268
14.1.1 Commerce and Public Services		1					1				211	17	229
14.1.2 Residential		1					1				99	39	1,039
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3,243	0	0		3,243

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2004 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	139								294		1,385		1,817
2. Imports		369	92	44	226	4	2	0				24	393
3. Exports	-111											-209	-319
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	28	328	92	3	226	4	2	0	294		1,385	-185	1,850
8. Total Transformation Sector									-294		-94	294	-94
8.1 Main Activity Producer									-294			294	
8.8 Charcoal Processing											-94		-94
9. Loss and Own Use												-31	-31
10. Discrepancy		-5	-2	-3	0		0				0	0	-5
11. Total Final Energy Consumption	28	323	91		226	4	2	0			1,291	78	1,719
12. Industry Sector	28	9			5	4					52	19	107
13. Transport Sector		312	91		221			0					312
13.2 Domestic Air Transport													
13.3 Road		312	91		221			0					312
14. Other Sector		2			0		2				1,239	59	1,300
14.1 Residential and Commercial		2					2				1,239	55	1,296
14.1.1 Commerce and Public Services		1					1				216	16	233
14.1.2 Residential		1					1				1,023	39	1,063
14.2 Agriculture		0			0							3	4
15. Non-energy Use		0						0					0
16. Electricity Output in GWh	0								3,416				3,416

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2005 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	148								308		1,418		1,874
2. Imports		384	100	44	233	4	2	0				28	412
3. Exports	-118											-216	-334
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	30	343	100	3	233	4	2	0	308		1,418	-187	1,912
8. Total Transformation Sector									-308		-96	308	-96
8.1 Main Activity Producer									-308			308	
8.8 Charcoal Processing											-96		-96
9. Loss and Own Use												-34	-34
10. Discrepancy		-4	-4	0	0		0				0	0	-4
11. Total Final Energy Consumption	30	338	96	3	233	4	2	0			1,322	87	1,777
12. Industry Sector	30	8			3	4					53	20	111
13. Transport Sector		329	96	3	229			0					329
13.2 Domestic Air Transport		3		3									3
13.3 Road		325	96		229			0					325
14. Other Sector		2			0		2				1,269	67	1,337
14.1 Residential and Commercial		2					2				1,269	64	1,334
14.1.1 Commerce and Public Services		1					1				221	20	242
14.1.2 Residential		1					1				1,047	44	1,092
14.2 Agriculture		0			0							3	3
15. Non-energy Use		0						0					0
16. Electricity Output in GWh									3,581				3,581

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2006 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	164								315		1,452		1,931
2. Imports		485	111	45	322	4	3	1				54	539
3. Exports	-126											-214	-340
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	37	443	111	3	322	4	3	1	315		1,452	-160	2,082
8. Total Transformation Sector									-315		-98	315	-98
8.1 Main Activity Producer									-315			315	
8.8 Charcoal Processing											-98		-98
9. Loss and Own Use												-35	-35
10. Discrepancy		-7	-7	0			0				0	0	-7
11. Total Final Energy Consumption	37	436	104	3	322	4	2	1			1,353	121	1,948
12. Industry Sector	37	83			79	4					54	47	222
13. Transport Sector		350	104	3	243			1					350
13.2 Domestic Air Transport		3		3									3
13.3 Road		347	104		243			1					347
14. Other Sector		2			0		2				1,299	74	1,375
14.1 Residential and Commercial		2					2				1,299	70	1,371
14.1.1 Commerce and Public Services		1					1				226	21	249
14.1.2 Residential		1					1				1,072	49	1,122
14.2 Agriculture		0			0							3	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh									3,668				3,668

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2007 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	186								296		1,574		2,056
2. Imports		498	117	45	328	4	3	1				68	566
3. Exports	-141											-192	-333
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	45	456	117	3	328	4	3	1	296		1,574	-124	2,248
8. Total Transformation Sector									-296		-109	296	-109
8.1 Main Activity Producer									-296			296	
8.8 Charcoal Processing											-109		-109
9. Loss and Own Use												-34	-34
10. Discrepancy		0		0	0		0				0	0	0
11. Total Final Energy Consumption	45	456	117	3	328	4	2	1			1,464	139	2,104
12. Industry Sector	45	68			64	4					59	54	226
13. Transport Sector		385	117	3	264			1					385
13.2 Domestic Air Transport		3		3									3
13.3 Road		382	117		264			1					382
14. Other Sector		2			0		2				1,406	85	1,493
14.1 Residential and Commercial		2					2				1,406	81	1,489
14.1.1 Commerce and Public Services		1					1				246	26	273
14.1.2 Residential		1					1				1,160	55	1,216
14.2 Agriculture		0			0							4	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh	0								3,442				3,442

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2008 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	210								326		1,710		2,246
2. Imports		569	123	45	393	5	3	1				73	641
3. Exports	-140											-199	-339
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	70	527	123	3	393	5	3	1	326		1,710	-126	2,507
8. Total Transformation Sector									-326		-129	326	-129
8.1 Main Activity Producer									-326			326	
8.8 Charcoal Processing											-129		-129
9. Loss and Own Use												-35	-35
10. Discrepancy	0	0		0	0		0				0		0
11. Total Final Energy Consumption	70	527	123	3	393	5	2	1			1,581	165	2,343
12. Industry Sector	70	84			79	5					63	60	278
13. Transport Sector		440	123	3	313			1					440
13.2 Domestic Air Transport		3		3									3
13.3 Road		437	123		313								436
14. Other Sector		2			0		2				1,518	104	1,625
14.1 Residential and Commercial		2					2				1,518	100	1,620
14.1.1 Commerce and Public Services		1					1				269	40	310
14.1.2 Residential		1					1				1,249	61	1,311
14.2 Agriculture		0			0							4	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh									3,793				3,793

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2009 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	236								295		1,704		2,235
2. Imports		654	137	45	463	5	3	1				101	755
3. Exports	-148											-165	-313
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	88	612	137	3	463	5	3	1	295		1,704	-64	2,636
8. Total Transformation Sector									-295		-153	295	-153
8.1 Main Activity Producer									-295			295	
8.8 Charcoal Processing											-153		-153
9. Loss and Own Use												-37	-37
10. Discrepancy	0	0		0			0				0	0	0
11. Total Final Energy Consumption	88	612	137	3	463	5	2	1			1,551	194	2,445
12. Industry Sector	88	99			93	5					61	65	313
13. Transport Sector		511	137	3	369			1					511
13.2 Domestic Air Transport		3		3									3
13.3 Road		508	137		369								508
14. Other Sector		3			0		2				1,490	129	1,621
14.1 Residential and Commercial		2					2				1,490	125	1,618
14.1.1 Commerce and Public Services		1					1				272	55	329
14.1.2 Residential		1					1				1,218	70	1,289
14.2 Agriculture		0			0							3	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh	0								3,434				3,434

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2010 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	320								741		1,670		2,731
2. Imports		662	145	45	463	6	3	1				104	766
3. Exports	-164											-527	-736
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	155	620	145	3	463	6	3	1	741		1,670	-468	2,719
8. Total Transformation Sector									-741		-156	741	-156
8.1 Main Activity Producer									-741			741	
8.8 Charcoal Processing											-156		-156
9. Loss and Own Use												-64	-64
10. Discrepancy	0	0			0		0				0	0	0
11. Total Final Energy Consumption	155	620	145	3	463	6	2	1			1,514	210	2,499
12. Industry Sector	155	93			88	6					59	61	369
13. Transport Sector		524	145	3	374			1					524
13.2 Domestic Air Transport		3		3									3
13.3 Road		520	145		374			1					520
14. Other Sector		3			0		2				1,455	149	1,607
14.1 Residential and Commercial		2					2				1,455	145	1,603
14.1.1 Commerce and Public Services		1					1				267	64	333
14.1.2 Residential		1					1				1,188	81	1,270
14.2 Agriculture		0			0							4	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh									8,621				8,621

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2011 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	364								1,138		1,635		3,138
2. Imports		683	152	45	473	8	3	1				78	761
3. Exports	-172											-917	-1,089
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	192	641	152	3	473	8	3	1	1,138		1,635	-840	2,768
8. Total Transformation Sector									-1,138		-158	1,138	-158
8.1 Main Activity Producer									-1,138			1,138	
8.8 Charcoal Processing											-158		-158
9. Loss and Own Use												-79	-79
10. Discrepancy	0	0		0			0				0	0	0
11. Total Final Energy Consumption	192	641	152	3	473	8	3	1			1,477	220	2,531
12. Industry Sector	192	103			95	8					58	64	417
13. Transport Sector		535	152	3	378			1					535
13.2 Domestic Air Transport		3		3									3
13.3 Road		531	152		378			1					531
14. Other Sector		3			0		3				1,420	156	1,579
14.1 Residential and Commercial		3					3				1,420	152	1,575
14.1.1 Commerce and Public Services		2					2				262	66	330
14.1.2 Residential		1					1				1,157	86	1,245
14.2 Agriculture		0			0							4	4
15. Non-energy Use		1						1					1
16. Electricity Output in GWh	0								13,234				13,234

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2012 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	401								1,146		1,585		3,132
2. Imports		735	160	46	517	8	3	2				114	850
3. Exports	-193											-891	-1,084
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	208	693	160	3	517	8	3	2	1,146		1,585	-777	2,855
8. Total Transformation Sector									-1,146		-160	1,146	-160
8.1 Main Activity Producer									-1,146			1,146	
8.8 Charcoal Processing											-160		-160
9. Loss and Own Use												-104	-104
10. Discrepancy		-1		0		0	-1				0	0	-1
11. Total Final Energy Consumption	208	692	160	3	517	7	3	2			1,424	264	2,590
12. Industry Sector	208	86			78	7					40	76	409
13. Transport Sector		604	160	3	438			2					604
13.2 Domestic Air Transport		3		3									3
13.3 Road		600	160		438			2					600
14. Other Sector		3			0		3				1,385	189	1,576
14.1 Residential and Commercial		3					3				1,385	185	1,573
14.1.1 Commerce and Public Services		2					2				258	85	345
14.1.2 Residential		1					1				1,127	100	1,228
14.2 Agriculture		0			0							3	4
15. Non-energy Use		2						2					2
16. Electricity Output in GWh	0								13,323				13,323

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2013 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	446										1,580		3,387
2. Imports		780	169	46	552	8	4	2	1,361			109	890
3. Exports	-101											-1,074	-1,175
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	345	738	169	3	552	8	4	2	1,361		1,580	-965	3,059
8. Total Transformation Sector									-1,361		-164	1,361	-164
8.1 Main Activity Producer									-1,361		-2	1,361	-2
8.8 Charcoal Processing											-162		-162
9. Loss and Own Use												-105	-105
10. Discrepancy		-3	-3	0			-1					0	-3
11. Total Final Energy Consumption	345	735	166	3	552	8	3	2			1,416	291	2,787
12. Industry Sector	345	102			94	8					59	96	602
13. Transport Sector		630	166	3	458			2					630
13.2 Domestic Air Transport		3		3									3
13.3 Road		626	166		458			2					626
14. Other Sector		3			0		3				1,357	195	1,555
14.1 Residential and Commercial		3					3				1,357	192	1,551
14.1.1 Commerce and Public Services		2					2				263	82	346
14.1.2 Residential		1					1				1,094	110	1,205
14.2 Agriculture		0			0							3	3
15. Non-energy Use		2						2					2
16. Electricity Output in GWh									15,821		6		15,827

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2014 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	491								1,340	0	1,599		3,430
2. Imports		817	164	46	592	9	4	2				134	951
3. Exports	-127											-1,027	-1,153
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-42		-42									-42
5. Stock Changes													
6. Total Primary Energy Supply	364	774	164	3	592	9	4	2	1,340	0	1,599	-892	3,186
8. Total Transformation Sector									-1,340	0	-169	1,340	-169
8.1 Main Activity Producer									-1,340	0	-2	1,340	-2
8.8 Charcoal Processing											-167		-167
9. Loss and Own Use												-122	-122
10. Discrepancy	0	-3	-2	0		0	-1			0	0	0	-3
11. Total Final Energy Consumption	364	772	162	3	592	9	4	2			1,430	326	2,892
12. Industry Sector	364	38			30	9					57	134	594
13. Transport Sector		729	162	3	562			2					729
13.2 Domestic Air Transport		3		3									3
13.3 Road		726	162		562			2					726
14. Other Sector		4			0		4				1,373	192	1,569
14.1 Residential and Commercial		4					4				1,373	189	1,565
14.1.1 Commerce and Public Services		2					2				268	66	337
14.1.2 Residential		1					1				1,105	122	1,229
14.2 Agriculture		0			0							3	3
15. Non-energy Use		2						2					2
16. Electricity Output in GWh									15,582	0	5		15,587

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.

Lao PDR Energy Balance Table, 2015 (ktoe)

	1. Coal	4. Petroleum Product	4.1 Motor Gasoline	4.3 Jet Fuel	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	8. Geothermal, Solar, etc.	9. Others	10. Electricity	12 Total
1. Indigenous Production	1,801								1,232	0	1,619		4,652
2. Imports		971	180	44	729	10	4	2				176	1,147
3. Exports												-993	-993
4. International Marine Bunkers													
13.1 International Aviation Bunkers		-41		-41									-41
5. Stock Changes													
6. Total Primary Energy Supply	1,801	930	180	3	729	10	4	2	1,232	0	1,619	-817	4,765
8. Total Transformation Sector	-1,410								-1,232	0	-173	1,453	-1,362
8.1 Main Activity Producer	-1,410								-1,232	0	-2	1,453	-1,190
8.8 Charcoal Processing											-172		-172
9. Loss and Own Use												-272	-272
10. Discrepancy	0	-9	-8	0		0	-1			0	0	0	-9
11. Total Final Energy Consumption	392	920	172	3	729	10	4	2			1,446	165	3,122
12. Industry Sector	392	46			37	10					56	150	644
13. Transport Sector		870	172	3	692			2					870
13.2 Domestic Air Transport		3		3									3
13.3 Road		867	172		692			2					867
14. Other Sector		4			0		4				1,390	214	1,608
14.1 Residential and Commercial		4					4				1,390	212	1,605
14.1.1 Commerce and Public Services		2					2				274	74	351
14.1.2 Residential		1					1				1,116	137	1,254
14.2 Agriculture		0			0							3	3
15. Non-energy Use		2						2					2
16. Electricity Output in GWh	2,567								14,326	0	4		16,896

GWh = gigawatt-hour, LPG = liquefied petroleum gas.
Source: This Working Group's own data source using International Standard on Energy Balance Table Format, IEA, IEEJ, 2018.