Chapter 3

Data

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Chapter 3

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The energy demand projections of the Lao People's Democratic Republic (Lao PDR) up to 2040 were implemented applying the econometrics approach wherever possible. The energy demand projections up to 2040 applied historical correlations of final energy consumption and economic activity from 2000 to 2015. The historical data consisted of energy data, socioeconomic data, and energy price.

3.1 Energy Data

The historical energy demand data were taken from the Lao PDR Energy Balance Tables 2000–2015 (MEM, 2018). The Department of Energy Policy and Planning (DEPP), the Department of Planning and Cooperation, under the Ministry of Energy and Mines (MEM) compiled the national energy data. The primary energy sources of the Lao PDR consist of coal, oil, hydropower, and biomass. Oil products were imported to meet domestic requirements.

Table 3.1 shows the historical energy data of the Lao PDR from 2000 to 2015 and Table 3.2 shows the 2015 Energy Balance Table of the Lao PDR, which was used as the base year for this *Lao PDR Energy Outlook*.

In the case of the transport sector, the final energy consumption was broken down to domestic aviation and road transport. In road transport, the final consumption included the consumption of other petroleum products, which were actually the lubricants used in the vehicles.

Table 3.1 Lao PDR Energy Data, 2000–2015 (ktoe)

Sector	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Intl Aviation Bunkers	Jet Fuel	-40.50	-40.64	-40.77	-40.90	-41.03	-41.17	-41.30	-41.44	-41.57	-41.71	-41.85	-41.98	-42.12	-42.26	-42.39	-40.97
Total Final Energy Consumption	Anthracite	9.17	11.91	18.85	22.99	27.88	30.30	37.20	45.00	62.87	67.17	127.03	135.00	130.31	120.00	121.67	81.31
	Lignite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.39	20.87	28.28	57.43	77.90	225.27	242.52	310.46
	Motor Gasoline	77.39	77.37	82.42	84.88	90.80	95.74	103.72	117.47	122.82	137.34	144.62	152.29	160.37	166.11	162.08	172.02
	Jet Fuel	3.28	3.29	3.30	3.31	0.00	3.33	3.34	3.35	3.36	3.37	3.39	3.40	3.41	3.42	3.43	3.31
	Gas/Diesel Oil	184.20	210.96	212.62	219.65	225.78	232.76	322.30	328.01	392.75	462.69	462.69	473.07	516.64	552.45	591.63	729.25
	Fuel Oil	3.48	3.54	3.95	4.04	4.05	4.18	4.21	4.50	4.81	5.49	5.51	7.86	7.38	7.74	8.74	9.64
	LPG	1.78	1.78	1.85	1.85	1.87	1.89	2.05	2.06	2.16	2.25	2.32	2.87	2.97	3.13	3.53	3.78
	OOP	0.22	0.23	0.30	0.33	0.37	0.42	0.52	0.63	0.63	0.93	1.30	1.48	1.68	1.91	2.17	2.47
	Biomass	1103.48	1129.96	1157.08	1184.85	1213.29	1242.41	1272.22	1374.50	1474.68	1424.60	1385.93	1347.26	1292.44	1282.44	1292.71	1304.03
	Charcoal	70.69	72.32	73.98	75.68	77.42	79.20	81.02	89.96	106.18	126.30	128.22	130.14	132.00	133.50	137.50	141.50
	Electricity	55.03	61.09	65.94	76.00	77.64	86.95	120.92	138.96	164.75	194.16	209.90	219.79	264.45	290.76	326.09	364.52
	Total	1508.72	1572.43	1620.28	1673.59	1719.10	1777.18	1947.51	2104.44	2342.41	2445.18	2499.20	2530.58	2589.55	2786.73	2892.08	3122.30
Industry Sector	Anthracite	9.17	11.91	18.85	22.99	27.88	30.30	37.20	45.00	62.87	67.17	127.03	135.00	130.31	120.00	121.67	81.31
	Lignite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.39	20.87	28.28	57.43	77.90	225.27	242.52	310.46
	Gas/Diesel Oil	10.79	7.56	7.89	4.15	4.52	3.33	79.11	63.93	79.00	93.12	87.95	95.08	78.13	93.80	29.60	36.55
	Fuel Oil	3.48	3.54	3.95	4.04	4.05	4.18	4.21	4.50	4.81	5.49	5.51	7.86	7.38	7.74	8.74	9.64
	Biomass	47.16	48.29	49.45	50.63	51.85	53.09	54.37	58.74	63.02	60.88	59.23	57.58	39.84	59.44	57.01	55.73
	Charcoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Electricity	11.59	11.60	14.10	17.49	18.80	20.34	47.25	53.85	60.48	65.38	60.80	63.67	75.91	96.17	134.47	150.10
	Total	82.21	82.90	94.24	99.31	107.10	111.25	222.14	226.02	277.56	312.91	368.81	416.63	409.46	602.42	594.01	643.79
Transport Sector	Motor Gasoline	77.39	77.37	82.42	84.88	90.80	95.74	103.72	117.47	122.82	137.34	144.62	152.29	160.37	166.11	162.08	172.02
	Jet Fuel	3.28	3.29	3.30	3.31	0.00	3.33	3.34	3.35	3.36	3.37	3.39	3.40	3.41	3.42	3.43	3.31
	Gas/Diesel Oil	173.11	203.12	204.45	215.23	220.99	229.15	242.91	263.80	313.47	369.30	374.47	377.70	438.24	458.37	561.76	692.43
	OOP	0.22	0.23	0.30	0.33	0.37	0.42	0.52	0.63	0.63	0.93	1.30	1.48	1.68	1.91	2.17	2.47
	Total	254.00	284.00	290.46	303.75	312.16	328.65	350.49	385.25	440.29	510.94	523.77	534.87	603.70	629.81	729.44	870.23
Other Sector	Gas/Diesel Oil	0.29	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
	LPG	1.78	1.78	1.85	1.85	1.87	1.89	2.05	2.06	2.16	2.25	2.32	2.87	2.97	3.13	3.53	3.78
	Others	1127.01	1153.99	1181.61	1209.90	1238.86	1268.51	1298.88	1405.72	1517.84	1490.02	1454.92	1419.82	1384.60	1356.50	1373.20	1389.80
	Biomass	1056.32	1081.67	1107.63	1134.22	1161.44	1189.31	1217.86	1315.76	1411.66	1363.72	1326.70	1289.68	1252.60	1223.00	1235.70	1248.30
	Charcoal	70.69	72.32	73.98	75.68	77.42	79.20	81.02	89.96	106.18	126.30	128.22	130.14	132.00	133.50	137.50	141.50
	Electricity	43.43	49.49	51.84	58.51	58.83	66.61	73.67	85.10	104.27	128.78	149.10	156.12	188.54	194.60	191.61	214.42
	Total	1172.52	1205.53	1235.57	1270.53	1299.85	1337.29	1374.88	1493.16	1624.56	1621.33	1606.62	1579.09	1576.39	1554.50	1568.62	1608.28

Note: ktoe = kilotons of oil equivalent, Intl= international, LPG = liquefied petroleum gas, OOP = other petroleum product.
Source: Ministry of Energy and Mines (MEM), (2018), *Lao PDR Energy Statistics 2018*.

Table 3.2 Lao PDR Energy Balance Table, 2015 (ktoe)

		1. Coal	4. Petroleum Products	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 & Own Use												-272	-272
10.	Discrepancy	0	-9	-8	0		0	-1			0	0	0	-9
11.	Total Final Energy Consumptions	392	920	172	3	729	10	4	2			1.446	365	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 & 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.	of which Non-Energy Use		2						2					2
16	Electricity Output in GWh	2.567								14.326	0	4		16.896

Note: GWh = gigawatt hour, ktoe = kilotons of oil equivalent, LPG = liquefied petroleum gas.

Source: Ministry of Energy and Mines (MEM), (2018), *Lao PDR Energy Statistics 2018*.

In estimating the aviation fuel demand function, the aviation fuel consumption is defined as the domestic demand and international aviation bunkers (aviation fuel for international flights). The international aviation bunkers in the Energy Balance Table was reported as part of the total primary energy supply (TPES) and the absolute value was used in the summation.

The 'Others' sector consumption of the Lao PDR is the commercial/services sector, residential, and agriculture sectors. The demand function was estimated for the fuels consumed in each of the subsectors of Others.

3.2 Macroeconomic Data

The economic indicators used in energy modelling were taken from the World Development Indicators database of the World Bank (World Bank, 2018). These data were gross domestic product (GDP), major sectors gross value-added (GVA), GDP deflator, consumer price index (CPI), official exchange rate, total population, urban and rural population, and population in the largest city (Table 3.3).

There were other economic indicators used in the estimation of the final energy demand equation, but these data were obtained from national statistics as described in the national data section.

3.3 International Crude Oil Price

The international crude oil price in the Lao PDR outlook model used the imported price of Japan cost, insurance, and freight (CIF) as representing the world crude oil price. The data were based on ERIA's activities on Energy Outlook and Saving Potential provided by the Institute of Energy and Economics, Japan (IEEJ). Figure 3.1 shows the CIF crude oil price from 2000 to 2015.

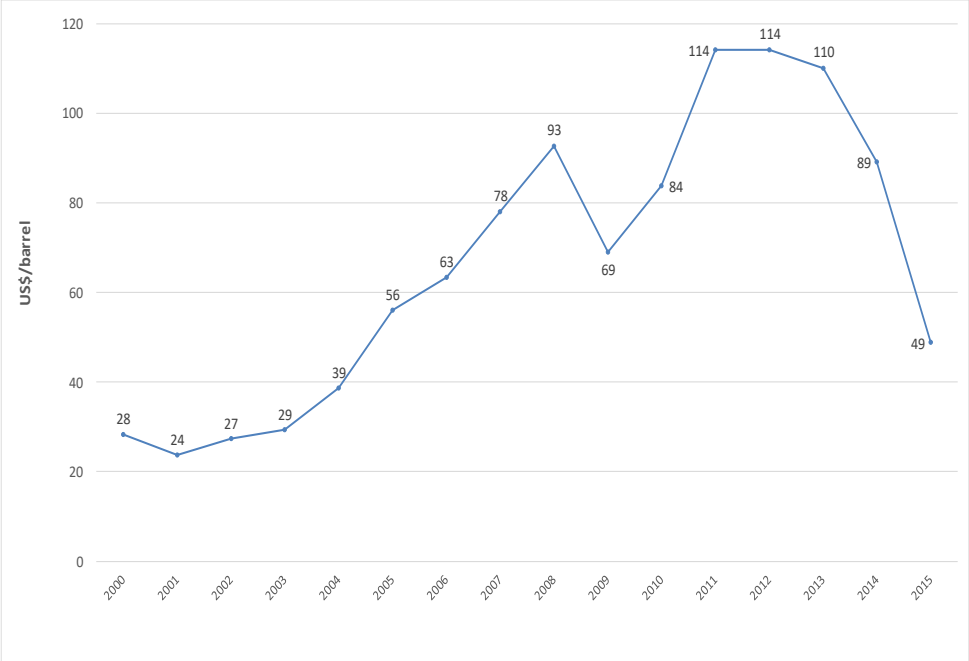
Table 3.3 World Development Indicators, 2000–2015

Series Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Agriculture, value added (constant 2010 US$)	1.49E+09	1.55E+09	1.61E+09	1.65E+09	1.70E+09	1.73E+09	1.80E+09	1.93E+09	2.00E+09	2.06E+09	2.11E+09	2.13E+09	2.18E+09	2.25E+09	2.34E+09	2.42E+09
Agriculture, value added (constant LCU)	1.03E+13	1.07E+13	1.11E+13	1.14E+13	1.18E+13	1.20E+13	1.25E+13	1.34E+13	1.39E+13	1.43E+13	1.47E+13	1.47E+13	1.51E+13	1.56E+13	1.62E+13	1.68E+13
Consumer price index (2010 = 100)	48.14	51.90	57.42	66.32	73.26	78.50	83.84	87.64	94.32	94.36	100.00	107.58	112.16	119.30	124.23	125.81
GDP (constant 2010 US$)	3.58E+09	3.79E+09	4.01E+09	4.26E+09	4.53E+09	4.85E+09	5.27E+09	5.67E+09	6.11E+09	6.57E+09	7.13E+09	7.70E+09	8.32E+09	8.99E+09	9.67E+09	1.04E+10
GDP (constant LCU)	3.51E+13	3.72E+13	3.94E+13	4.18E+13	4.44E+13	4.76E+13	5.17E+13	5.56E+13	5.99E+13	6.44E+13	6.99E+13	7.55E+13	8.16E+13	8.82E+13	9.49E+13	1.02E+14
GDP deflator (base year varies by country)	38.81	42.25	44.92	50.96	56.41	61.28	67.91	72.96	79.42	77.10	84.19	87.81	100.00	106.47	112.57	115.21
Industry, value added (constant 2010 US$)	6.38E+08	7.02E+08	7.73E+08	9.15E+08	9.84E+08	1.11E+09	1.30E+09	1.41E+09	1.59E+09	1.82E+09	2.17E+09	2.53E+09	2.86E+09	3.08E+09	3.30E+09	3.54E+09
Industry, value added (constant LCU)	5.90E+12	6.50E+12	7.16E+12	8.47E+12	9.11E+12	1.03E+13	1.21E+13	1.30E+13	1.47E+13	1.68E+13	2.01E+13	2.34E+13	2.65E+13	2.85E+13	3.06E+13	3.27E+13
Manufacturing, value added (constant 2010 US$)	1.93E+08	2.16E+08	2.44E+08	2.58E+08	2.97E+08	3.27E+08	3.72E+08	4.23E+08	4.61E+08	4.88E+08	5.06E+08	5.59E+08	6.14E+08	6.36E+08	6.98E+08	7.29E+08
Manufacturing, value added (constant LCU)	2.30E+12	2.58E+12	2.91E+12	3.08E+12	3.54E+12	3.91E+12	4.44E+12	5.04E+12	5.51E+12	5.83E+12	6.04E+12	6.67E+12	7.33E+12	7.59E+12	8.33E+12	8.70E+12
Official exchange rate (LCU per US$, period average)	7887.64	8954.58	10056.33	10569.04	10585.38	10655.17	10159.94	9603.16	8744.22	8516.05	8258.77	8030.06	8007.76	7860.14	8048.96	8147.91
Population in largest city	4.42E+05	4.67E+05	4.93E+05	5.20E+05	5.50E+05	5.80E+05	6.13E+05	6.47E+05	6.83E+05	7.21E+05	7.61E+05	8.04E+05	8.48E+05	8.96E+05	9.46E+05	9.97E+05
Population, total	5.33E+06	5.41E+06	5.50E+06	5.58E+06	5.66E+06	5.75E+06	5.85E+06	5.95E+06	6.05E+06	6.15E+06	6.25E+06	6.33E+06	6.42E+06	6.49E+06	6.58E+06	6.66E+06
Rural population	4.16E+06	4.17E+06	4.18E+06	4.18E+06	4.18E+06	4.18E+06	4.18E+06	4.18E+06	4.19E+06	4.18E+06	4.18E+06	4.16E+06	4.15E+06	4.13E+06	4.11E+06	4.09E+06
Services, etc., value added (constant 2010 US$)	1.23E+09	1.30E+09	1.38E+09	1.43E+09	1.56E+09	1.72E+09	1.85E+09	1.99E+09	2.16E+09	2.31E+09	2.44E+09	2.62E+09	2.82E+09	3.10E+09	3.35E+09	3.62E+09
Services, etc., value added (constant LCU)	1.43E+13	1.51E+13	1.60E+13	1.66E+13	1.81E+13	1.99E+13	2.14E+13	2.31E+13	2.51E+13	2.68E+13	2.83E+13	3.04E+13	3.28E+13	3.60E+13	3.89E+13	4.20E+13
Urban population	1.17E+06	1.24E+06	1.32E+06	1.40E+06	1.49E+06	1.58E+06	1.67E+06	1.77E+06	1.87E+06	1.97E+06	2.07E+06	2.17E+06	2.27E+06	2.37E+06	2.47E+06	2.57E+06

GDP = gross domestic product, LCU = local currency unit.

Source: World Bank, World Development Indicators. https://data.worldbank.org/country/lao-pdr?view=chart (accessed 16 June 2018).

Figure 3.1 Nominal Crude Oil Price (CIF Japan)



CIF = cost, insurance, and freight.

Source: ERIA (2018), *Energy Outlook and Energy Saving Potential 2018.*

3.4 National Data

In principle, national data should be used in estimating energy demand formulas. The World Bank's World Development Indicators data for the Lao PDR exclude the local energy price and other activity data that were relevant for estimating energy demand equations.

Local energy price

The Lao PDR local energy price included petroleum products (gasoline, diesel, LPG, etc.), electricity price, coal, and electricity. Import CIF, CPI, and sales price were the basis in determining the domestic energy price. As explained in the previous section on methodology, these local energy prices should be the relative price not the absolute price.

$$Energy\ Demand\ (De) = f(Y, \mathbf{Pe/PGDP}, De_{-1})$$

Where:

Y: Income (GDP, etc.)

Pe: Energy price (Oil price, etc.)

PGDP: GDP` deflator (Overall price, CPI, etc.)

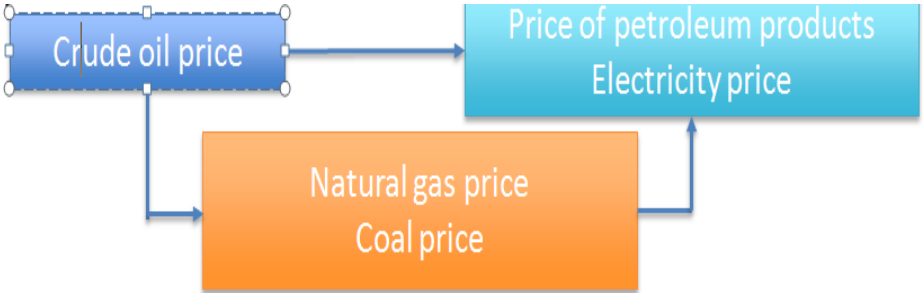
Pe/PGDP: Relative variable

De: Energy demand (Coal, oil, gas, and electricity)

De_{-1}: Lag variable (show habit)

The international energy price can be used to explain the local energy price if the data are not available. Thus, the local energy price will be a function of the international energy price.

Figure 3.2 Estimating Local Energy Price



Source: Prepared by author.

Examples:

Motor gasoline price	:	MGprice = f(Poil/exr/pgdp, MGprice(-1))
Electricity price	:	Eprice = f(NGprice, Eprice(-1))
Natural gas price	:	NGprice = f(Poil/exr/pgdp, NGprice(-1))
Poil	:	Crude oil price (US$/barrel, nominal)
Exr	:	Exchange rate
Pgdp	:	GDP deflator

In the Lao PDR, electricity generation is mostly from hydropower resources. Thus, the local electricity price should not be explained by the international crude oil or coal price. The DEPP was able to obtain the local electricity price by the different consumer tariff groups, which were services, households, industry, and 'Others' sectors (Table 3.4).

Table 3.4 Electricity Price (KN/MWh)

Year	Households	Services	Industry	Other Sectors
2000	109,370	384,900	217,560	85,700
2001	170,390	450,580	332,780	159,350
2002	204,790	635,990	378,490	188,770
2003	252,420	783,140	480,650	221,390
2004	352,350	876,190	587,550	279,220
2005	371,160	882,040	590,140	289,030
2006	425,410	877,510	586,280	283,270
2007	406,950	874,260	567,560	248,010
2008	415,960	860,600	565,200	236,560
2009	469,920	845,160	546,540	251,500
2010	480,240	848,090	544,740	364,070
2011	492,010	844,630	527,850	390,820
2012	561,130	933,110	577,410	411,340
2013	607,940	939,780	647,840	464,780
2014	624,270	1,004,150	674,990	482,000
2015	650,510	1,109,190	687,490	492,940

KN = kip, MWh = megawatt hour.
Source: Department of Energy Policy and Planning.

Local activity data

The local activity data that were commonly used in estimating the energy demand function of the final sectors were:

- Industry sector: Index of Industrial Production (IIP)
- Road sector: Number of vehicles
- Residential sector: Number of households
- Commercial sector: Number of buildings, floor area

These local activity data were usually explained by macro variables such as GDP. Examples:

Index of Industrial Production : IIP = f(Industrial GDP, IIP(-1))

Number of cars : Ncar = f(GDP, Ncar(-1))

Floor area : Floor = f(commercial GDP, floor(-1))

Number of Households : NHH = f(Population, NHH(-1))

The local activity data collected by DEPP for estimating the demand function for road transport was the number of vehicles (Table 3.5)

Table 3.5 Vehicle Statistics of the Lao PDR, 2000–2015

	Motorcycle	Tuk-Tuk	Sedan	Pickup	Van	SUV	Truck	Bus	TOTAL
2000	153.781	4.347	8.995	15.074	2.199	3.970	10.559	1.831	200.756
2001	168.379	4.405	9.428	17.581	2.603	4.355	11.841	1.899	220.491
2002	196.963	4.405	9.696	19.042	3.691	4.584	13.085	2.042	253.508
2003	195.353	6.407	8.045	25.490	2.729	5.832	8.424	2.164	254.444
2004	285.740	7.871	10.063	36.421	3.777	6.949	11.346	3.972	366.139
2005	337.719	8.043	11.204	42.994	4.862	7.909	13.441	4.234	430.406
2006	453.158	8.441	12.939	59.519	7.236	8.668	15.296	3.033	568.290
2007	509.421	8.518	14.792	68.360	9.355	10.399	17.994	2.242	641.081
2008	623.310	8.460	15.203	77.616	12.675	9.752	19.070	2.520	768.606
2009	711.800	8.624	17.671	93.080	18.634	10.801	23.031	2.707	886.348
2010	804.087	8.542	21.638	109.362	24.727	12.155	25.452	2.825	1.008.788
2011	899.436	8.537	27.901	127.913	22.156	24.052	28.673	3.190	1.141.858
2012	950.238	8.545	31.673	137.723	32.228	15.336	30.799	3.337	1.209.879
2013	1.112.072	8.601	43.860	162.633	50.124	19.876	38.454	3.861	1.439.481
2014	1.218.379	8.737	51.284	185.086	42.770	22.515	44.293	4.120	1.577.184
2015	1.280.673	8.761	51.540	204.360	46.293	24.665	46.654	4.448	1.667.394

Source: Department of Energy Policy and Planning.

References

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