



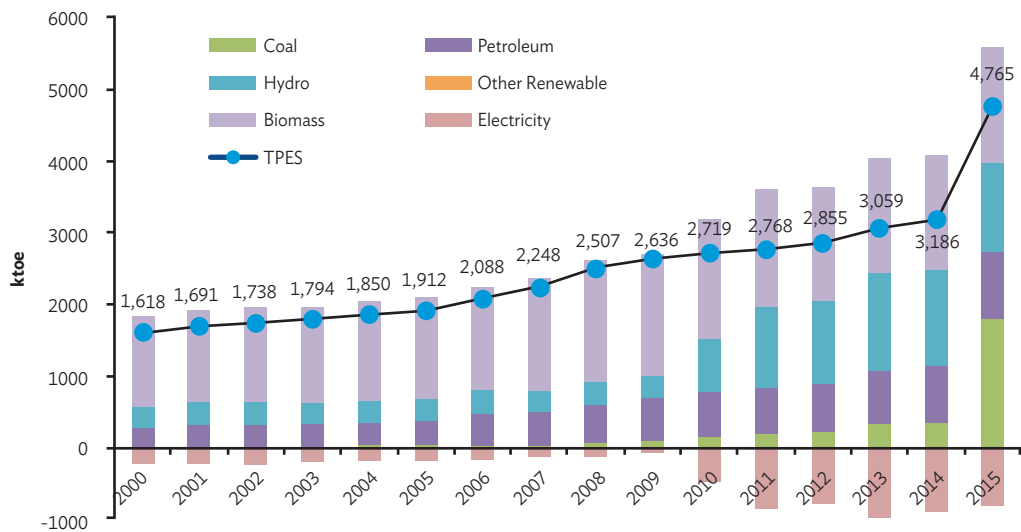
Chapter 4

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.

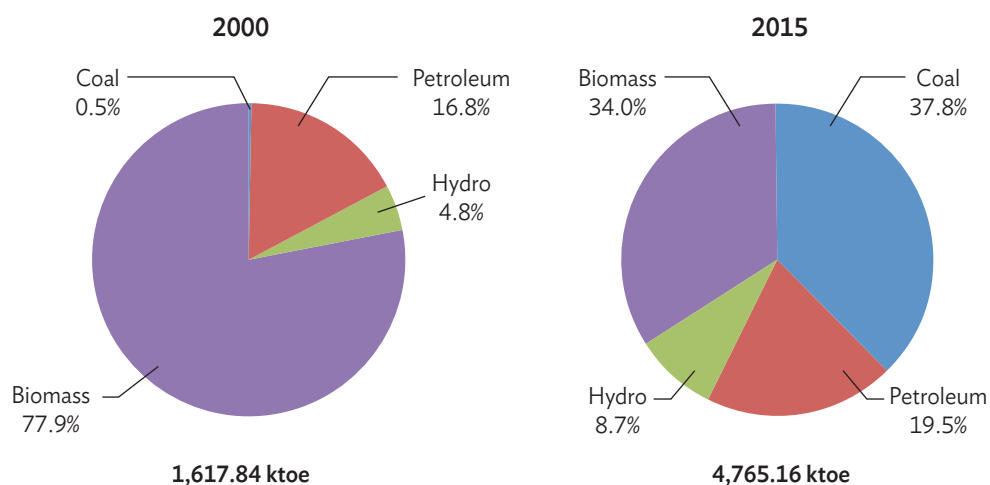
The second-highest growth during the period was hydro at 9.8% per year. Hydro is the major energy source for electricity production in the Lao PDR. Petroleum supply also increased rapidly at an average of 8.5% a year. Since the power sector does not use oil products, most of the increased demand came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

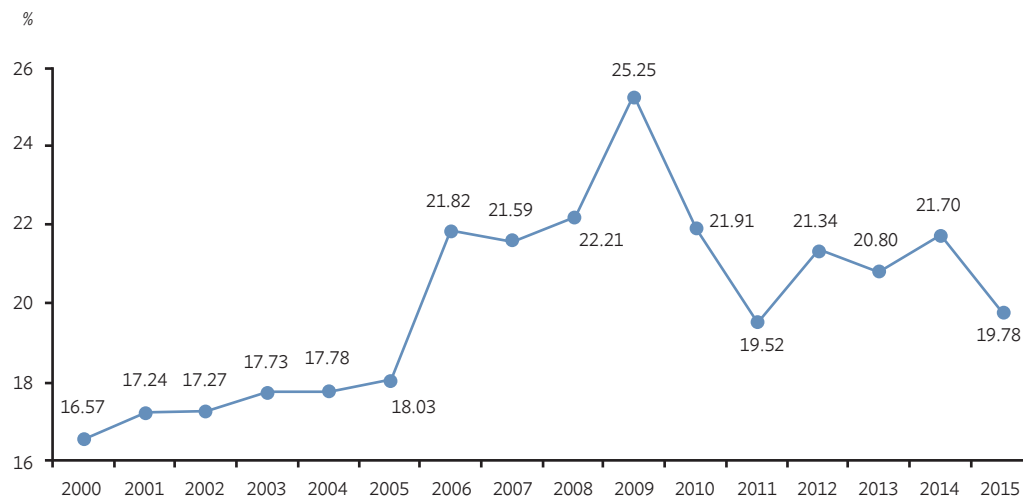
Year	Indigenous Production					Imports			Dependence on Imported Energy
	Indigenous	Hydro	Biomass	Coal	Other Renewables	Petroleum	Electricity		
2000	1,649.99	301.74	1,260.02	88.24	0.00	327.60	312.10	15.49	16.57
2001	1,706.51	320.63	1,290.10	95.78	0.00	355.49	339.69	15.81	17.24
2002	1,742.42	316.28	1,320.91	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
2004	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

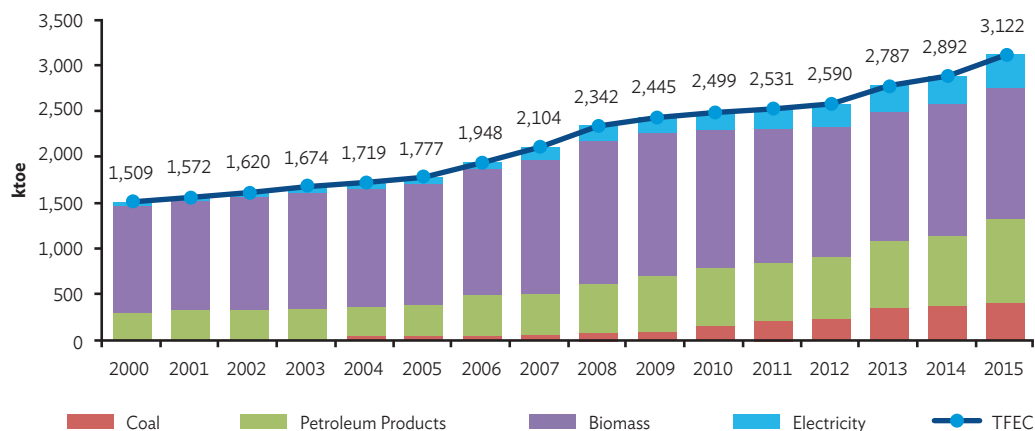


Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

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

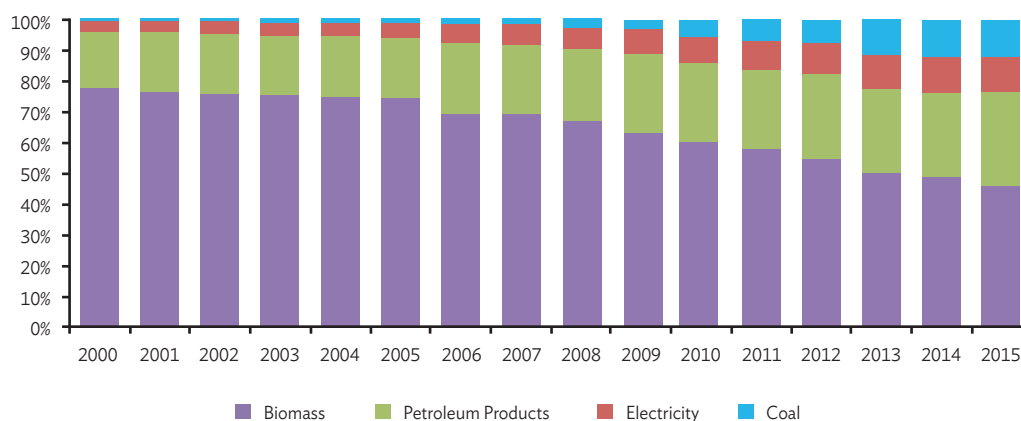


ktOE = thousand ton of oil equivalent, TFEC = total final energy consumption.

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								Non-energy Use
		Industry	Transport	Other	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.

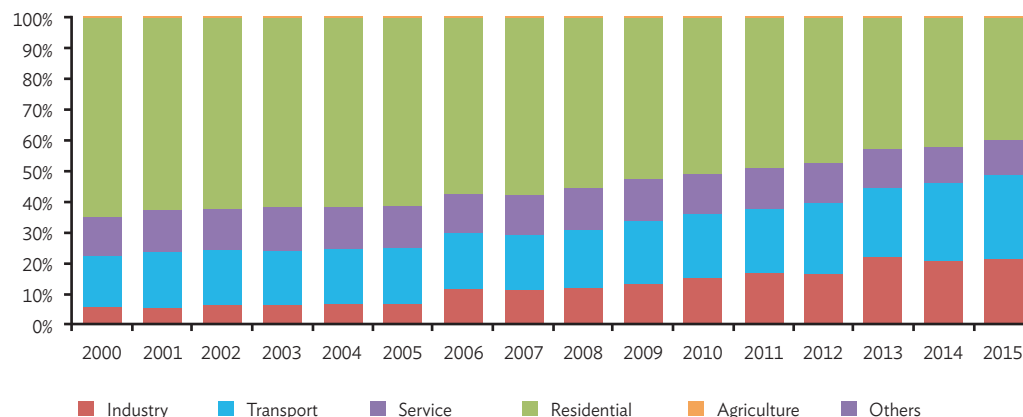
Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

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)

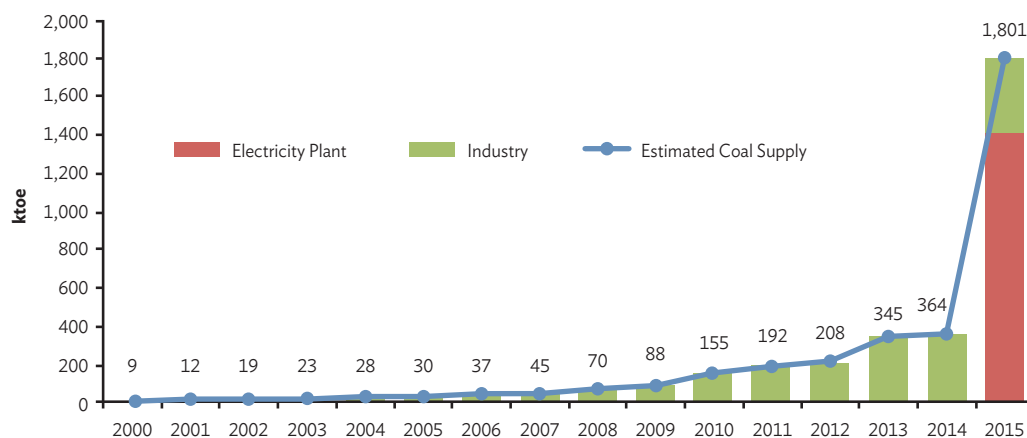
Year	Estimated Coal Supply	Coal Consumption		
		Electricity Plant	Industry	
2000	9.17	0.00	9.17	
2001	11.91	0.00	11.91	
2002	18.85	0.00	18.85	
2003	22.99	0.00	22.99	
2004	27.88	0.00	27.88	
2005	30.30	0.00	30.30	
2006	37.20	0.00	37.20	
2007	45.00	0.00	45.00	
2008	70.25	0.00	70.25	
2009	88.04	0.00	88.04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

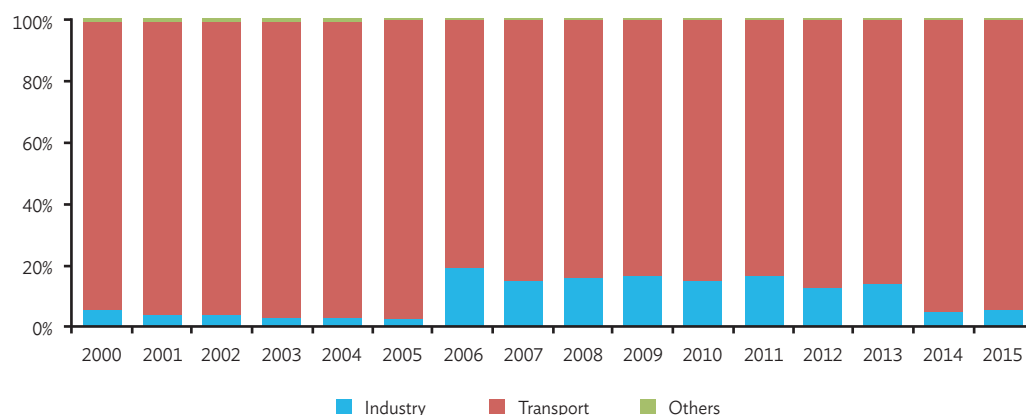
Source: Economic Research Institute for ASEAN and East Asia, calculated from the 2000–2015 Lao PDR EBT.

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.

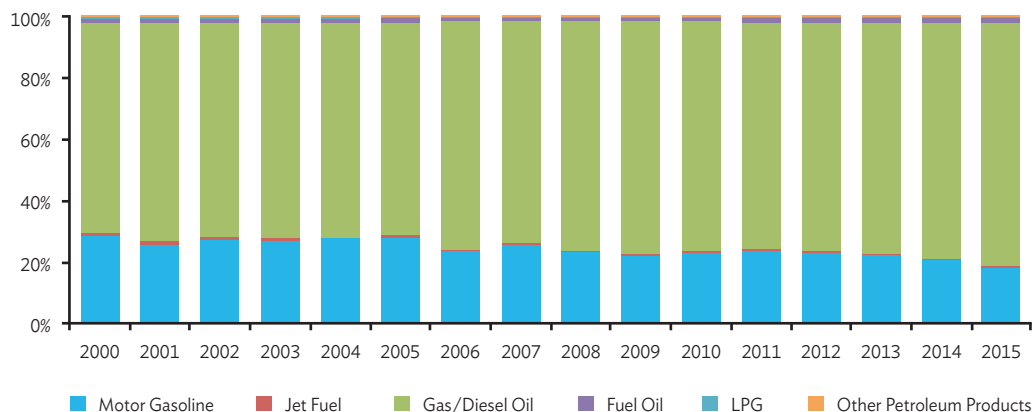
LPG's share in the consumption of total petroleum products was less than 1% since LPG is consumed only for cooking in the residential and service sectors (restaurants, cafeterias, and the like). Although the share of LPG was small, consumption showed an increasing trend over the 2010–2015 period, i.e. 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



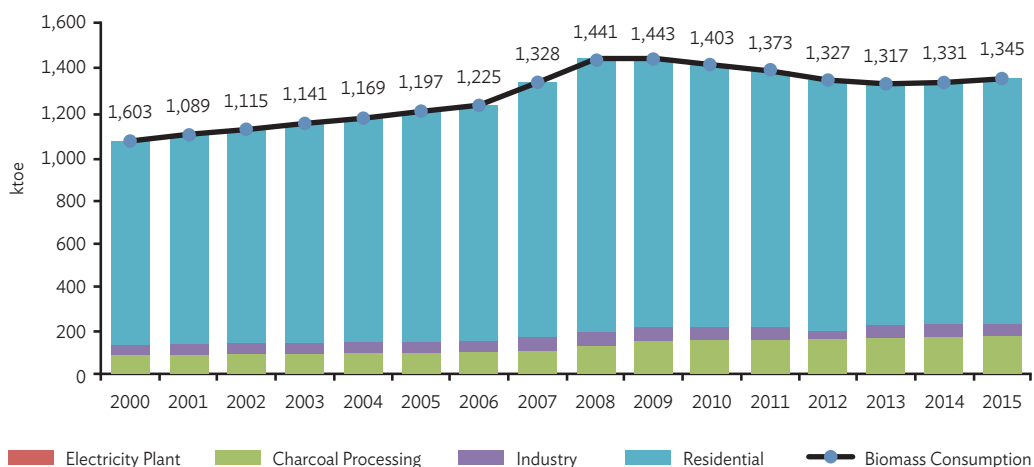
LPG = liquefied petroleum gas.

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)	Estimated Own Use	Gross Production					Export	Import
				Hydro	Coal	Wood and Biomass	Others			
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	Sector				Estimated Distribution Loss	Electricity Supply
		Industry	Service	Residential	Other		
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

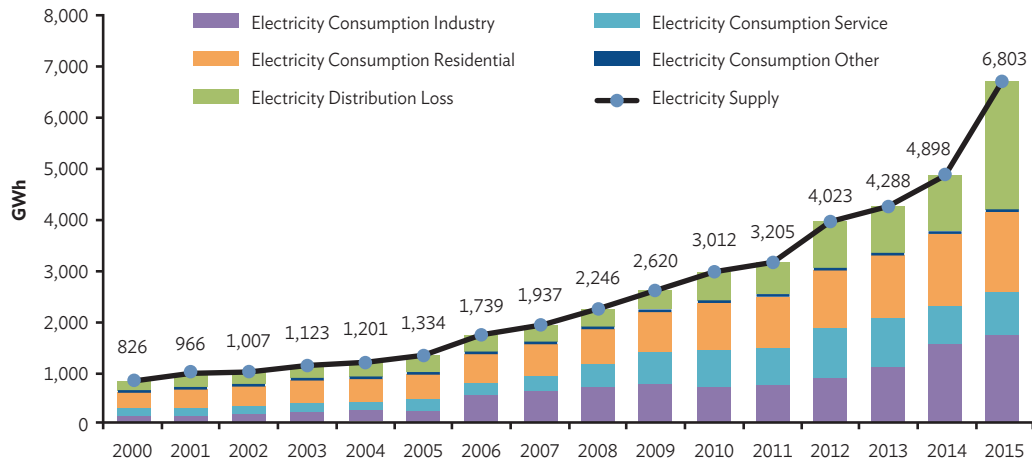
AAGR = average annual growth rate, GWh = gigawatt-hour.

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 (CO₂)/GDP and CO₂/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 (Trudeau, 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

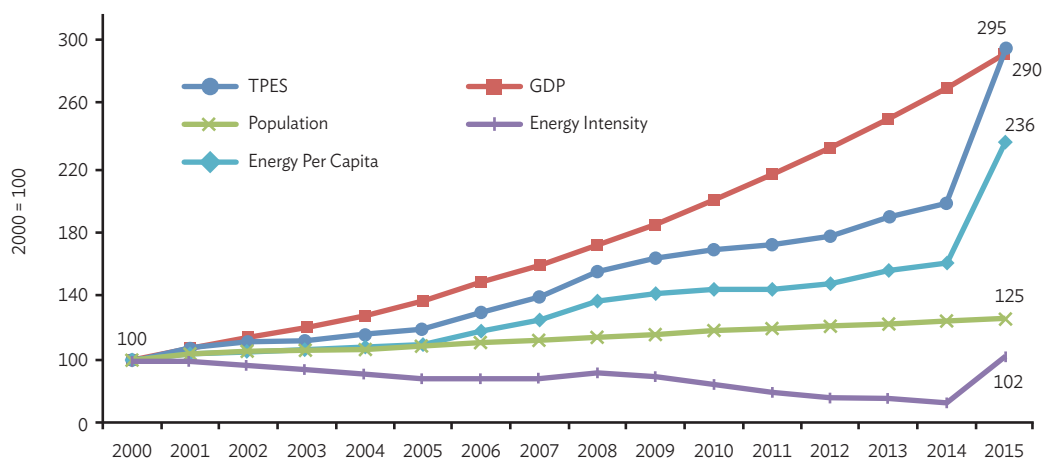
AAGR = average annual growth rate, GDP = gross domestic product, ktoe = thousand ton of oil equivalent, PPP = purchasing power parity, TPES = total primary energy supply.

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:

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

The production effect is estimated as:

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

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

$$\begin{aligned} \Delta TPES = & \Delta(TPES/GDP) * GDP + \textit{Intensity Effect} \\ & (TPES/GDP) * \Delta GDP + \textit{Production Effect} \\ & \textit{Cross-over Term} \end{aligned}$$

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

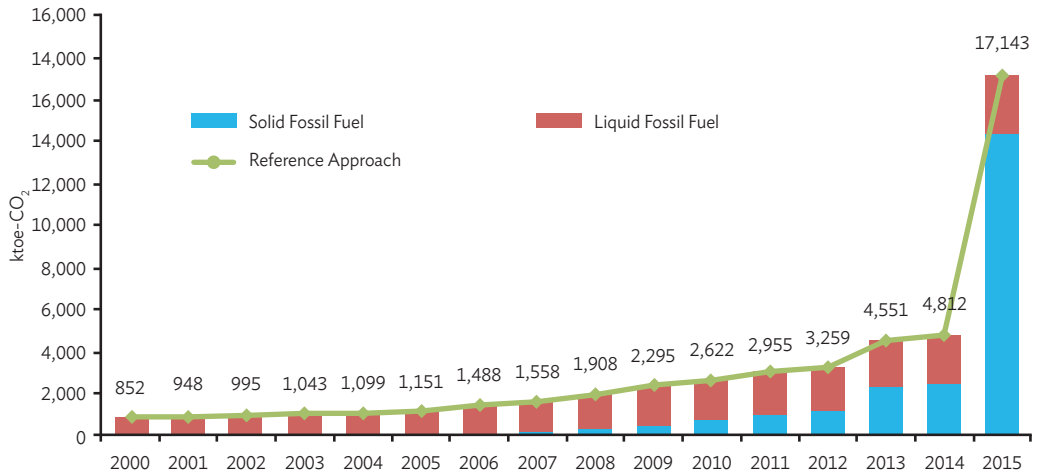
Energy and CO₂ Emissions

CO₂ 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 CO₂ emissions from all fuel combustion and some fugitive emissions. The sectoral approach provides estimates of CO₂ 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 CO₂ (Simmons, n.d.).

The reference approach was used to estimate the CO₂ emission of the Lao PDR based on its 2000–2015 EBT. The result of the calculation showed that CO₂ emission increased in 2000–2015 at an average rate of 22.1% per year. The major sources of CO₂ emission from fuel combustion were solid fossil fuel (coal) and liquid fossil fuel (oil). The CO₂ 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 CO₂ emission came from burning oil at that time (Figure 4.14).

Figure 4.14. CO₂ Emissions from Fuel Combustion by Sector



CO₂ = carbon dioxide, kt = 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 CO₂ emission from oil combustion was 814 kiloton (kt)-CO₂ in 2000.

By 2015, CO₂ emission from oil increased to 2,813 kt-CO₂ as the number of vehicles continued to increase and as the residential sector shifted to biomass. Emission of CO₂ 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 CO₂ emission indicators. The CO₂ intensity measures the impact of an increase in GDP or TPES to the absolute emission of CO₂. The intensities (CO₂/GDP and CO₂/TPES) increased from 2000 to 2015 but at a different average annual growth rate. For the CO₂/GDP intensity, the increase was 9.8% per year, from 68 kt CO₂/thousand PPP \$ to 278 ton CO₂/thousand PPP \$. The CO₂/TPES intensity increased at a slower rate of 9.7% per year, from 527 ton CO₂/toe in 2000 to 2,112 ton CO₂/toe in 2015.

Table 4.10. Energy and CO₂ Emission Indicators

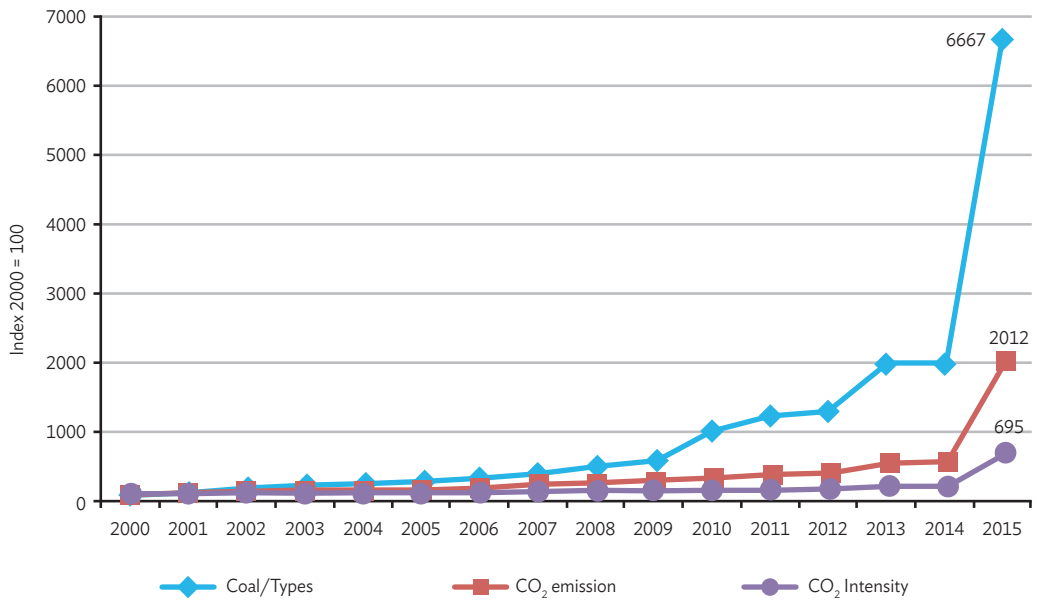
Year	Total Primary Energy Supply	GDP	CO ₂ Emissions	CO ₂ /GDP	CO ₂ /TPES
	ktoe	10 ⁶ US\$ in PPP	kt CO ₂	ton CO ₂ /thousand \$ PPP	ton CO ₂ /toe
2000	1,617.84	12,504.87	852.00	0.07	0.53
2001	1,690.56	13,224.08	948.15	0.07	0.56
2002	1,738.23	14,006.78	995.32	0.07	0.57
2003	1,793.57	14,856.57	1,043.44	0.07	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, CO₂ = 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 CO₂ 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 CO₂ emission of the country sharply increased in 2015. The relationship between changes of coal share in the TPES, CO₂ emission, and CO₂ intensity (CO₂/GDP) is shown in Figure 4.15. The index (2000=100) is used to describe these relationships.

Figure 4.15. Coal Share in TPES, CO₂ Emissions, and CO₂ Intensity



CO₂ = carbon dioxide, TPES = total primary energy supply.

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