Chapter 4
Analysis of Energy Demand–Supply Situation in Myanmar

Primary Energy Supply

The total primary energy supply (TPES) of Myanmar increased from 10,353 kilo tons of oil equivalent (ktoe) in 2000 to 14,484 ktoe in 2016 at an average annual growth rate (AAGR) of 3.7% (Figure 4.1). Coal had the highest growth over the 2000–2016 period, at an average rate of 12.8% per year. This rapid increase in coal supply was to meet the increasing demand of the industries.

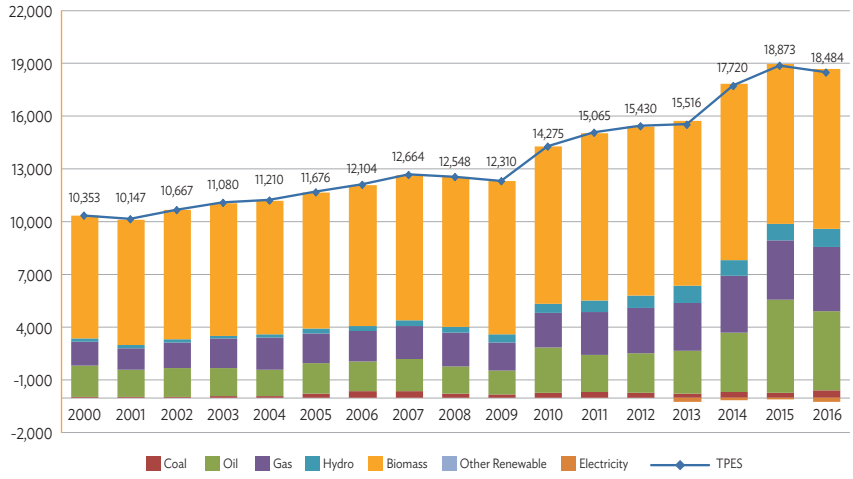
Hydro growth was slightly slower than coal, at an average rate of 12.3% per year. Hydro supply plays a major role in providing the electricity needed to meet the increasing domestic demand as more houses are being electrified and more commercial buildings are constructed. Moreover, electricity from hydro is also exported.

Oil supply also increased rapidly at an average rate of 6% a year as demand from the transport sector, particularly the road subsector, increased. Natural gas supply was lower than oil supply but grew faster at an average rate of 6.4% per year. This high growth contributed mainly to the increase in power sector consumption.Myanmar started to export its electricity generated from hydropower to neighbouring countries in 2013. The net electricity export of Myanmar in the TPES was -218 ktoe in 2013 and -205 ktoe in 2016.

Biomass experienced the slowest growth in 2000–2016. Its share in the TPES, although declining, was the largest. In 2000, the share of biomass was 67% whilst, in 2016, the share declined to 49%. The slower growth of biomass supply indicated that there was a substitution in the use of biomass for cooking in the residential sector.

Oil share in the TPES of 2000 was the second largest (17%), followed by gas (13%), hydro (2%), and coal (1%). Since hydro grew very rapidly, by 2016, its share in the total TPES increased to 5%. Similarly, the share of the other energy sources also increased. The share of oil in 2016 increased to 24% whilst gas share increased to 20%. Coal share, on the other hand, increased by only 2% in 2016. Figure 4.2 shows the energy mix in the TPES of Myanmar for 2000 and 2016. Myanmar produced and imported its petroleum products to meet the increasing demand. Domestic production of petroleum products required imported crude (including natural gas liquid) only for 2000 to 2003.

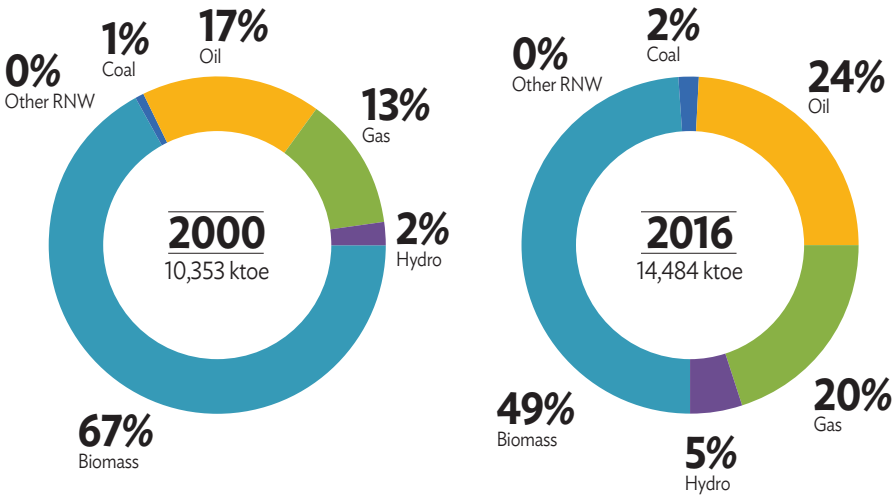
Figure 4.1. Total Primary Energy Supply



TPES = total primary energy supply.

Source: Author's calculation.

Figure 4.2. Energy Mix of the Total Primary Energy Supply



ktoe = kilo ton of oil equivalent, RNW = renewable.

Source: Author's calculation.

Afterwards, Myanmar refineries processed only domestic crude. Indigenous crude production of Myanmar grew at an average rate of 2.3% over 2000–2016. Imported crude and petroleum products (oil) increased faster at an average rate of 6.7% over the same period (Table 4.1).

Table 4.1. Indigenous Production and Imports of Energy (ktoe)

	Indigenous Production							Imports			Dependence on Imported Energy
		Coal	Oil	Gas	Hydro	Biomass	Other RNW		Coal	Oil	
2000	12,321	241	420	4,508	163	6,989	0	1,405	0	1,405	10.2
2001	15,387	286	597	7,180	173	7,151	0	1,137	0	1,137	6.9
2002	17,336	253	828	8,755	182	7,318	0	956	0	956	5.2
2003	18,214	418	941	9,138	178	7,540	0	676	0	676	3.6
2004	19,728	448	1,004	10,473	207	7,595	0	691	0	691	3.4
2005	20,361	534	1,072	10,758	258	7,740	0	830	0	830	3.9
2006	21,216	593	1,007	11,316	286	8,014	0	856	0	856	3.9
2007	21,806	504	1,023	11,718	311	8,250	0	945	0	945	4.2
2008	20,003	274	916	9,966	350	8,497	0	705	0	705	3.4
2009	21,052	209	879	10,804	452	8,709	0	502	0	502	2.3
2010	21,627	313	937	10,920	532	8,924	0	1,619	0	1,619	7.0
2011	22,771	309	849	11,426	649	9,537	0	1,559	21	1,537	6.4

2012	22,919	305	842	11,477	668	9,627	0	1,443	2	1,442	5.9
2013	23,288	235	854	11,853	973	9,372	0	1,926	16	1,910	7.6
2014	28,398	181	820	16,499	886	10,012	1	3,828	150	3,679	11.9
2015	27,960	159	673	17,110	915	9,101	1	4,826	114	4,712	14.7
2016	27,406	209	618	16,466	1,043	9,069	1	4,174	208	3,966	13.2
AAGR	**5.1**	**-0.9**	**2.4**	**8.4**	**12.3**	**1.6**		**7.0**		**6.7**	**1.6**

AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent, RNW = renewable.

Source: Author's calculation.

Besides petroleum products, Myanmar also imported coal but only for 2011, 2015, and 2016 to meet the needs of the domestic coal power plant. In the future, the Government of Myanmar will import liquefied natural gas (LNG) more for domestic requirements, including for power generation.

In addition to crude oil, Myanmar indigenous production also includes coal, gas, hydro, biomass, and other renewables (solar and wind). Compared with energy imports, Myanmar's total indigenous energy production grew more slowly at an average rate of 5.1% per year.

Biomass was the main energy source produced indigenously in 2000 with a 57% share in total indigenous production. Biomass production increased slightly from around 7,000 ktoe in 2000 to almost 9,070 ktoe in 2016, growing at an average rate of 1.6% per year. The slower growth of biomass production decreased the share to 33% in 2016.

Hydro share in the total indigenous production was the smallest in 2000 (1%). Hydro production, however, experienced rapid growth, at 12.3% per year, resulting in an increase of its share to 4% in 2016.

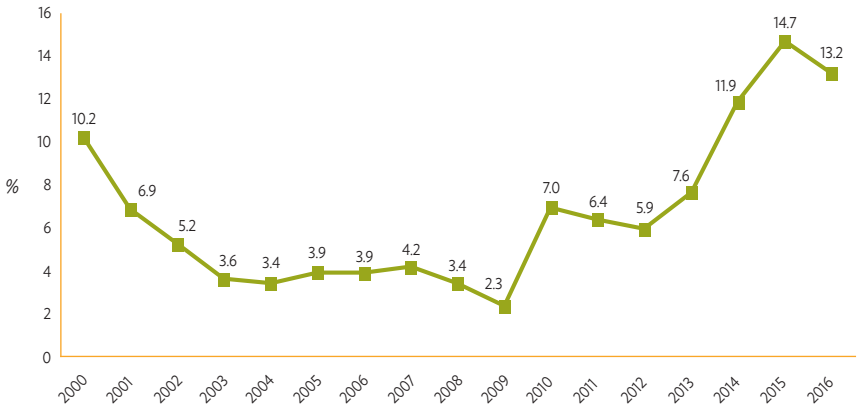
Myanmar exported gas to Thailand. The indigenous production of natural gas was the second largest in the total indigenous production of the country in 2000. Its production increased significantly at an average rate of 8.4% per year – from 4,500 ktoe in 2000 to almost 16,500 ktoe in 2016.

Coal production was only around 241 ktoe in 2000 and declined to 209 ktoe in 2016 at an average rate of minus 0.9% per year. As a result, coal production

share in the total indigenous production decreased from 2% in 2000 to 1% in 2016.

In 2011, Myanmar started to generate electricity from solar and wind energy although the amount is still very small (0.8 ktoe in 2016).Compared with its total supply (indigenous production plus import), the dependence of Myanmar on imported energy was about 10% in 2000 and 13% in 2016. In 2015, Myanmar's import dependence was highest at 15% (Figure 4.3).

Figure 4.3. Dependence on Imported Energy

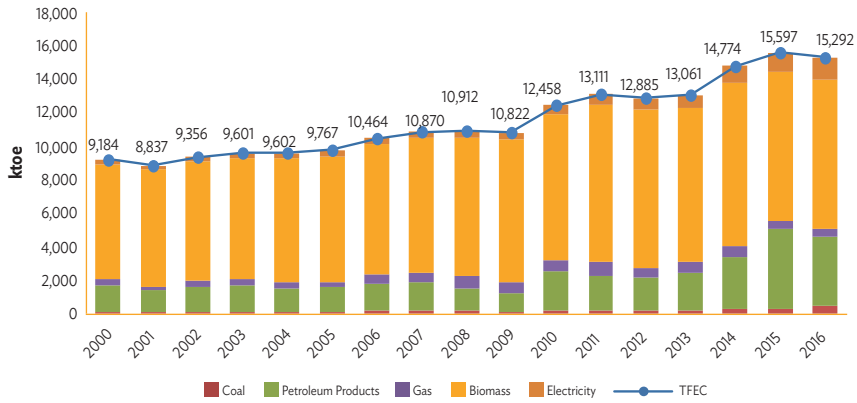


Source: Author's calculation.

Total Final Energy Consumption

The total final energy consumption (TFEC) of Myanmar increased at an AAGR of 3.2%, from around 9,200 ktoe in 2000 to almost 15,300 ktoe in 2016 (Figure 4.4). By type of fuel, coal grew the fastest over the period at 12.8% per year, followed by electricity at 10.2% per year. Petroleum product and biomass consumption, which are the most used types of fuel in Myanmar, grew at a slower rate than coal and electricity. The AAGR of petroleum product consumption was 6.2% whilst biomass consumption grew only by 1.7% per year over 2000–2016. Natural gas consumption grew the most slowly over the same period at an average rate of 0.5% per year.

Figure 4.4. Total Final Energy Consumption by Fuel

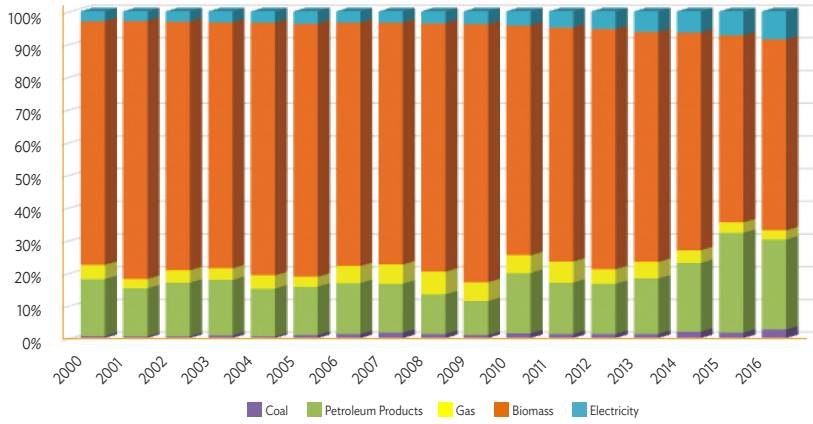


TFEC = total final energy consumption.

Source: Author's calculation.

Despite the high AAGR of consumption for 2000–2016, electricity share in the TFEC was only 9% in 2016. Coal share in the TFEC was the lowest in 2016 (3%). Petroleum products and biomass had a total share of more than 85% in 2000–2016 (Figure 4.5). Although the largest, biomass share in the TFEC decreased from 75% in 2000 to 58% in 2016. Natural gas share was 3% in 2016, slightly higher than coal.

Figure 4.5. Fuel Mix in Total Final Energy Consumption



Source: Author's calculation.

Table 4.2 shows Myanmar's TFEC from 2000 to 2016 by the final sectors. These are the industry, transport, and 'others' sectors covering residential, services (commercial), agriculture, and others. The non-energy use in Myanmar includes

bitumen, lubricant, and paraffin waxes, which the industry, transport, and other sectors, respectively, consumed.

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

Year	Consumption	Industry	Transport	Others				Of which Non-energy Use
					Service	Residential	Others	
2000	9,184	3,250	931	5,002	2,111	2,872	20	152
2001	8,837	2,998	763	5,076	2,151	2,914	11	92
2002	9,356	3,301	850	5,206	2,210	2,986	10	126
2003	9,601	3,321	977	5,302	2,250	3,043	10	121
2004	9,602	3,341	821	5,440	2,307	3,123	10	137
2005	9,767	3,405	803	5,558	2,353	3,195	10	93
2006	10,464	3,868	894	5,701	2,430	3,264	7	163
2007	10,870	4,096	894	5,880	2,508	3,366	6	183
2008	10,912	3,950	887	6,075	2,589	3,479	7	213
2009	10,822	3,761	783	6,278	2,673	3,598	7	161
2010	12,458	4,511	1,441	6,506	2,754	3,743	8	177
2011	13,111	4,664	1,388	7,060	2,933	4,118	9	307
2012	12,885	4,784	1,013	7,088	2,967	4,113	8	283
2013	13,061	4,958	1,060	7,044	2,863	4,135	46	324
2014	14,773	5,803	1,436	7,535	3,049	4,444	42	429
2015	15,597	6,366	2,059	7,172	2,864	4,268	41	426
2016	15,292	5,743	2,230	7,320	2,928	4,350	42	529
AAGR	**3.2**	**3.6**	**5.6**	**2.4**	**2.1**	**2.6**	**4.8**	**8.1**

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

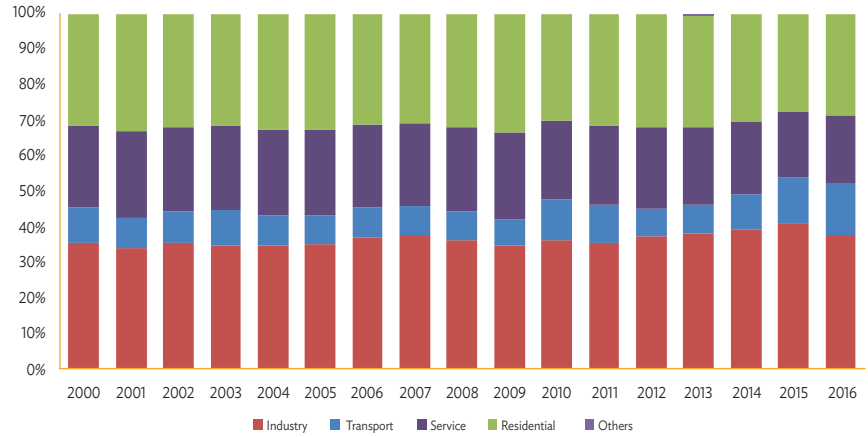
Source: Author's calculation.

The industry sector has been the highest contributor to the TFEC, with biomass having the highest share in the sector's TFEC. Energy consumption in the industry sector increased from 3,250 ktoe in 2000 to 5,743 ktoe in 2016 at an average rate of 3.6% per year. The industry sector's share in the TFEC increased from 35% in 2000 to 38% in 2016 (Figure 4.6).

The residential sector had the second-highest share of energy consumption in 2000 (31%) and this share decreased to around 28% in 2016. The energy consumption in the residential sector grew at an AAGR of 2.6% over 2000–2016, from 2,872 ktoe in 2000 to 4,350 ktoe in 2016.

The fastest growth of energy consumption during the same period was that of the transport sector, at an average rate of 5.6% per year. Consequently, the share of the transport sector in the TFEC increased from 10% in 2000 to 15% in 2016. The total consumption of the remaining sectors (services, agriculture, and others) contributed around 23% of the Myanmar TFEC in 2000. The growth in the total consumption of these sectors was around 2.1% per year, resulting in a declining share of their contribution in the TFEC to 19% in 2016.

Figure 4.6. Total Final Energy Consumption by Sector



Source: Author's calculation.

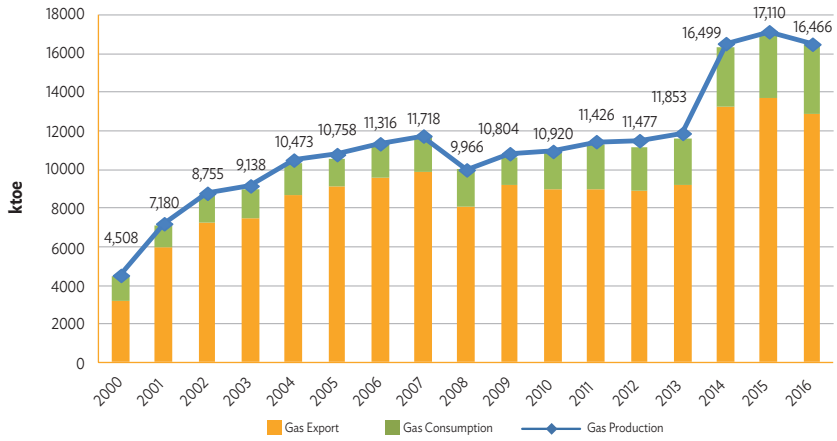
Supply and Consumption by Energy Product

Gas

Myanmar's gas production is mainly for export to Thailand, which was almost 3,160 ktoe in 2000, about 70% of total gas production. Gas export increased around fourfold by 2016, reaching 12,834 ktoe. This exported gas is 78% of the total production of 2016.

Domestic gas consumption also significantly increased in 2000–2016, but more slowly than export. For gas export, the AAGR was 9.2% whilst for domestic gas consumption the rate was 6.6%. Domestic gas consumption increased from 1,300 ktoe in 2000 to 3,600 ktoe in 2016. Figure 4.7 shows the country's gas production and its use domestically and for export.

Figure 4.7. Myanmar Gas Production and Use



ktoe = kilo ton of oil equivalent.

Source: Author's calculation.

Gas is consumed domestically in the transformation and the final sectors. Gas is used in the transformation sector for power generation, gas processing plants, and own use. In the final sector, gas is consumed by industries, vehicles, and commercial buildings.

Most of the gas used domestically is for power generation. Power generation share in total consumption was 62% in 2000 and increased to 76% in 2016. Currently, the government plans to increase gas use domestically through imports of LNG.

The industry sector was the second major user of the gas domestically. Its consumption, however, decreased from around 400 ktoe in 2000 to 265 ktoe in 2016. In contrast, gas use in the road transport sector increased from 2 ktoe in 2000 to 164 ktoe in 2016 as the number of taxis using gas increased, especially in Yangon. The services/commercial sector has started to use gas since 2012. Table 4.3 shows Myanmar's gas supply and consumption.

Oil

Myanmar is one of the world's oldest oil producers, exporting its first barrel of crude oil in 1853. Due to several factors such as sanctions, opaque regulatory policies, and insufficient investment, the country's upstream sector is still in its infancy. Since the United States and the European Union lifted their sanctions in

2012, Myanmar has taken active steps to reform its foreign investment laws and has held several successful international bid rounds for onshore and offshore oil and gas blocks (Norton Rose Fulbright, 2015).

Table 4.3. Gas Supply and Consumption (ktoe)

Year	Estimated Gas Supply	Gas Consumption	Electricity Plant	Gas Processing	Own Use	Industry	Transport	Services
2000	1,349.01	1,297.18	806.72	0.00	92.65	395.99	1.82	0.00
2001	1,213.72	1,112.08	714.31	0.00	147.58	248.39	1.80	0.00
2002	1,490.53	1,360.53	827.94	0.00	179.94	350.97	1.69	0.00
2003	1,651.78	1,451.51	950.90	0.00	160.78	338.00	1.83	0.00
2004	1,788.21	1,653.39	1,080.29	0.00	182.53	386.88	3.68	0.00
2005	1,691.21	1,484.72	1,000.63	0.00	185.89	262.81	35.39	0.00
2006	1,735.42	1,687.05	909.52	0.00	232.57	462.46	82.50	0.00
2007	1,898.90	1,892.16	1,014.51	0.00	240.84	518.52	118.28	0.00
2008	1,910.00	1,932.56	976.81	0.00	204.83	603.32	147.60	0.00
2009	1,615.65	1,409.27	566.40	0.00	222.02	457.08	163.77	0.00
2010	1,932.66	1,912.24	1,013.16	0.00	224.44	501.63	173.01	0.00
2011	2,456.43	2,316.12	1,282.75	0.00	196.95	660.33	176.09	0.00
2012	2,576.73	2,240.98	1,409.00	21.16	238.26	392.80	165.28	14.48
2013	2,694.03	2,422.61	1,488.39	11.85	268.21	475.23	178.28	0.65
2014	3,253.66	3,089.90	2,116.36	13.08	387.15	391.40	181.24	0.67
2015	3,402.05	3,370.49	2,384.68	17.31	470.32	330.33	167.33	0.52
2016	3,631.01	3,608.40	2,730.47	16.71	431.38	264.90	164.40	0.44
AAGR	**6.38**	**6.60**	**7.92**	**-5.74**	**10.09**	**-2.48**	**32.51**	**-5.74**

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

Source: Author's calculation.

Myanmar's production of crude oil (including natural gas liquid) was 420 ktoe in 2000 and reached 607 ktoe in 2016, increasing at an average growth of 2.3% per year. The crude produced was exported and consumed domestically in refineries. Myanmar also imported crude to its refineries to meet the petroleum product requirement of the country. Although crude production increased in 2000–2016, the total crude supply decreased from 1,068 ktoe in 2000 to 461 ktoe in 2016 at an average rate of -5.1% per year (Table 4.4).

Table 4.4. Crude Oil Supply and Consumption (ktoe)

Year	Crude Production	Crude Export	Crude Import	Stock Change	Crude Supply	Crude Consumption (Refineries)	Refineries Production
2000	42p0	0	654	-6	1068	-1068	894
2001	597	-169	-544	35	1007	-996	799
2002	828	-170	475	-19	1115	-1067	989
2003	941	0	0	15	956	-975	912
2004	1004	-58	0	-13	934	-918	814
2005	1072	-165	0	5	912	-876	770
2006	1007	-113	0	-40	855	-861	843
2007	1023	-143	0	7	886	-866	773
2008	916	0	0	-15	901	-833	730
2009	879	-95	0	38	822	-806	663
2010	937	0	0	7	944	-891	765
2011	849	0	0	-32	817	-835	793
2012	829	-141	0	62	750	-697	642
2013	846	-238	0	3	611	-557	496
2014	810	-243	0	-31	536	-561	509
2015	659	-150	0	-29	481	-432	409
2016	607	-146	0	0	461	-418	419
AAGR	**2.3**	**-1.0**	**-14.8**	**-**	**-5.1**	**-5.7**	**-4.6**

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

Source: Author's calculation.

The declining crude supply was in line with the limited downstream investments, low operational efficiencies, and ageing infrastructure of the refineries (PwC Growth Markets Centre, 2018). Total domestic petroleum production decreased from 894 ktoe in 2000 to 419 ktoe in 2016.

Total Myanmar supply of petroleum products is the sum of domestic production and import. Petroleum products are used to meet the requirements of domestic demand and international aviation and marine bunkers.

Continuous demand for petroleum products resulted in a significant increase of imported petroleum products. In 2000, imported petroleum products totalled 751 ktoe. By 2016, these reached almost 4,000 ktoe, increasing at an average annual rate of 11% per year.

Some petroleum products were used to supply the needs of international aviation and marine bunkers. Therefore, these products must be deducted to derive the supply for domestic consumption. Total domestic petroleum product supply was 1,618 ktoe in 2000 and increased to 4,489 ktoe at an average annual rate of 6.6% per year (Table 4.5).

Table 4.5. Gas Supply and Consumption (ktoe)

Year	Production	Export	Import	International Marine Bunker	International Aviation Bunker	Stock Change	Total Supply	Total Consumption
2000	894	0	751	0	-18	-9	1,618	1,617
2001	799	0	594	-3	-18	-16	1,356	1,325
2002	989	0	481	-2	-15	44	1,496	1,556
2003	912	0	676	-3	-13	7	1,580	1,642
2004	814	0	691	-2	-17	-74	1,413	1,426
2005	770	0	830	-2	-11	6	1,593	1,455
2006	843	0	856	-1	-14	12	1,697	1,647
2007	773	0	945	-1	-13	-14	1,690	1,641
2008	730	0	705	-1	-13	-56	1,365	1,344
2009	663	0	502	-2	-13	30	1,179	1,141
2010	765	0	1,619	-2	-19	30	2,394	2,317
2011	793	0	1,537	-1	-27	-223	2,079	2,083
2012	654	0	1,442	-2	-36	84	2,143	1,995
2013	504	0	1,910	-3	-78	19	2,352	2,243
2014	520	0	3,679	0	-84	-772	3,342	3,314
2015	422	034	4,712	-1	-41	163	5,220	4,783
2016	430	-173	3,966	-1	-89	357	4,489	4,288
AAGR	**-4.6**	**-**	**11.0**	**11.6**	**10.5**	**-**	**6.6**	**6.2**

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

Source: Author's calculation.

Table 4.5 shows that supply has a higher figure than consumption, indicating an excess of petroleum product supply. Usually, petroleum product importers reserve some stock. Because of the absence of information, this is considered a discrepancy in Myanmar's energy balance table (EBT).

Petroleum products were mainly consumed by the final sector (industry, transport, service, residential, and others) as well as for power generation and own use. In 2000, the total petroleum products consumed was 1,618 ktoe;

98.9% of this consumption (1,599 ktoe) was that of the final sectors. The remaining 1.1% was the share of consumption of the power sector (0.7%) and own use (0.4%). Since the consumption of the final sectors increased faster than that of the power sector and own use, the share of the final sectors in the total consumption increased to 99.4% in 2016 (Table 4.6).

Table 4.6. Gas Supply and Consumption (ktoe)

Year	Petroleum Consumption	Electricity Plant	Own Use	Total Supply					Of which Non-energy Use
				Industry	Transport	Service	Residential	Others	
2000	1,617	11	7	629	930	12	16	13	13
2001	1,325	10	11	513	761	10	17	3	5
2002	1,556	9	11	639	848	29	17	3	3
2003	1,642	10	6	597	975	34	17	3	2
2004	1,426	10	6	548	817	28	13	3	2
2005	1,455	10	6	626	768	26	17	2	1
2006	1,647	9	6	781	812	25	13	2	1
2007	1,641	10	6	817	776	22	9	1	1
2008	1,344	13	6	553	739	22	9	2	1
2009	1,141	9	6	480	619	18	8	2	1
2010	2,317	10	6	1,004	1,268	15	12	3	1
2011	2,083	12	5	818	1,212	16	18	2	75
2012	1,995	16	5	1,094	847	16	16	1	105
2013	2,243	19	5	1,261	881	13	27	37	186
2014	3,134	20	5	1,782	1,254	12	31	31	302
2015	4,783	17	5	2,791	1,892	23	23	31	283
2016	4,228	19	5	2,037	2,065	34	35	32	424
AAGR	**6.2**	**3.3**	**-2.6**	**7.6**	**5.1**	**7.0**	**5.0**	**6.1**	**24.4**

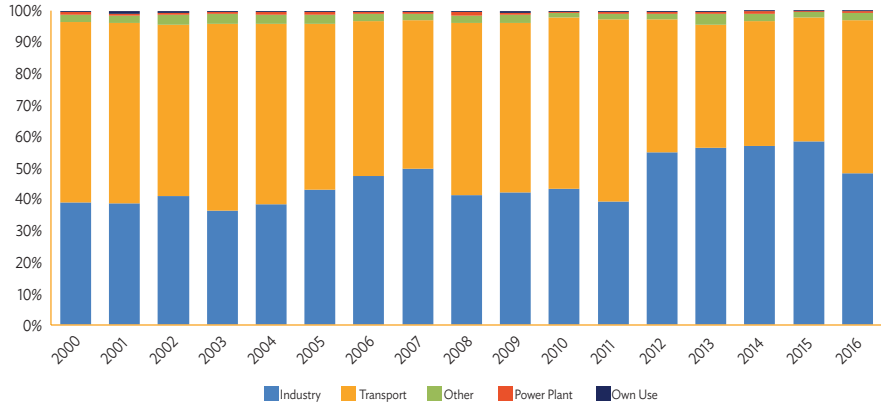
AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent.

Source: Author's calculation.

Most of the petroleum products consumed by the final sectors were for the transport sector – 930 ktoe in 2000 and increased to 2,065 ktoe in 2016. Although increasing, the AAGR of 5.1% per year was still slower than that of the industry or others sector. Consequently, the share of the transport sector in the total consumption decreased from 57% in 2000 to around 49% in 2016 (Figure 4.8).

In industry, the consumption of petroleum products increased at an average rate of 7.6% per year. This rate is higher than that of the transport sector, which resulted in an increasing share of this sector in the total petroleum products consumed, from around 39% in 2000 to 48% in 2016. Diesel dominated the petroleum products consumed by the industries. Diesel consumption increased at an average rate of 7.4% per year, from 562 ktoe in 2000 to 1,754 ktoe in 2016. The diesel consumption of the industry sector also included that of the self-generating system when blackouts occurred. Thus, the increased use of this system – because of the instability of electricity supply from the public utility – also contributed to the upward trend of diesel consumption.

Figure 4.8. Petroleum Product Consumption Share by Sector



Source: Author's calculation.

The consumption by the other sectors – comprising services, residential, agriculture, and others – increased at an average rate of 5.9% per year in 2000–2016. Most of the consumption is in the residential and the services sectors, with a total share of around 69% in 2000 until 2016. The largest share of petroleum products consumed by these two sectors consisted of liquefied petroleum gas (LPG) used as cooking fuel in households or restaurants in major cities.By type of petroleum product, diesel was the main fuel consumed by the sectors from 2000 to 2016. Its share in the total petroleum product consumption, however, decreased from 68% in 2000 to 52% in 2016, indicating that the growth of its consumption was slower than that of the other fuels. Total diesel consumption grew at an average rate of 4.4% per year, from around 1,100 ktoe in 2000 to 2,200 ktoe in 2016 (Table 4.7).

Table 4.7. Petroleum Product Consumption by Product (ktoe)

Year	Petroleum Products	Motor Gasoline	Jet Fuel	Kerosene	Gas/Diesel Oil	Fuel Oil	LPG	Other Petroleum Products
2000	1,617	354	47	3	1,099	47	16	51
2001	1,325	285	52	1	880	42	17	48
2002	1,556	301	61	1	1,015	117	17	44
2003	1,642	380	70	1	1,004	140	17	31
2004	1,426	344	56	1	874	115	13	24
2005	1,455	323	55	1	929	108	17	23
2006	1,647	340	57	1	1,113	100	13	24
2007	1,641	326	56	0	1,135	91	9	24
2008	1,344	334	50	1	835	88	9	26
2009	1,141	381	52	1	607	72	8	21
2010	2,317	370	60	2	1,790	61	12	24
2011	2,083	468	74	1	1,360	66	18	96
2012	1,995	496	73	0	1,218	64	16	128
2013	2,243	477	47	0	1,439	53	27	200
2014	3,134	784	56	0	1,903	48	31	313
2015	4,783	1,125	97	0	3,183	47	35	296
2016	4,228	1,331	128	0	2,202	80	50	437
AAGR	**6.2**	**8.6**	**6.4**	**-16.7**	**4.4**	**3.3**	**7.2**	**14.4**

AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent, LPG = liquefied petroleum gas.

Source: Author's calculation.

Motor gasoline accounted for about 31.5% of the total consumption in 2016, higher than it was in 2000 (22%). This implies that motor gasoline consumption increased at a faster rate than diesel, which was widely used across the sectors. The average growth rate for motor gasoline was 8.6% per year.

Fuel oil consumption grew at an average rate of 3.3% per year in 2000–2016. The growth was slower than that of diesel and gasoline consumption, resulting in a declining share in the consumption of total petroleum products from around 3% in 2000 to 2% in 2016 (Figure 4.9.). Fuel oil was consumed only in the industry sector and usually as fuel in industrial boilers.

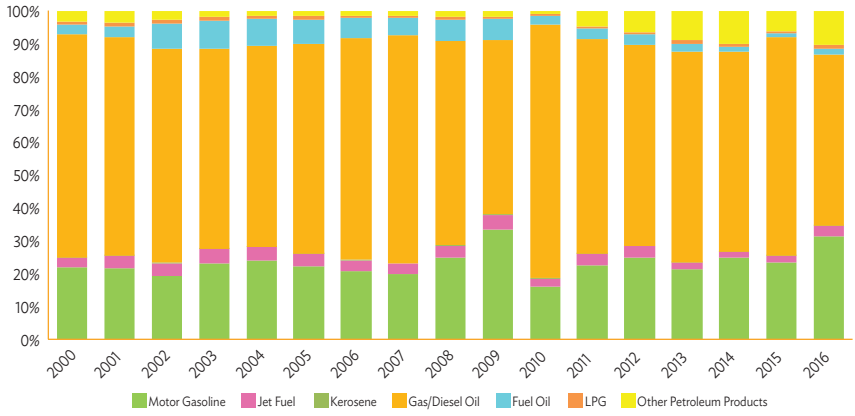
LPG share in the total petroleum product consumption of Myanmar remained at around 1% in 2000–2016 since it was used only for cooking in the residential and services sectors (restaurants, cafeterias, etc.). Although the share of LPG

was small, its consumption showed an increasing trend over the period; i.e., on average at 7.2% per year. Increasing consumption of LPG indicated a substitution in the fuelwood used for cooking, particularly in the residential sector.

Domestic jet fuel consumption was only 47 ktoe in 2000 and increased significantly to 128 ktoe in 2016 at an average rate of 6.4% per year. This result indicated that domestic flights in Myanmar changed drastically in 2000–2016, particularly between Yangon and the capital city, Nay Pyi Taw.

Consumption of other petroleum products was 51 ktoe in 2000, or about 3% of total consumption. This covered mainly bitumen consumed mostly by the construction sector, and lubricants by the transport sector. More road construction activities and number of vehicles increased the consumption of these products significantly. By 2016, consumption of other petroleum products reached 437 ktoe, resulting in an increased share of these products to 10%.

Figure 4.9. Shares of Petroleum Product Consumption by Fuel



LPG = liquefied petroleum gas.

Source: Author's calculation.

Coal

Table 4.8 shows Myanmar's coal supply and consumption. The coal production of Myanmar is for export and domestic consumption. Deducting coal production from its export results in the coal supply available to meet domestic consumption.

In 2000, coal consumption in Myanmar was only for the industry sector – mainly for the cement and steel industries. In 2004, the power sector, in addition to the

industries, started to consume coal. Coal consumption for power plants was only 40 ktoe in 2004 but then increased to 154 ktoe in 2005 (Figure 4.10). Coal was to meet the requirement of the first coal-fired power plant (60 MW × 2 units) constructed at Tigyit in Pinlaung County in the southern part of Shan state (JICA-JCEC, 2013).

Table 4.8. Coal Supply and Consumption (ktoe)

Year	Estimated Coal Supply	Coal Consumption	Electricity Plant	Coal Tranformation	Industry
2000	59.89	59.89	0.00	0.00	59.89
2001	45.88	45.88	0.00	0.00	45.88
2002	54.34	54.34	0.00	0.00	54.34
2003	84.92	84.92	0.00	0.00	84.92
2004	86.70	86.70	40.00	0.00	46.70
2005	252.37	252.37	153.56	0.00	98.81
2006	360.32	360.32	228.89	0.00	131.43
2007	401.07	401.07	213.36	0.00	187.71
2008	254.75	254.75	110.60	0.00	144.15
2009	195.38	195.38	93.22	0.00	102.17
2010	312.71	312.71	130.92	0.00	181.79
2011	319.53	319.53	152.59	0.00	166.94
2012	306.38	301.71	130.92	0.00	170.79
2013	227.21	227.39	59.31	0.00	168.09
2014	325.16	324.24	33.59	0.84	289.80
2015	268.06	268.06	0.00	1.53	266.52
2016	413.98	413.98	4.63	2.06	407.29
AAGR	**12.8**	**12.8**	**-16.4**	**56.4**	**12.7**

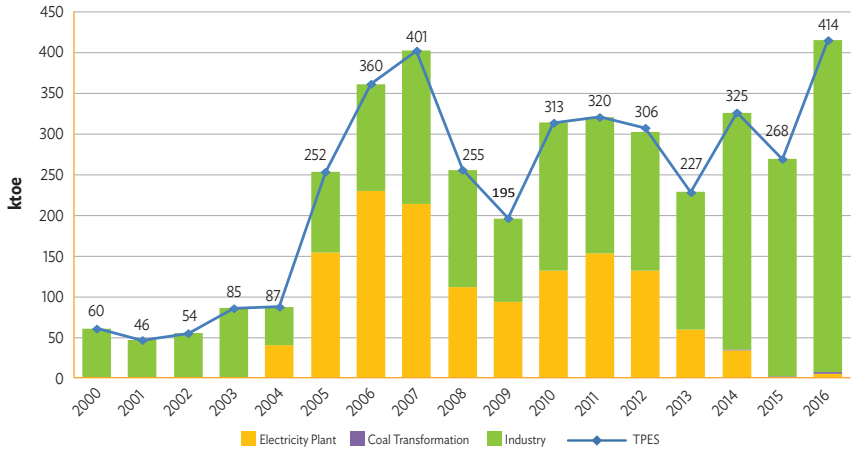
AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent.

Source: Author's calculation.

The Tigyit coal power plant has an average capacity factor of 31%, which is below the ideal operating capacity of 75%–80%, indicating inefficiencies in operation (Nam et al., 2015). As a result, coal consumption fluctuated and, in 2014, the plant was closed due to residents' complaints about environmental damage, public health problems, and commercial losses. The plant started to reopen despite opposition from the local community. But in 2016, reopening was postponed pending the results of the test operations conducted to analyse the effects of coal production on the environment and the local population after

modern and up-to-date equipment was installed at the plant. Coal was also consumed to produce briquette, which the other sectors used.

Figure 4.10. Coal Consumption



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

Source: Author's calculation.

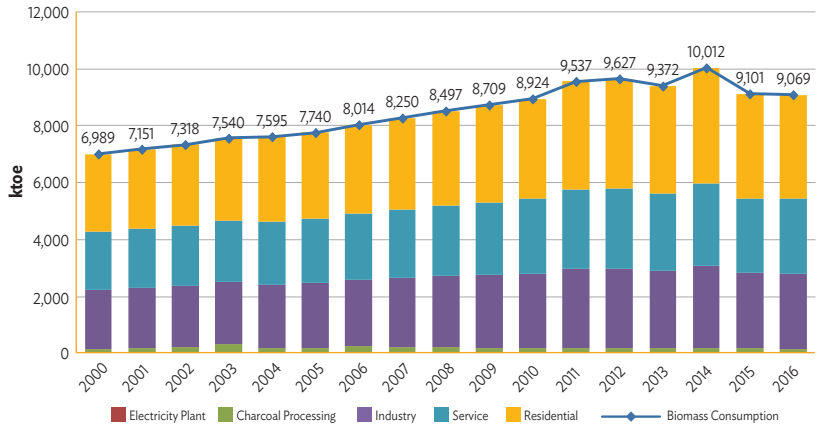
Biomass

Biomass is the major energy source consumed in Myanmar. Total biomass consumption increased from around 7,000 ktoe in 2000 to 9,000 ktoe in 2016 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 4.11).

Biomass consumed by the residential sector was mainly fuelwood, although a smaller amount of charcoal was also used. Total biomass consumption in the residential sector increased at an average rate of 1.8% per year, from 2,738 ktoe in 2000 to 3,661 ktoe in 2016. This growth is faster than that of total biomass consumption, resulting in an increasing share of biomass used in the residential sector, particularly in the rural areas.

Biomass consumption was estimated to be the same in the industry and services sectors. It also experienced an increasing share from 29.4% in 2000 to around 33% in 2016. The AAGR of biomass consumption in the services and industry

Figure 4.11. Biomass Consumption



ktoe = kilo ton of oil equivalent.

Source: Author's calculation.

sectors was 1.6%, respectively, increasing from 2,054 ktoe in 2000 to 2,633 ktoe in 2016.

For charcoal production, the amount of biomass (fuelwood) consumed slightly declined at an average rate of 0.08% per year, from 143 ktoe in 2000 to 141 ktoe in 2016. The share of biomass used for charcoal production declined from 2.0% in 2000 to 1.8% in 2016.

Electricity

Myanmar's sources for power generation were mainly natural gas and hydro resources. In 2000, total electricity production was 5,118 gigawatt-hours (GWh) and 62% of this total was generated from natural gas power plants. The remaining shares were hydro (37%) and oil (1%). By 2016, total electricity production reached 20,258 GWh where 60% was production from hydro plants and 39.7% from gas plants. The share of oil power plants declined to 0.3% in 2016. Other renewables such as solar and wind (9 GWh) and coal plants (10 GWh) also generated electricity.

Some of the electricity generated was used internally by the power plants (own use). Electricity for own use by the power plants was estimated by applying an appropriate rate for the existing power plants. The remaining generated electricity (net production) was available to the market. Myanmar was not an

electricity-importing country and it has been exporting electricity to China since 2013. Table 4.9 shows the electricity supply of Myanmar in 2000 to 2016.

Table 4.9. Electricity Supply (GWh)

Year	Electricity Supply	Net Production (Marketable)	Estimated Own Use	Gross Production	Coal	Oil	Gas	Hydro	Others	Export
2000	5,016	5,016	-102	5,118	0	36	3,190	1,892	0	0
2001	4,590	4,590	-99	4,689	0	31	2,650	2,008	0	0
2002	4,976	4,976	-92	5,068	0	29	2,928	2,111	0	0
2003	5,348	5,348	-78	5,426	0	31	3,320	2,075	0	0
2004	5,528	5,528	-80	5,608	60	33	3,107	2,408	0	0
2005	5,983	5,983	-81	6,064	244	33	2,786	3,001	0	0
2006	6,082	6,082	-82	6,164	401	28	2,410	3,325	0	0
2007	6,260	6,260	-138	6,398	436	34	2,310	3,619	0	0
2008	6,468	6,468	-153	6,622	220	40	2,291	4,071	0	0
2009	6,849	6,849	-115	6,964	250	30	1,428	5,256	0	0
2010	8,505	8,505	-120	8,625	391	33	2,012	6,189	0	0
2011	10,322	10,322	-133	10,455	312	38	2,556	7,544	4	0
2012	10,773	10,773	-196	10,969	265	51	2,883	7,766	4	0
2013	12,032	14,565	-174	14,739	136	61	3,228	11,310	4	-2,532
2014	14,024	15,488	-152	15,639	70	65	5,193	10,298	14	-1,463
2015	15,830	17,069	-154	17,223	0	55	6,518	10,639	11	-1,239
2016	17,749	20,131	-127	20,258	10	61	8,052	12,125	9	-2,381
AAGR	**8.2**	**9.1**	**1.4**	**9.0**	**-14**	**3.3**	**6.0**	**12.3**	**17.0**	**-2.0**

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

Source: Author's calculation.

Electricity supply increased from 5,016 GWh in 2000 to 17,749 GWh in 2016 at an average rate of 8.2% per year. The transmission and distribution losses must be subtracted from the total electricity supply before the final users can consume electricity. The estimated transmission and distribution losses were around 35% of the total electricity produced in 2000. Most of the losses were due to the poor distribution system and illegal electricity use. Transmission losses were around 5%–10%. Upgrading the system and increasing the electrification ratio had reduced the transmission and distribution losses to 12% by 2016.

Total electricity consumption was 3,268 GWh in 2000. Of this total consumption, the industry sector's consumption of electricity accounted for 40% whereas that of the residential sector was 42%. The remaining 19% was the share of the services sector (16%) and that of the other sectors (3%).

By 2016, total electricity consumption increased to 15,365 GWh at an average rate of 10.2% per year. Industry sector consumption increased at a slower rate of 8.3% per year compared with that of the residential sector at 11.3% per year. As a result, the share of the industry sector to total consumption declined to 30% whilst that of the residential sector increased to 49%.

Table 4.10. Electricity Consumption (GWh)

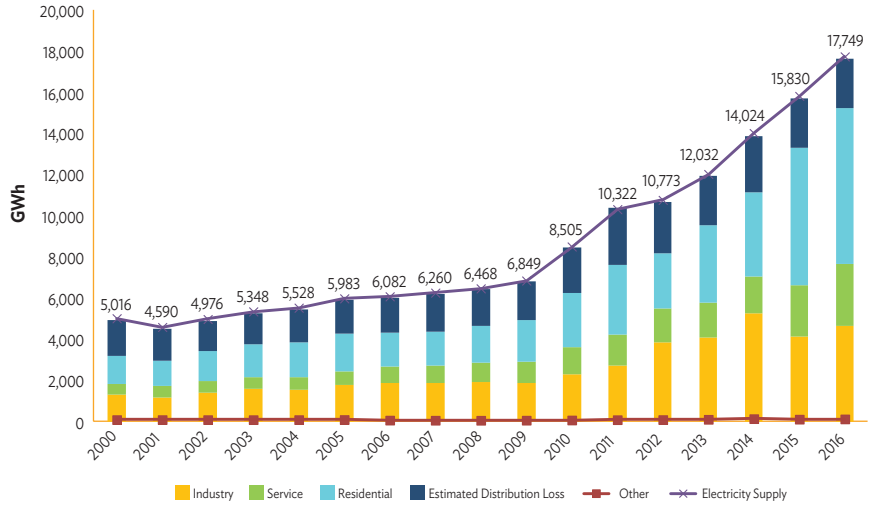
Year	Domestic Electricity Consumption	Industry	Service	Residential	Other	Estimated Distribution Loss	Electricity Supply
2000	3,268	1,295	527	1,361	85	1,748	5,016
2001	3,041	1,148	564	1,245	85	1,550	4,590
2002	3,484	1,417	552	1,431	84	1,492	4,976
2003	3,850	1,577	578	1,612	83	1,498	5,348
2004	3,909	1,549	613	1,662	85	1,619	5,528
2005	4,353	1,756	695	1,812	89	1,630	5,983
2006	4,355	1,854	827	1,614	61	1,727	6,082
2007	4,438	1,872	864	1,647	55	1,822	6,260
2008	4,701	1,904	945	1,799	53	1,767	6,468
2009	4,993	1,850	1,071	2,015	57	1,856	6,849
2010	6,312	2,287	1,306	2,653	66	2,193	8,505
2011	7,701	2,711	1,531	3,378	81	2,777	10,322
2012	8,258	3,848	1,643	2,681	86	2,515	10,773
2013	9,617	4,061	1,692	3,764	100	2,416	12,032
2014	11,275	5,276	1,755	4,113	131	2,750	14,024
2015	13,408	4,121	2,50	6,675	107	2,422	15,830
2016	15,365	4,651	3,023	7,573	118	2,385	17,749
AAGR	**10.2**	**8.3**	**11.5**	**11.3**	**2.1**	**2.0**	**8.2**

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

Source: Author's calculation.

Electricity consumption of the services sector increased the fastest at an average rate of 11.5% as more commercial buildings, especially hotels and offices, were constructed. The share of the services sector increased to almost 20% in 2016. That of the other sectors decreased to 1% since consumption grew the most slowly at 2.1% per year (Figure 4.12).

Figure 4.12. Electricity Consumption



GWh = gigawatt-hour.

Source: Author's calculation.

Energy Indicators

Energy consumption is the result of human activities. Therefore, analysis of human activities and energy consumption makes sense. The activities are:

- Producing primary and secondary products
- Transporting persons or cargo from point A to point B
- Service activities
- Household activities
- Agriculture, forestry, and fishery

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

- TPES/GDP

- Factor analysis of TPES/GDP
- CO_2/GDP and CO_2/TPES

These 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 energy-efficiency efforts.

GDP is a popular index reflecting a country's economy. It is easily found in national accounts and statistics. GDP may be expressed in a national currency, US dollars, international dollars (using purchasing power parity [PPP] conversions), or other common currency. 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

The real GDP of Myanmar increased at an average rate of 10.1% per year from 2000 to 2016. GDP, measured in constant 2010 US dollars, increased from around $16 billion in 2000 to $74 billion in 2016. The services sector – mainly wholesale and retail trade, mining and quarrying, agriculture (planting), and electricity – drove Myanmar's economic growth. The population grew by 0.9% per year on average, from 46 million to 53 million over the same period. The TPES/capita indicator increased at an average annual growth of 2.8% from 0.22 to 0.35 toe/person whilst the TPES/GDP declined from 0.65 to 0.25 toe/thousand dollars (at constant 2010 US dollars) over 2000–2016 (Table 4.11).

Table 4.11. Energy and Economic Indicators

Year	TPES	GDP	Population	TPES/GDP	TPES/POP
	ktoe	million $ (constant 2010 US$)	thousand persons	toe / thousand $ (constant 2010 US$)	toe/capita
2000	10,353	15,985	46,095	0.65	0.22
2001	10,147	17,798	46,628	0.57	0.22
2002	10,667	19,938	47,140	0.53	0.23
2003	11,080	22,699	47,625	0.49	0.23
2004	11,210	25,778	48,074	0.43	0.23
2005	11,676	29,275	48,483	0.40	0.24
2006	12,104	33,103	48,846	0.37	0.25
2007	12,664	37,073	49,172	0.34	0.26
2008	12,548	40,875	49,480	0.31	0.25
2009	12,310	45,187	49,801	0.27	0.25
2010	14,275	49,541	50,156	0.29	0.28
2011	15,065	52,311	50,553	0.29	0.30
2012	15,430	56,147	50,987	0.27	0.30
2013	15,516	60,878	51,448	0.25	0.30
2014	17,720	65,742	51,924	0.27	0.34
2015	18,873	70,340	52,404	0.27	0.36
2016	18,484	74,470	52,885	0.25	0.35
AAGR	**3.69**	**10.09**	**0.86**	**-5.82**	**2.80**

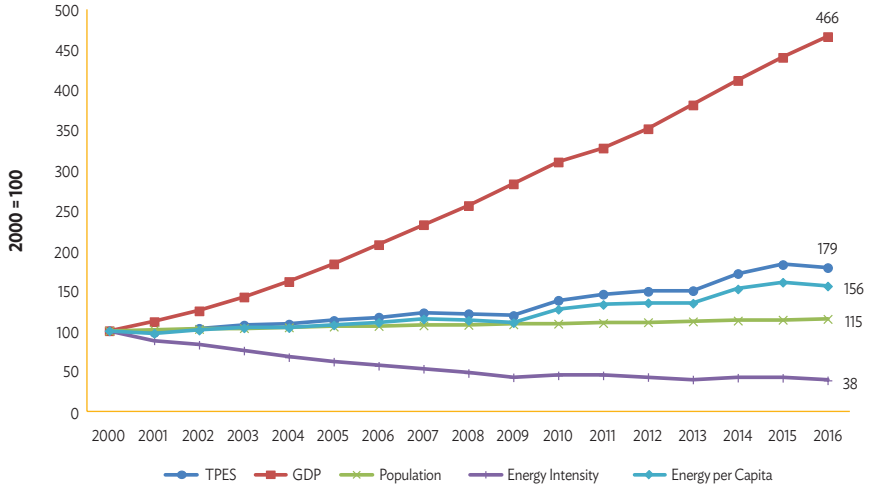
AAGR = average annual growth rate, GDP = gross domestic product, ktoe = kiloton of oil equivalent, POP = population , toe = ton of oil equivalent, TPES = total primary energy supply.

Source: Author's calculation.

Figure 4.13 shows the relative changes of GDP, population, TPES, and energy indicators (TPES/GDP and TPES/capita) with 2000 as baseline (2000 = 100). As shown, the energy per capita changes 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.

The energy intensity (TPES/GDP) declined from 2000 to 2016. The intensity in 2016 was 62% lower than it was in 2000. The growth in the TPES was significantly smaller compared to GDP, which drastically decreased the energy intensity.

Figure 4.13. TPES and Energy Intensity



TPES = total primary energy supply.

Source: Author's calculation.

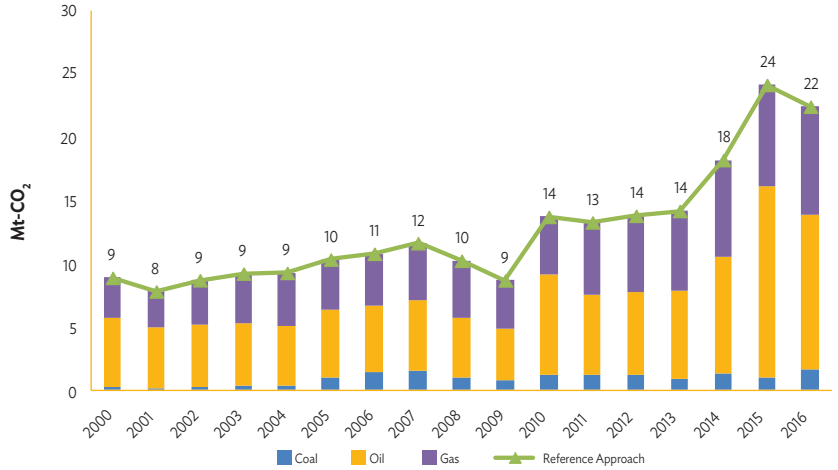
Energy and CO_2 emissions

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

The reference approach was often applied to countries which have insufficient data for the sectoral approach. National fuel supply statistics were used to calculate the carbon flows. The sectoral approach used the deliveries or consumption of fuels to each main source category, together with their carbon content, to estimate CO_2 emissions of (Simmons, 2000).

The reference approach was used to estimate the CO_2 emission of Myanmar based on the Myanmar EBT 2000–2016. The result of the calculation showed that CO_2 emission increased from 8,888 kt-CO_2 in 2000 to 22,385 kt-CO_2 in 2016 at an average rate of 5.9% per year (Figure 4.14).

Figure 4.14. CO_2 Emissions from Fuel Combustion (Reference Approach)



Mt-CO_2 = million tons of carbon dioxide.

Source: Author's calculation.

Most of CO_2 emission was from the use of oil sources. The CO_2 emission from oil was 62% of the total emission in 2000 whilst from gas it was 36%. The remaining was from coal combustion in industries.

Although the smallest, CO_2 emission from coal combustion grew the fastest over 2000–2016 at an average growth rate of 12.8% per year as a result of the rapid increase in coal consumed by industries. The total CO_2 emission from coal sources increased to almost 1,640 kt-CO_2 in 2016, which was around 7% of the total CO_2 emission of Myanmar.

CO_2 emission from oil will still be the largest in 2016, but the share declined to 55% because the rate of increase was slower than coal or even gas. Total CO_2 emission from oil combustion reached 12,216 kt-CO_2 in 2016 from around 5,500 kt-CO_2 in 2000. The burning of gasoline and diesel fuel especially in the transport and the industry sectors contributed to the high CO_2 emission from oil.

CO_2 emission from natural gas was mainly from its usage in the power sector. Total CO_2 emission from gas resources increased from 3,168 kt-CO_2 in 2000 to 8,528 kt-CO_2 in 2016 at an average annual rate of 6.4%, higher than oil. The share of CO_2 emission from gas increased to 38% in 2016.

Table 4.12 shows the energy and CO_2 emission indicators. The CO_2 intensity measured the impact of an increase in the GDP or the TPES to the absolute emission of CO_2. The CO_2/TPES intensity increased from 0.5 ton CO_2/toe in 2000 to 2,112 tons CO_2/toe in 2016 whilst the CO_2/GDP intensity decreased from 0.6 to 0.3 ton CO_2/thousand dollars (constant 2010 US dollars).

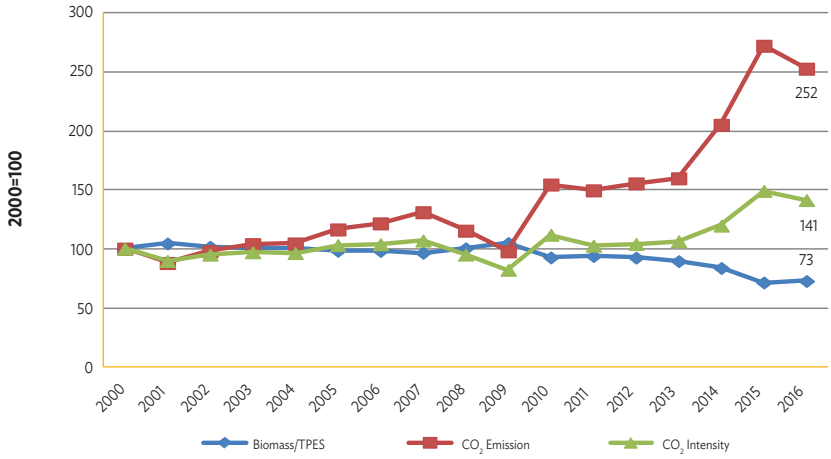
Table 4.12. Energy and CO_2 Emission Indicators

Year	Total Primary Energy Supply	GDP	CO_2 Emissions	CO_2 / GDP	CO_2 / TPES
	ktoe	million $ (constant 2010 US$)	kt-CO_2	ton CO_2 / thousand $ (constant 2010 US$)	ton CO_2 / toe
2000	10,353	15,985	8,888	0.56	0.86
2001	10,147	17,798	7,812	0.44	0.77
2002	10,667	19,938	8,699	0.44	0.82
2003	11,080	22,699	9,225	0.41	0.83
2004	11,210	25,778	9,277	0.36	0.83
2005	11,676	29,275	10,328	0.35	0.88
2006	12,104	33,103	10,784	0.33	0.89
2007	12,664	37,073	11,619	0.31	0.92
2008	12,548	40,875	10,235	0.25	0.82
2009	12,310	45,187	8,687	0.19	0.71
2010	14,275	49,541	13,696	0.28	0.96
2011	15,065	52,311	13,261	0.25	0.88
2012	15,430	56,147	13,781	0.25	0.89
2013	15,516	60,878	14,162	0.23	0.91
2014	17,720	65,742	18,175	0.28	1.03
2015	18,873	70,340	24,105	0.34	1.28
2016	18,484	74,470	22,385	0.30	1.21
AAGR	**3.69**	**10.09**	**5.94**	**-3.77**	**2.17**

AAGR = average annual growth rate, GDP = gross domestic product, ktoe = kiloton of oil equivalent, TPES = total primary energy supply.
Source: Author's calculation.

Biomass dominates Myanmar's TPES. A decreased share of biomass indicates faster growth of the fossil fuel use in the country. Consequently, this will increase CO_2 intensity (CO_2/TPES). The relationship between changes in biomass share in the TPES, CO_2 emission, and CO_2 intensity is shown in Figure 4.15. The index (2000 = 100) is used to describe these relationships.

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



TPES = total primary energy supply.

Source: Author's calculation.

References

World Bank Group/Data Bank/World Development Indicator Database Archives (2018). https://databank.worldbank.org/data/reports.aspx?source=wdi-database-archives-%28beta%29# (accessed 10 March 2018.)

JICA–JCEC (2013), *The Republic of the Union of Myanmar: Data Collection Survey on Coal Fired Thermal Power Generation Final Report*. http://open_jicareport.jica.go.jp/pdf/12087573.pdf (accessed 12 July 2017)

Nam, K.-Y., et al. (2015), 'Power Sector Development in Myanmar', *ADB Economics Working Paper Series,* No. 460, October. https://www.adb.org/sites/default/files/publication/175801/ewp-460.pdf (accessed 29 May 2016).

Norton Rose Fulbright (2015), *Oil and Gas Exploration and Production in Myanmar*. http://www.nortonrosefulbright.com/knowledge/publications/133109/oil-and-gas-exploration-and-production-in-myanmar (accessed 12 July 2017).

PwC Growth Markets Centre (2018), *The Future of ASEAN – Time to Act Refined Fuels*. https://www.pwc.com/gx/en/growth-markets-centre/assets/pdf/future-of-asean-chapter-6.pdf (accessed 10 September 2018).

Simmons, T. (2000), *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 (accessed 16 July 2016).

Trudeau, N. (2012), *Energy Efficiency Indicators Overview*. Paris: International Energy Agency.