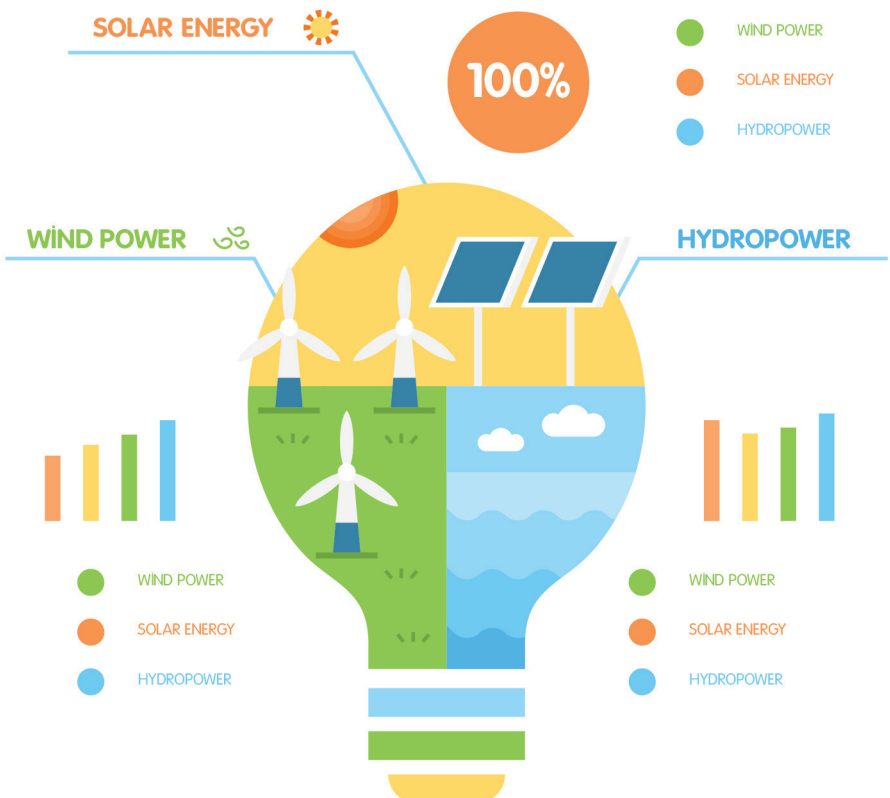
Myanmar Energy Statistics 2019



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Foreword

The Republic of the Union of Myanmar has achieved remarkably high economic growth, with average gross domestic product (GDP) growth rate of 7.28% over 2010 to 2017, the second-highest growth rate among ASEAN member states during the same period. Myanmar's real GDP per capita was US$1,300 in 2017. This strong economic growth during the last 6 years was also accompanied by an increase in energy consumption in all sectors. Myanmar is endowed with abundant, rich natural resources that, if fully developed, would be sufficient to meet most of the country's daily energy needs. Myanmar's energy policy is generally aimed at ensuring energy independence by increasing national production of available primary energy resources through intensive exploration and development activities. Myanmar also acknowledges electricity as the main power source driving economic development and addresses the need to generate and distribute more power in terms of greater volume, density, and reliability. But, so far, the country does not have national energy statistics, especially energy balance tables. Consequently, nobody knows the accurate situation of both energy demand and supply sides.

To fill the gap regarding energy data and statistics of Myanmar, the Ministry of Electricity and Energy requested the Economic Research Institute for ASEAN and East Asia (ERIA) to support the Oil and Gas Planning Department (OGPD) in preparing accurate energy statistics for Myanmar. With ERIA's kind acceptance of this request, the OGPD formed its team to work with ERIA's expert team in early 2018. Data was collected and shared with the ERIA expert team. Energy consumption surveys for the transport, industry, residential, and commercial sectors were also carried out. During the project period, ERIA also conducted capacity-building trainings, such as basic understanding of energy statistics, for OGPD staff.

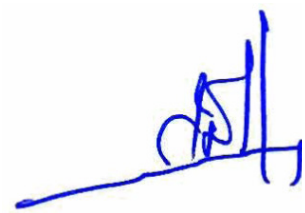
On behalf of the Ministry of Electricity and Energy of Myanmar, I am very grateful for the technical and financial support for this Myanmar Energy Statistics Project. We always can count on the support from ERIA to build energy data and statistics on energy policy and planning in Myanmar. We will continue to consult with ERIA for future updates of the data and statistics nd include many other energy policies and planning activities in Myanmar.

U Win Khaing
Union Minister
Ministry of Electricity and Energy
March 2019

Acknowledgements

This statistics publication was developed by a working group consisting of Myanmar's team and the Economic Research Institute for ASEAN and East Asia (ERIA) team. The Myanmar team consisted of staff of the Oil and Gas Planning Department (OGPD), Ministry of Electricity of the Republic of the Union of Myanmar and line ministries. The ERIA team consisted of experts in energy statistics, building and industry energy consumption, and legal framework. We would like to acknowledge the members of the working group for their excellent work and contribution. We also would like to take this opportunity to thank the ministries and agencies involved in providing the data and information for their highest cooperation in this project.

Special acknowledgement is also given to Shigeru Kimura and his team for their excellent contribution to the project.



U Zaw Aung
Director General, Oil and Gas Planning Department
March 2019

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List of Abbreviations

AAGR	average annual growth rate
BEI	building energy intensity
BKB	brown coal briquettes
CO_2	carbon dioxide
CSO	Central Statistical Organization
EBT	energy balance table
EEC	energy efficiency and conservation
EMS	energy management system
ERIA	Economic Research Institute for ASEAN and East Asia
EUI	energy use intensity
GCV	gross calorific value
GDP	gross domestic product
GFA	gross floor area
GJ	gigajoule
GWh	gigawatt-hour
Ktoe	kilo ton oil equivalent
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MOEE	Ministry of Electricity and Energy
MONREC	Ministry of Natural Resource and Environmental Conservation
MPE	Myanmar Petrochemical Enterprise
MSR	Myanmar Survey Research
NCV	net calorific value
OGPD	Oil and Gas Planning Department
TFEC	total final energy consumption
TPES	total primary energy supply

Chapter 1
Primary Energy Data

The Oil and Gas Planning Department of the Ministry of Electricity and Energy (OGPD, MOEE) collects coal, oil, gas, electricity, and renewable energy data from various agencies, and compiles the energy statistics of Myanmar.

Coal

Coal data is maintained by the Ministry of Natural Resources and Environmental Conservation (MONREC) in Myanmar. It contains the supply and consumption of sub-bituminous coal and lignite.

Coal Production

Coal production has been disaggregated by sub-bituminous coal and lignite since 2012. Before 2011, all data was reported under sub-bituminous coal.

Table 1.1. Sub-bituminous Coal and Lignite Production

Unit: 1,000 metric tons

	Sub-bituminous Coal				Lignite			
	Production		Imports	Exports	Production		Imports	Exports
	Of which: Underground	Of which: Surface			Of which: Underground	Of which: Surface		
2000	-	534.59	-	401.88	-	-	-	-
2001	-	632.92	-	531.25	-	-	-	-
2002	-	560.27	-	439.87	-	-	-	-
2003	-	925.42	-	737.26	-	-	-	-
2004	-	992.00	-	799.88	-	-	-	-
2005	-	1,182.50	-	623.30	-	-	-	-

2006	-	1,313.62	-	515.21	-	-	-	-
2007	-	1,117.29	-	228.59	-	-	-	-
2008	-	607.57	-	43.09	-	-	-	-
2009	-	462.93	-	30.00	-	-	-	-
2010	-	692.90	-	-	-	-	-	-
2011	-	685.42	47.10	24.50	-	-	-	-
2012	2.47	643.13	3.50	-	-	47.30	-	-
2013	56.43	391.28	35.09	53.41	-	117.61	-	-
2014	5.62	173.59	331.35	-	61.50	291.87	-	20.00
2015	55.11	185.29	238.16	-	14.52	164.95	23.82	20.00
2016	36.66	280.16	437.88	-	20.92	212.11	37.68	12.50

- = no production and consumption.

Source: MONREC (2018).

Coal consumption

The 73.15 KT coal consumption in 2012 was reported under FeNi factory. This data needs to be disaggregated by sub-bituminous coal and lignite. Besides, coal consumption data is reported by multiplying the coal production with a fixed percentage, which is the same for sub-bituminous coal and lignite in 2014 and 2016. As a result, the reported coal consumption of electricity plants was not consistent with coal-fired electricity generation and needed to be estimated.

Crude Oil and Petroleum Products

The OGPD collects data on crude oil production, condensate production, refined petroleum products, and import of petroleum products from the Myanmar Oil and Gas Enterprise (MOGE), Myanmar Petrochemical Enterprise (MPE), and Myanmar Customs.

Crude oil supply and consumption

Crude oil production consists of oil from the oil wells owned by MOGE and some small wells. Lack of detailed data on the transformation of input to output in small wells assumes that small well oil production is equal to direct use. In addition to oil production, the imports, exports, stock, and refinery intake are also reported by MOGE. However, stock data is not always consistent and needs to be adjusted.

Table 1.2. Sub-bituminous Coal Consumption

Unit: 1,000 metric tons

	Total Transformation Sector		Total Industry Sector		
	BKB/PB Plants	Main Activity Producer – Electricity Plants	Iron and Steel	Non-metallic Minerals	Not Elsewhere Specified
2000	–	–	63.48	64.83	4.40
2001	–	–	34.66	64.83	2.18
2002	–	–	38.04	76.12	6.24
2003	–	–	49.08	133.78	5.30
2004	–	88.64	49.71	51.34	2.43
2005	–	340.26	50.90	136.87	31.17
2006	–	507.19	65.31	140.52	85.39
2007	–	472.76	63.48	202.16	150.30
2008	–	245.06	49.08	227.25	43.09
2009	–	206.55	46.81	128.30	51.27
2010	–	290.09	–	362.34	40.47
2011	–	338.12	69.30	237.65	62.95
2012	–	290.09	73.15	315.34	3.50
2013	–	131.41	–	199.09	99.09
2014	1.79	8.96	51.97	53.76	394.07
2015	2.40	12.02	43.27	144.24	276.62
2016	3.17	15.84	57.03	190.09	488.57

BKB/PB = brown coal briquette/peat briquette.

Source: MONREC (2018).

Table 1.3. Lignite Consumption

Unit: 1,000 metric tons

	Total Transformation Sector		Total Industry Sector		
	BKB/PB Plants	Main Activity Producer-- Electricity Plants	Iron and Steel	Non-metallic Minerals	Not Elsewhere Specified
2000	–	–	–	–	–
2001	–	–	–	–	–
2002	–	–	–	–	–
2003	–	–	–	–	–
2004	–	–	–	–	–
2005	–	–	–	–	–
2006	–	–	–	–	–

2007	–	–	–	–	–
2008	–	–	–	–	–
2009	–	–	–	–	–
2010	–	–	–	–	–
2011	–	–	–	–	–
2012	–	–	–	–	–
2013	–	–	88.94	–	29.00
2014	3.53	16.67	96.68	100.01	116.67
2015	1.59	7.97	28.70	95.68	25.52
2016	2.21	11.03	39.70	132.32	35.28

BKB/PB = brown coal briquette/peat briquette.

Source: MONREC (2018).

Table 1.4. Crude Oil Supply and Consumption

Unit: 1,000 MT

	Indigenous Production	Imports	Exports	Direct Use	Stock at Opening	Stock at Closing	Refinery Intake
2000	415.96	647.11	–	–	–	–	1,057.18
2001	591.03	538.22	167.24	–	75.68	41.23	986.26
2002	820.06	470.27	167.81	–	41.23	59.95	1,056.14
2003	931.26	–	–	–	59.95	44.63	965.36
2004	994.24	–	57.47	35.18	44.63	57.05	909.14
2005	1,061.47	–	163.27	8.99	57.05	52.47	866.99
2006	996.80	–	111.48	13.40	52.47	91.81	852.14
2007	1,012.75	–	141.74	18.33	91.81	85.27	857.31
2008	906.83	–	–	28.37	85.27	100.18	825.07
2009	870.26	–	94.03	23.34	100.18	62.83	797.71
2010	927.93	–	–	21.53	62.83	56.00	882.46
2011	840.39	–	–	41.26	62.94	87.97	827.04
2012	821.08	–	139.52	25.22	54.23	26.63	689.58
2013	837.73	–	235.64	36.97	26.99	23.58	551.79
2014	801.46	–	240.59	80.30	39.52	53.89	555.46
2015	652.77	–	148.58	75.66	50.44	82.24	427.83
2016	600.89	–	144.06	76.67	83.94	82.56	414.16

MT = metric ton.

Source: MOEE (2018).

LPG supply and consumption

LPG is produced by the MPE-owned refinery and LPG plants in Myanmar. The LPG plants use natural gas to produce LPG and naphtha. The MPE reports their production, stock, and sales of LPG. However, stock data is not always consistent and needs to be adjusted. Moreover, sales data is aggregated and, since 2015, only the amount sold to government agencies can be divided. The disaggregated LPG consumption in 2013 and 2014 is estimated by the OGPD with the type of LPG consumed, and needs to be reclassified. As for LPG imports, the data is gathered from the customs office.

Table 1.5. Liquefied Petroleum Gas Supply and Consumption

Unit: 1,000 MT

	Supply					Final Consumption		
						Other Sectors		
	Primary Products Receipts	Gross Refinery Output	Imports	Stock at Opening	Stock at Closing	C&PS	Residential	NES
2000	-	14.47	-	-	-	-	-	14.47
2001	-	15.63	-	2.30	3.06	-	-	14.87
2002	-	15.43	-	3.06	3.41	-	-	15.08
2003	-	12.76	-	3.41	1.48	-	-	14.69
2004	-	11.95	-	1.48	2.04	-	-	11.39
2005	-	15.63	-	2.30	3.06	-	-	14.87
2006	-	10.39	-	1.69	0.70	-	-	11.35
2007	-	8.96	-	0.70	1.49	-	-	8.17
2008	-	8.96	-	0.70	1.49	-	-	8.17
2009	-	7.54	-	3.85	4.73	-	-	6.66
2010	-	7.54	3.62	0.33	1.10	-	-	10.38
2011	-	7.24	7.05	4.73	2.99	-	-	16.03
2012	7.18	7.85	0.60	2.99	3.16	-	-	7.27
2013	4.31	6.07	15.54	3.16	1.45	14.43	5.02	-
2014	5.74	3.73	22.53	1.45	4.51	23.12	4.12	-
2015	8.11	5.55	22.25	4.51	6.37	10.49	20.53	-
2016	6.42	4.19	31.41	6.37	3.56	12.79	31.41	-

C&PS = commercial and public service, MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Naphtha supply and consumption

Naphtha is the by-product of LPG plants in Myanmar and is blended to produce motor gasoline in Myanmar. The production and stock data are reported by the MPE. However, the closing stock is missing in 2012.

Table 1.6. Naphtha Supply and Consumption

Unit: 1,000 MT

	Primary Products Receipts	Inter-product Transfers	Stock at Opening	Stock at Closing
2012	3.96	- 3.71	-	-
2013	2.73	- 2.90	0.25	0.08
2014	3.62	- 3.52	0.08	0.17
2015	4.11	- 4.12	0.17	0.16
2016	3.54	- 3.73	0.16	0.11

MT = metric ton.

Source: MOEE (2018).

Motor gasoline supply and consumption

The MPE reports the motor gasoline production, stock, and sales data. However, the stock data has not been consistent for some years and needs to be adjusted. The classification of sales data is also inconsistent and needs to be reclassified into road sector only. As for motor gasoline imports, the data is gathered from the customs office.

Table 1.7. Motor Gasoline Supply and Consumption

Unit: 1,000 MT

	Supply					Final Consumption	
						Transport Sector	
	Gross Refinery Output	Imports	Inter-product Transfers	Stock at Opening	Stock at Closing	Road	NES
2000	262.95	73.11	-	-	-	-	334.50
2001	232.24	72.32	-	7.89	12.91	269.47	-
2002	277.01	40.32	-	12.91	14.87	284.16	-
2003	357.85	5.64	-	14.87	10.62	359.50	-
2004	359.15	21.51	-	10.62	20.02	324.83	-
2005	350.30	19.20	-	20.02	23.66	305.51	-
2006	358.68	10.49	-	23.66	26.64	321.26	-

2007	360.54	5.59	-	26.64	41.50	308.13	-
2008	340.65	5.96	-	41.50	36.23	-	315.60
2009	369.50	13.97	-	36.23	15.17	-	360.01
2010	360.54	84.31	-	26.64	41.50	349.56	-
2011	428.47	90.87	-	54.96	80.14	-	441.94
2012	329.88	216.23	-	69.88	58.03	-	468.55
2013	230.04	323.25	2.90	58.03	55.81	-	451.34
2014	234.18	893.78	3.52	63.84	272.46	-	740.73
2015	142.74	1,276.38	4.12	272.46	284.41	-	1,063.08
2016	144.49	1,091.28	4.12	40.58	34.19	1,258.31	-

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Aviation gasoline supply and consumption

The MPE reports the aviation gasoline production, stock, and sales data. However, stock data has been missing for most years and needs to be adjusted. Moreover, the classification of sales data is inconsistent and needs to be reclassified.

Kerosene-type jet fuel supply and consumption

The MPE reports the data on kerosene-type jet fuel production, stock, and sales. However, the stock data has been inconsistent for some years and needs to be adjusted. As for the sales data, the MOEE keeps a clear account of kerosene-type jet fuel consumed by international civil aviation and domestic air transport, which can be used for sales data disaggregation. As for kerosene-type jet fuel imports, the data is gathered from the customs office.

Other kerosene supply and consumption

The MPE reports other kerosene production, stock, and sales data. However, the stock data has been missing for most years and needs to be adjusted. As for the sales data, the classification is not always consistent, and needs to be reclassified.

Table 1.8. Aviation Gasoline Supply and Consumption

Unit: 1,000 MT

	Supply			Final Consumption		
				Transport Sector		
	Gross Refinery Output	Stock at Opening	Stock at Closing	International Civil Aviation	Domestic Air Transport	NES
2000	-	-	-	-	-	-
2001	0.18	-	-	-	0.18	-
2002	0.02	-	-	-	0.02	-
2003	0.01	-	-	-	0.01	-
2004	0.01	-	-	0.01	-	-
2005	0.01	-	-	-	0.01	-
2006	0.01	-	-	-	-	-
2007	0.02	-	-	-	-	-
2008	0.02	-	-	-	0.02	-
2009	0.07	-	-	0.07	-	-
2010	0.06	-	-	0.06	-	-
2011	0.03	-	-	-	0.03	0.02
2012	0.03	-	-	-	-	-
2013	0.02	-	-	-	0.02	-
2014	0.02	0.07	0.05	-	0.06	-
2015	0.03	0.05	-	-	0.08	-
2016	0.01	0.05	-	-	0.08	0.01

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Table 1.9. Kerosene-Type Jet Fuel Supply and Consumption

Unit: 1,000 MT

	Supply				Final Consumption	
					Transport Sector	
	Gross Refinery Output	Imports	Stock at Opening	Stock at Closing	International Civil Aviation	Domestic Air Transport
2000	64.69	-	-	-	17.07	44.97
2001	67.12	3.28	1.59	3.61	17.02	49.72
2002	71.14	-	3.61	3.63	14.11	57.70
2003	77.69	3.18	1.66	3.63	11.89	66.35
2004	73.96	2.58	3.63	8.87	15.93	53.58
2005	55.11	5.68	8.87	5.58	10.91	52.04
2006	51.81	23.14	5.58	13.62	13.34	54.46
2007	53.85	6.12	13.62	5.29	12.26	53.12

2008	44.79	15.25	5.29	7.12	12.27	47.18
2009	35.92	29.00	7.12	9.57	12.02	49.16
2010	42.10	30.74	9.57	7.52	17.89	56.80
2011	41.94	68.17	11.38	24.15	25.45	70.34
2012	33.26	60.21	19.09	9.89	33.79	69.44
2013	21.23	103.59	9.89	21.03	73.82	44.87
2014	16.72	114.01	25.22	23.96	79.30	52.90
2015	15.73	103.06	23.96	10.45	39.40	92.35
2016	15.36	191.16	7.58	8.51	89.15	120.98

MT = metric ton.

Source: MOEE (2018).

Table 1.10. Other Kerosene Supply and Consumption

Unit: 1,000 MT

	Supply			Final Consumption	
				Other Sectors	
	Gross Refinery Output	Stock at Opening	Stock at Closing	C&PS	NES
2000	0.67	-	-	-	2.44
2001	1.31	-	-	-	1.31
2002	1.40	-	-	-	1.38
2003	1.42	-	-	-	0.86
2004	1.25	-	-	-	0.88
2005	1.53	-	-	-	0.82
2006	1.55	-	-	-	0.72
2007	1.70	-	-	-	-
2008	1.44	-	-	-	1.01
2009	1.17	-	-	-	1.06
2010	1.57	0.20	0.15	-	1.62
2011	0.89	-	-	0.67	-
2012	0.63	-	-	-	-
2013	0.32	-	-	-	0.33
2014	0.34	-	-	-	0.34
2015	0.23	-	-	-	0.23
2016	0.13	-	-	-	0.13

C&PS = commercial and public service, MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Gas/diesel oil supply and consumption

The MPE reports gas/diesel oil production, stock, and sales data. However, the stock data has been inconsistent for some years and needs to be adjusted. Moreover, the sales data is disaggregated by the OGPD by the structure of governmental agency diesel consumption, which cannot reflect the structure of national diesel consumption. It is suggested to classify them to 'not elsewhere specified' of the industry sector if detailed information is not available. The transformation input of electricity plants is suggested to be estimated with oil-fired electricity generation. As for gas/diesel oil imports, the data is gathered from the customs office.

Table 1.11. Gas/Diesel Oil Supply and Consumption

Unit: 1,000 MT

	Final Consumption									
	Transport Sector			Industry Sector				Other Sectors		
	Road	Rail	NES	Mining	Food	Wood	Construction	Agriculture	Fishing	NES
2000	-	-	1,068.60	-	-	-	-	-	-	-
2001	409.41	-	-	24.04	11.21	33.65	38.81	99.47	10.30	183.79
2002	-	-	472.39	27.73	12.93	38.83	44.78	114.77	11.89	212.06
2003	511.26	-	-	32.58	12.10	34.73	40.93	133.84	16.64	80.66
2004	406.45	-	-	23.86	11.13	33.41	38.53	98.75	10.23	182.46
2005	379.73	-	-	111.74	45.40	33.82	46.82	89.36	49.21	113.38
2006	371.23	32.71	-	188.50	45.66	35.68	67.92	78.94	65.10	188.32
2007	352.41	31.17	-	187.37	112.90	26.53	148.00	72.40	68.18	127.96
2008	-	33.05	313.04	79.21	57.59	25.51	128.94	71.62	44.28	81.09
2009	-	35.07	146.31	36.28	29.34	19.70	141.81	51.50	10.31	126.40
2010	781.21	35.53	-	115.42	168.04	59.48	316.26	180.77	2.68	69.06
2011	-	37.26	593.84	87.74	127.73	45.21	240.41	137.42	2.03	52.50
2012	-	35.13	209.74	106.09	103.51	63.20	134.97	78.43	61.80	348.69
2013	-	35.60	273.36	71.08	23.73	79.05	173.06	265.38	3.49	452.09
2014	-	36.40	311.83	79.66	29.75	97.82	411.14	271.99	5.04	545.13
2015	-	35.68	521.57	136.12	45.56	118.55	517.17	452.55	411.94	738.09
2016	-	34.59	383.26	116.75	23.33	39.61	345.63	285.73	8.37	835.26

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Fuel oil supply and consumption

The MPE reports fuel oil production, stock, and sales data. However, stock data has been missing or inconsistent for some years and needs to be adjusted. Moreover, the sales data is disaggregated by the OGPD by the structure of governmental agency diesel consumption, which cannot reflect the structure of national diesel consumption. The sale to governmental agencies should be classified as commerce and public services, while the rest is supposed to be consumed by industry and is suggested to be classified as 'not elsewhere specified' of the industry sector if detailed information is not available. As for fuel oil imports, the data is gathered from the customs office.

Table 1.12. Fuel Oil Supply and Consumption

Unit: 1,000 MT

	Supply				Final Consumption			
					Industry Sector		Other Sectors	
	Gross Refinery Output	Imports	Stock at Opening	Stock at Closing	Construction	NES	Agriculture	NES
2000	50.43	-	-	-	-	134.41	-	-
2001	46.06	-	1.55	4.59	0.47	-	5.80	28.98
2002	120.20	5.14	4.59	8.81	0.50	-	6.19	30.93
2003	106.06	34.08	8.99	4.10	0.68	-	6.08	28.43
2004	79.02	45.06	4.10	8.94	0.43	-	5.41	27.01
2005	90.99	22.69	8.94	10.84	0.22	-	4.43	18.61
2006	88.91	16.26	10.84	11.99	0.14	-	4.57	21.48
2007	84.55	2.19	11.99	4.74	0.21	-	4.62	26.80
2008	91.25	-	4.74	4.41	0.01	-	4.57	34.45
2009	76.47	5.47	4.41	11.24	-	-	3.57	34.97
2010	64.43	-	11.24	12.70	0.00	-	2.95	27.51
2011	70.94	-	12.70	15.30	-	16.86	2.06	22.45
2012	65.42	-	15.30	14.86	-	30.51	3.29	30.74
2013	54.61	-	14.86	14.84	-	8.28	8.00	18.41
2014	60.74	-	14.84	25.93	-	2.29	2.43	41.75
2015	67.03	-	25.93	44.36	-	1.29	2.29	45.00
2016	78.21	-	44.36	39.83	-	4.24	4.50	32.89

C&PS = commercial and public service, LPG = liquefied petroleum gas, MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

White spirit supply and consumption

The MPE reports white spirit production, stock, and sales data. However, the stock data has not been consistent for some years and needs to be adjusted. Moreover, the classification of sales data is inconsistent, and needs to be reclassified to 'not elsewhere specified' of industry sector only.

Table 1.13. White Spirit Supply and Consumption

Unit: 1,000 MT

	Supply			Final Consumption	
	Gross Refinery Output	Stock at Opening	Stock at Closing	Industry Sector	Others Sector
				NES	Agriculture
2000	2.60	-	-	2.37	-
2001	3.45	0.03	0.08	3.40	-
2002	3.47	0.08	0.15	3.40	-
2003	3.53	0.15	0.09	3.59	-
2004	1.78	0.09	0.05	1.82	-
2005	2.38	0.05	0.10	2.33	-
2006	3.09	0.10	0.06	3.13	-
2007	2.89	0.06	0.09	2.86	-
2008	2.76	0.09	0.08	2.77	-
2009	2.33	0.08	0.05	2.33	-
2010	2.89	0.06	0.09	2.86	-
2011	1.77	0.04	0.07	1.60	-
2012	0.55	0.07	0.03	0.59	-
2013	0.34	0.03	0.01	-	0.26
2014	0.28	0.01	0.05	-	0.24
2015	0.39	0.05	0.02	-	0.24
2016	0.22	0.02	-	0.24	-

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Lubricants supply and consumption

The MPE reports lubricants stock and sales data. However, stock data has been missing for most years and needs to be adjusted. Moreover, the classification of sales data is inconsistent and is suggested to be reclassified to road sector only. As for lubricant imports, the data is gathered from the customs office.

Table 1.14. Lubricants Supply and Consumption

Unit: 1,000 MT

	Supply			Final Consumption	
	Imports	Stock at Opening	Stock at Closing	Transport Sector	Industry Sector
				NES	NES
2000	3.08	-	-	-	3.08
2001	3.62	-	-	3.62	-
2002	1.44	-	-	1.44	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	23.40	0.72	0.72	23.40	-
2012	28.27	-	-	28.27	-
2013	40.98	0.37	0.39	40.96	-
2014	59.80	0.30	0.31	59.79	-
2015	101.28	0.31	0.07	101.52	-
2016	184.78	-	-	184.78	-

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Bitumen supply and consumption

Data on bitumen imports is gathered from the customs office. However, the classification of consumption data is inconsistent and needs to be reclassified to the construction industry only.

Supply and consumption of paraffin waxes

The MPE reports paraffin waxes production, stock, and sales data. However, stock data has been missing or inconsistent for some years and needs to be adjusted. Data on paraffin waxes imports is gathered from the customs office.

Table 1.15. Bitumen Supply and Consumption

Unit: 1,000 MT

	Supply	Final Consumption		
	Imports	Industry Sector	Transport Sector	
		Construction	Road	NES
2000	-		-	-
2001	-		-	-
2002	-		-	-
2003	-		-	-
2004	-		-	-
2005	-		-	-
2006	-		-	-
2007	-		-	-
2008	-		-	-
2009	-		-	-
2010	-		-	-
2011	54.11		-	54.11
2012	80.99		-	80.99
2013	114.34		114.34	-
2014	223.73		223.73	-
2015	160.40		160.40	-
2016	223.73	223.73	-	-

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Table 1.16. Supply and Consumption of Paraffin Waxes

Unit: 1,000 MT

	Supply				Final Consumption
	Gross Refinery Output	Imports	Stock at Opening	Stock at Closing	Others Sectors
					NES
2000	10.37	-	-	-	10.37
2001	1.94	-	0.27	0.46	1.75
2002	2.33	-	0.46	1.02	1.77
2003	1.87	-	1.02	0.82	2.07
2004	1.23	-	0.82	0.29	-
2005	1.06	-	0.29	0.24	1.11
2006	1.05	-	0.24	0.06	1.23

2007	0.87	-	0.06	0.03	0.90
2008	1.16	-	0.03	0.05	1.14
2009	0.82	-	0.05	0.01	-
2010	0.85	-	0.01	0.06	0.80
2011	0.91	-	0.06	0.09	0.88
2012	0.53	-	0.09	-	0.61
2013	0.71	37.49	-	0.08	-
2014	1.05	30.46	0.08	0.25	-
2015	0.77	31.63	0.25	0.19	-
2016	0.22	32.97	0.14	0.05	33.27

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Supply and consumption of petroleum coke

The MPE reports petroleum coke production, stock, and sales data. However, stock data has been missing for some years and needs to be adjusted. Moreover, the classification of sales data is inconsistent and is suggested to be reclassified to 'not elsewhere specified' of the industry sector only.

Supply and consumption of other products

The MPE reports the production data of other products, and it is used as refinery fuel directly.

Table 1.17. Supply and Consumption of Petroleum Coke

Unit: 1,000 MT

	Supply			Final Consumption	
	Gross Refinery Output	Stock at Opening	Stock at Closing	Industry Sector	Others Sectors
				NES	NES
2000	32.95	-	-	36.98	-
2001	33.46	3.54	0.65	36.35	-
2002	34.51	0.65	1.13	34.03	-
2003	25.16	1.13	1.19	25.10	-
2004	21.69	1.19	5.18	17.70	-
2005	19.52	5.18	7.53	17.17	-
2006	22.29	7.53	13.19	-	16.63
2007	19.52	13.19	13.75	-	18.96
2008	20.76	-	-	20.76	-

2009	17.56	16.90	19.26	15.20	-
2010	16.62	19.26	17.36	18.52	-
2011	12.69	17.36	11.19	-	-
2012	13.21	11.19	2.29	21.50	-
2013	13.52	2.89	4.89	11.35	-
2014	12.39	4.89	8.84	8.29	-
2015	12.99	8.84	12.07	9.75	-
2016	12.17	12.07	14.35	9.90	-

MT = metric ton, NES = not elsewhere specified.

Source: MOEE (2018).

Table 1.18. Other Products Supply and Consumption

Unit: 1,000 MT

	Gross Refinery Output	Refinery Fuel
2000	7.36	7.36
2001	11.65	11.65
2002	11.72	11.72
2003	6.37	6.37
2004	6.66	6.66
2005	6.27	6.27
2006	6.76	6.76
2007	6.00	6.00
2008	6.72	6.72
2009	6.35	6.35
2010	6.20	6.20
2011	5.18	5.18
2012	5.18	5.18
2013	5.06	5.06
2014	4.73	4.73
2015	5.35	5.35
2016	4.80	4.80

MT = metric ton.

Source: MOEE (2018).

Gas

The MOEE collects data on natural gas production by onshore and offshore gas field. The data collected includes the amount of production, export, sale, own use, flaring and venting, and loss in gas fields. Gas sales amount by clients has also been collected since 2012.

Gas production

Most of Myanmar gas is non-associated gas, whose production started in 2012. The stock data is available only after 2014, and venting and flaring data is available after 2011.

Table 1.19. Gas Production

Unit: million cubic metres

	Indigenous Production		Exports	Opening Stock	Closing Stock	Gas Vented/ Gas Flared
	Of which: Associated Gas	Of which: Non-associated Gas				
2000	-	5,190.83	3,637.39	-	-	-
2001	-	8,268.52	6,870.87	-	-	-
2002	-	10,081.82	8,365.42	-	-	-
2003	-	10,522.26	8,620.17	-	-	-
2004	-	12,060.63	10,001.44	-	-	-
2005	-	12,387.74	10,440.24	-	-	-
2006	-	13,030.51	11,032.10	-	-	-
2007	-	13,494.26	11,307.60	-	-	-
2008	-	11,476.24	9,276.80	-	-	-
2009	-	12,441.10	10,580.61	-	-	-
2010	-	12,575.10	10,349.56	-	-	-
2011	-	13,157.77	10,329.08	-	-	17.55
2012	27.75	13,188.48	10,249.01	-	-	69.09
2013	13.65	13,635.77	10,547.13	-	-	112.27
2014	13.46	18,985.32	15,244.42	39.52	47.15	33.95
2015	19.94	19,683.40	15,790.16	47.15	42.72	27.81
2016	19.24	18,941.99	14,778.53	42.72	44.15	93.95

Source: MOEE (2018).

Gas consumption in transformation and energy sector

Natural gas is used to generate electricity and produce LPG in Myanmar. It is also used in gas fields and refineries. However, data on the natural gas input in LPG plants and consumption in refinery is available only after 2012. The gas fields' own use and loss data can be traced back to 2011.

Table 1.20. Gas Consumption in Transformation and Energy Sector

Unit: million cubic metres

	Transformation Sector		Energy Sector		
	Main Activity Producer–Electricity Plants	Gas to Liquid	Oil and Gas Extraction	Oil Refineries	Distribution Losses
2000	928.98	-	-	-	-
2001	822.56	-	-	-	-
2002	953.40	-	-	-	-
2003	1,095.01	-	-	-	-
2004	1,244.01	-	-	-	-
2005	1,152.26	-	-	-	-
2006	1,047.36	-	-	-	-
2007	1,168.25	-	-	-	-
2008	1,124.84	-	-	-	-
2009	652.23	-	-	-	-
2010	1,166.70	-	-	-	-
2011	1,477.15	-	216.38	-	10.42
2012	1,622.52	24.37	217.51	56.03	0.82
2013	1,713.94	13.64	255.40	53.22	0.24
2014	2,437.08	15.06	408.67	37.16	-
2015	2,746.06	19.94	438.80	22.86	79.93
2016	3,144.26	19.24	470.96	25.42	0.49

Source: MOEE (2018).

Gas consumption by sector

Natural gas is used in the industry, transport, and other sectors. Sector consumption data can be disaggregated after 2012. Moreover, the natural gas consumption of the construction industry is found to be by the cement and the brick production industries; it needs to be reclassified.

Table 1.21. Gas Consumption by Sector

Unit: million cubic metres

	Indigenous Production					
	Iron and Steel	Chemical and Petrochemical	Non-ferrous Metals	Non-metallic Minerals	Transport Equipment	Machinery
2000	-	-	-	-	-	-
2001	-	-	-	-	-	-
2002	-	-	-	-	-	-
2003	-	-	-	-	-	-
2004	-	-	-	-	-	-
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	-	-	-
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	17.06	226.92	1.77	8.14	2.03	5.12
2013	10.32	176.68	1.81	13.43	1.70	5.23
2014	11.18	161.68	2.17	7.95	1.28	5.28
2015	6.14	184.11	2.04	7.25	0.02	5.99
2016	7.49	134.57	1.98	6.45	0.07	5.88

Source: MOEE (2018).

Electricity

The MOEE collects the data on electricity generation, export, and final consumption.

Electricity generation by source

The MOEE also collects electricity generation data from all stakeholders. Table 1.23 shows hydro, coal-fired, oil-fired, gas-fired (steam and gas) power generation. However, the electricity generation data provided by the MOEE does not include micro hydro, photovoltaic (PV), and wind reported in the renewable sector. Moreover, the export of electricity is not reported under production and should be added to hydro power generation.

Table 1.23. Electricity Generation by Source

Unit: GWh

	Hydro	Steam	Diesel	Gas	Coal	RE	Total
2000	1,891.93	661.59	36.20	2,527.92			5,117.64
2001	2,008.25	549.74	30.64	2,100.35			4,688.98
2002	2,111.02	641.48	28.50	2,286.95			5,067.95
2003	2,074.81	634.31	31.45	2,685.31			5,425.88
2004	2,407.75	123.53	33.23	2,983.35	60.38		5,608.24
2005	3,000.80	387.45	33.37	2,398.08	244.46		6,064.16
2006	3,324.63	385.05	28.08	2,025.02	401.37		6,164.15
2007	3,618.51	418.35	33.59	1,891.22	436.36		6,398.03
2008	4,071.08	394.38	39.84	1,896.50	219.85		6,621.65
2009	5,256.36	223.39	29.57	1,204.98	249.97		6,964.27
2010	6,188.53	278.18	32.66	1,733.84	391.47		8,624.68
2011	7,544.07	438.11	38.33	2,118.02	311.66		10,450.19
2012	7,766.24	505.59	50.63	2,377.39	265.05		10,964.90
2013	8,778.11	433.25	60.76	2,794.30	135.66		12,202.08
2014	8,828.85	216.01	64.89	4,977.03	69.53		14,156.30
2015	9,398.98	284.98	55.23	6,232.77	-		15,971.96
2016	9,743.85	514.64	61.12	7,537.79	9.59		17,866.99

GWh = gigawatt-hour, RE = renewable energy.

Source: MOEE (2018).

Electricity export

Since 2013, Myanmar has exported electricity to neighbouring countries such as Thailand and China. The exported electricity all comes from hydroelectric plants.

Table 1.24. Electricity Export

Unit: gigawatt-hour

	Export
2013	2,532.27
2014	1,463.37
2015	1,238.82
2016	2,381.34

Source: MOEE (2018).

Electricity consumption by final users

MOEE data covers electricity sales to final users in Myanmar. The final users consist of the residential, commercial, industry, and other sectors.

Table 1.25. Electricity Consumption by Final Users

Unit: gigawatt-hour

	Own Use	Residential	Industrial	Commercial and Public Services	Others	Loss
2000	101.86	1,361.02	1,295.43	526.51	84.98	1,747.84
2001	98.51	1,244.72	1,147.86	563.51	84.81	1,549.57
2002	92.19	1,430.88	1,417.01	552.22	83.98	1,491.67
2003	78.04	1,611.90	1,576.82	578.31	82.63	1,498.18
2004	80.38	1,662.30	1,549.09	613.08	84.71	1,618.68
2005	81.21	1,811.97	1,756.42	695.41	88.86	1,630.29
2006	82.00	1,613.94	1,853.57	826.64	60.64	1,727.16
2007	138.18	1,646.92	1,871.83	863.96	55.38	1,821.75
2008	153.36	1,798.51	1,904.44	944.98	53.33	1,767.14
2009	114.98	2,015.13	1,849.74	1,071.07	57.42	1,855.93
2010	120.00	2,653.34	2,286.76	1,306.38	65.60	2,192.60
2011	132.54	3,377.84	2,710.92	1,531.05	80.74	2,776.62
2012	196.43	2,680.91	3,848.42	1,642.58	86.28	2,514.60
2013	174.00	3,763.78	4,060.97	1,692.36	99.77	2,415.52
2014	151.81	4,112.84	5,275.78	1,754.58	131.42	2,749.54
2015	154.26	6,674.66	4,120.77	2,506.08	106.78	2,421.69
2016	127.00	7,572.60	4,650.90	3,023.27	117.81	2,384.89

Source: MOEE (2018).

Renewable Energy

The MOEE collects renewable energy data from the Ministry of Education; Ministry of Agriculture, Livestock and Irrigation; Ministry of Natural Resources and Environmental Conservation; Myanmar Engineering Society; and Renewable Energy Association Myanmar. It consists of bagasse, fuelwood, charcoal, biomass, biogas, wood waste, PV, wind, and micro hydro (Table 1.26). Consumption data is unavailable and needs to be estimated.

Table 1.26. Renewable Energy Supply

	Bagasse	Fuelwood	Charcoal	Biomass	Biogas	Wood Waste (Gasifier)	Photovoltaic (Electricity)	Wind Turbine	Micro Hydro
	1000t	Cubic Ton	Cubic Ton	1000t	(10^{10} KCal)	1000t	GWh	GWh	GWh
2000	-	18,761.00	181.88	2,262.34	-		-	-	-
2001	-	19,196.00	223.30	2,325.11	-		-	-	-
2002	-	19,644.00	259.66	2,313.42	-		-	-	-
2003	-	20,240.00	408.71	2,454.58	-		-	-	-
2004	-	20,389.00	224.80	2,626.02	-		-	-	-
2005	-	20,776.00	232.58	2,937.04	-		-	-	-
2006	-	21,513.00	296.88	3,280.83	-		-	-	-
2007	-	22,145.00	268.56	3,336.74	-		-	-	-
2008	-	22,808.00	265.91	3,455.79	-		-	-	-
2009	-	23,377.00	210.33	3,467.35	-		-	-	-
2010	-	23,954.56	211.75	3,456.50	0.50		0.00	0.02	0.02
2011	417.00	22,264.66	200.96	3,077.81	0.52	0.56	4.32	0.00	0.00
2012	604.00	22,529.47	217.00	2,939.23	0.55	0.56	4.32	0.00	0.00
2013	775.00	21,673.38	228.58	3,004.85	0.52	0.56	4.32	0.00	0.00
2014	912.00	23,319.05	231.17	2,991.15	0.52	0.56	13.91	0.00	5.75
2015	737.00	20,911.51	233.27	3,061.49	0.52	0.56	10.94	0.01	1.25
2016	652.00	21,001.26	179.68	2,938.10	0.52	0.56	9.47	0.02	1.25

GWh = gigawatt-hour, Kcal = kilocalorie, t = ton.

Source: Ministry of Education; Ministry of Agriculture, Livestock and Irrigation; Ministry of Electricity and Energy; Ministry of Natural Resources and Environmental Conservation; Myanmar Engineering Society; Renewable Energy Association Myanmar.

Estimation of Missing Data

Lots of energy data clearly exists and is useful for making Myanmar energy balance tables from 2000 to 2016. But some energy data is still missing, making estimation of missing data indispensable. The following items are estimated under this project.

– Coal: transformation input of sub-bituminous coal and lignite in electricity plants from 2014 to 2016, production of brown coal briquettes, and FeNi Factory sub-bituminous coal and lignite consumption in 2012

– Crude oil and petroleum products

- Missing data: missing opening and closing stock; petroleum coke consumption in 2011; paraffin waxes consumption in 2004, 2009, and 2013—2016

- Unreasonable data: transformation input of diesel in electricity plants from 2000 to 2006 and 2009 to 2016
- Data disaggregation: fuel oil, LPG consumption before 2014
- Data reclassification: motor gasoline, diesel oil, aviation gasoline

– Gas: missing oil and gas extraction consumption from 2000 to 2010, reclassification of construction industry gas consumption to non-metallic minerals industry

– Biomass: transformation input and output of charcoal, and consumption of all biomass

– Electricity: disaggregation of the own use of electricity plants

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Chapter 2
Energy Demand Surveys

Introduction

The energy consumption survey was conducted for the industry, road transport, residential, and commercial sectors. The survey aimed to collect the necessary consumption data to enable the estimation of Myanmar's energy consumption by sector and by type of energy source. The estimated unit consumption of the different types of fuel consumed by the sectors served as the basis for estimating the total fuel consumption of Myanmar. Inflating the survey result to the whole of Myanmar was done by multiplying the specific energy consumption (intensity) with the respective sector's activity. However, in view of the voluntary nature of this survey, limited time frame, and relatively new experience of such energy consumption surveys in the country, it was understandable that some constraints and difficulties were experienced due to lack of full understanding of some items in the questionnaire and of full cooperation from the survey subjects. The data appeared to be inconsistent and some results were erratic. To eradicate the impact of outlier data, objective interpretation and judgment were made so that reasonable results, in accordance with building practices in other ASEAN countries of similar climate, could be made in analysing the survey data. The following sections discuss the assumptions and logic used in the analyses of data.

Methodology

To achieve the objective of the consumption survey, the following steps were undertaken.

Preparation of Questionnaire

The study team, consisting of the local consultant, Myanmar Survey Research (MSR), and experts from the Economic Research Institute for ASEAN and East Asia (ERIA), staff of the Oil and Gas Planning Department (OGPD), and other departments under the Ministry of Energy and Electricity (MOEE) of Myanmar, prepared the questionnaire for the survey. The questionnaire consisted of two parts: general information and energy consumption. In the case of the industry sector, the general information consisted of the general description of the manufacturing industry, such as the name of the factory, a major product, the International Standard Industrial Classification Code, the yearly production amount of the major product, and the industry's annual gross revenue.
The questionnaires were tested during the enumerator training and were adjusted and finalized with suggestions from experts.

Sampling and Sampling Size

The industry sector sampling consisted of 13 major industry sub-sectors (Table 2.1). The sample size was to be around 20 samples per sub-sector. The final coverage was 175 samples.

The transport sector sampling is for the parking lot survey. Vehicles sampled were sedans, SUVs, pickups, trucks, buses, motorcycles (private, taxi, tuk-tuk). The sample size was 200 vehicles in 10 parking lot locations (around 20 samples per location). Usually the parking lots did not have big buses. For big buses, the approach was to interview a bus company in Yangon. The residential sector survey consisted of urban and semi-urban areas. The total sample consisted of 200 residential dwellings.

The commercial sector survey consisted of four types of commercial building: (i) office, (ii) hotel, (iii) mall/shop, and (iv) hospital. The total sample numbered 151 commercial buildings.

All samples mainly came from Yangon. The sample frame was based on the available list of establishments that the survey team sought from different sources (such as hotel and restaurant association, chamber of commerce and industry, garment association, etc.), where applicable. The sampling used both

randomised and purposive techniques, as relevant. For each sector and sub-sector, certain criteria were developed, which were discussed with and suggested by the ERIA experts during the training workshop before the start of the field survey.

Distribution and collection of survey questionnaires

The questionnaires were used to collect fuel consumption data by sector. The target respondents who were available during the survey were interviewed face-to-face. In some cases, the target respondents were not available or requested to reply to the questionnaire at their convenience. In this case, the questionnaires were emailed or left with the administration officers to be filled out by their authorised officers. The enumerators would personally go back to collect and check the completion of the form. For all interviews, the letter of introduction about the survey provided by the MOEE was attached to the questionnaires.

Since quality of information was key, the following steps were undertaken for quality assurance: (i) first check by individual enumerator, (ii) second check by supervisor, and (iii) call back or revisit (random and spot check) by the team leader/supervisor.

Industry Sector

The survey was conducted to estimate the energy consumption of the sampled industry sub-sectors.

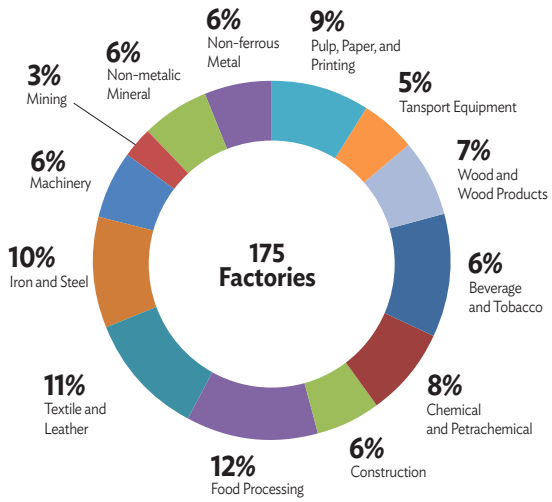
Survey results

Sampled in the survey were 175 factories under 13 industrial sub-sectors (Figure 2.1 and Table 2.1).

The survey collected the fuel consumption of the sub-sectors not only for the production process but also for other purposes such as lighting, transportation, standby power (auto generator/captive), feedstock, etc. The basis for the estimation of fuel consumption in the industry sector is the fuel consumed for the production process.

The fuel consumed by the sub-sectors was recorded in its physical unit. For coal, it is in kilogram; petroleum products except liquefied petroleum gas (LPG), in

Figure 2.1. Industry Sub-sector Samples



Source: Myanmar Survey Research (MSR) (2018).

Table 2.1. Overview Information of the Industry Sector

Industrial Sub-Sector	Sample	Total Worker	Average Worker/ facory	Main Products
Beverage and Tobacco	20	2400	120	Drinking water, fruit juice, soft drink, alcohol, energy beverage, bottling and packaging of beverages
Chemical and Petrochemical	15	2097	140	Paint, soap, liquid soap, organic fertiliser products, mosquito repellent coil, plastic bag, plastic carpet and mat, plastic basket, plastic seed products, plastic pipe products, plastic bottle, other plastic products
Construction	10	465	47	Construction work, scaffolding and construction formwork, system integrating and building solution
Food Processing	21	2329	111	Pudding bread, milk bread and cream cake, water snack, palm jam, puffed snack, milk powder, chilli sauce, edible peanut oil, canned fish, candy, sugar/mollases, instant noodle, rice paste, ice cream and ice bar, ready-made fish ball and fish bar, canned food
Textile and Leather	20	13130	657	Garment, shirt and sports shirt, uniform for office staff, female underwear, female blouse, pants and trousers, jackets, Cut-Make-Pack (CMP) garment, male jerkin production, knitting on traditional longyi, leather and PVC, leather shoes
Iron and Steel	17	1227	72	Iron sheet production, steel bar, steel rod, steel block, other steel products, elevator iron block, car rooftop tank with steel, raw iron, regulator box, iron construction material, iron ware
Machinery	10	2466	247	Agricultural machine parts production, water pump, fluorescent lamps and switch production, transformer production, electric motor, electronic, safeguard, invertor and regulator, electronic products, panel production, train jointer production

Mining	5	400	80	Lead, coal
Non-metalic mineral	10	1522	152	Cement, brick, concrete brick production, prefabricated tile, read-mixed concrete, autoclaved aerated concrete and aerial precast concrete, concrete and concrete-related product, glass and mirror
Non-ferrous metal	10	784	78	Electric wire with copper, wire production, melting of lead and aluminium, aluminium and glass, aluminium door frame, other aluminium products, car water tank with bronze
Pulp, Paper, and Printing	15	606	40	Paper, recycled paper, exercise book and ledger, poster, calendar, invitation card, paper box, other paper products, printing paper trading, carton box, printing & offset
Transport Equipment	9	769	85	Tire re-treading, battery manufacturing, car workshop, car engine air filter production, body of fibre speed boat, electric bicycle production, car production
Wood and Wood Products	13	1195	92	Wood, timbre, plywood and veneers, furniture, and other wood products
Total	175	29390	168	

Source: MSR (2018).

kilolitre; LPG, in ton; and electricity, in kilowatt-hour (kWh). The fuels must be converted into the energy unit before summation. Table 2.2 shows the density and heating values of the different fuels.

The activity of the sampled factory was represented by its sales revenue. Thus, the survey estimated the factory unit fuel consumption per sales revenue. Some sampled factories, however, consider sales revenue confidential. In this case, the samples only have consumption data. In some cases, the samples have sales revenue data, but the consumption data is only for purposes other than production. Both revenue and fuel consumption data are necessary for the production process to estimate the average unit consumption per sales revenue.

Table 2.3 shows the fuel consumption and sales revenue of the sampled factories in each sub-sector. Fuel consumption includes the fuel used for other purposes such as diesel for standby power and electricity for offices.

Table 2.2. Density and Heating Value of Fuel

Type of Fuel	Density		Heating Value	
	Unit	Value	Unit	Value
Steam Coal	-	-	kcal/kg	4,513
Lignite	-	-	kcal/kg	2,842
Wood/Blomass	-	-	kcal/kg	3,725
Sawdust	-	-	kcal/kg	2,300
Electricity	-	-	kcal/kWh	860
Natural Gas/CNG	kg/cum	0.900	kcal/cum	8,684
Liquefied Petroleum Gas	kg/ltr	0.510	kcal/kg	11,295
Diesel	kg/ltr	0.999	kcal/kg	10,268
Gasoline	kg/ltr	0.862	kcal/kg	10,579
Fuel Oil	kg/ltr	0.947	kcal/kg	9,648
Lubricant	kg/ltr	0.858	kcal/kg	9,600
Other Oil Products	kg/ltr	0.858	kcal/kg	9,600
Naptha	kg/ltr	0.740	kcal/kg	10,579

CNG = compressed natural gas, cum = cubic metre, kg = kilogram, ltr = litre, kcal = kilocalorie, kWh = kilowatt-hour.

Source: ASEAN/APEC-IEA Joint Energy Format-energy questionnaires of Myanmar.

Inflation to total consumption

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

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

Where:

ECi is the total energy consumption for sector i

IECi is the energy consumption per revenue for sector i (intensity)

GDPi is the total GDP for sector i

VARi is the value-added ratio for sector i (assumed to be 0.5 for all sector).

Table 2.3. Sales Revenue and Fuel Consumption

Sampled Industry Sub-sectors	Sales Revenue (mil. US$)	Fuel Consumption (ktoe)	ktoe/mil. US$	Fuel Share (%)							
				Coal	CNG	Electricity	Diesel	LPG	Other Oil Products	Biomas	Total
Manufacturing/Processing	206.636	31.199	0.1510	4%	5%	42%	19%		1%	30%	100%
Iron and Steel	5.860	5.309	0.906	3%		93%	2%			3%	100%
Chemical (incl. Petrochemical)	18.601	3.174	0.171		19%	60%	5%		0.01%	16%	100%
Non-ferrous Metals	4.409	0.535	0.121	10%		61%	29%				100%
Non-metalic Mineral Products	39.190	3.860	0.098	21%	9%	19%	43%		7.20%	0.1%	100%
Transportation Equipment	44.963	1.411	0.031		37%	52%	9%	3%			100%
Machinery	17.083	0.836	0.049			48%	32%			20%	100%
Food Processing	4.364	4.450	1.020	2%		20%	17%			61%	100%
Beverage and Tobacco	21.257	7.165	0.339			24%	24%			52%	100%
Pulp, Paper, and Printing	9.601	0.955	0.099			27%	10%			63%	100%
Wood nd Wood Products	11.740	0.657	0.056			2%	50%		0.17%	29%	100%
Textiles and Leather	29.669	2.848	0.096	7%		36%	17%		0.03%	41%	100%
Construction	9.364	0.241	0.026			29%	71%		0.4%		100%
Mining and Quarrying	8.982	0.452	0.050			3%	91%		6%		100%
Total Industry	224.982	31.893	0.142	4%	5%	41%	20%	0.1%	1%	29%	100%

Note: US$1.00 = 1,100 kyat (MK).

CNG = compressed natural gas, ktoe = kiloton of oil equivalent, LPG = liquefied petroleum gas.

Source: Author's calculation.

Myanmar's GDP structure comprises the agriculture, industry, and services sectors (Table 2.4). The data was collected by the MSR from the Central Statistical Organization (CSO) for 2013–2014 to 2016–2017. The GDP from 2010–2011 to 2012–2013 was obtained directly from the 2018 Myanmar Statistic Yearbook of the CSO.

Table 2.4. Myanmar GDP (Million MK, Current Price)

Sectors	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016 (PA)	2016-2017 (End of March)
AGRICULTURE	4,658,961.3	15,048,295.7	15,680,310	17,132,994	18,162,255	19,466,837	20,300,036
Agriculture	11,108,404	11,113,043	11,349,615	12,316,082	12,780,581	13,417,668	13,736,113
Livestock and Fishery	3,392,103	3,758,635	4,141,221	4,631,984	5,243,294	5,906,519	6,505,196
Foresty	158,45	176,617	189,474	184,929	138,380	142,650	58,727
INDUSTRY	10,528,140	14,490,502	16,594,171	18,773,850	22,508,640	25,063,666	27,917,838
Energy	66,995	2,241,424	2,745,828	2,919,975	4,011,395	3,687516	2,669,961
Mining	299,433	469,269	418,324	547,645	789,099	759,982	835,280
Processing and Manufacturing	7,900,494	9,132,523	10,299,192	11,553,545	13,007,190	15,130,437	18,167,437
Electric Power	421,883	481,449	614,930	695,854	926,866	1,030,837	1,111,244
Construction	1,839,335	2,165836	2,515,898	3,056,830	3,777,091	4,454,895	5,133,917
SERVICE	14,589,664	16,769,090	18,984,779	22,104,782	24,590,995	28,183,518	31,503,024
Transportation	4,589,664	5,511,332	6,112,724	6,925,716	7,512,856	8,239,653	8,948,035
Communications	332,227	401,983	605,797	913,832	1,158,120	1,512,271	1,638,900
Financial Institution	37,715	65,318	85,346	114,385	139,681	173,402	233,833
Social and Administrative Services	915,720	989,006	1,326,077	1,683,301	2,025,534	2,686,744	2,806,427
Rental and Other Services	738,484	883,291	1,095,646	1,323,898	1,537,312	1,812,108	2,159,037
Trade	7,971,161	8,918,160	9,759,190	11,143,651	12,217,492	13,759,341	15,716,793
GROSS DOMESTIC PRODUCT	39,776,765	46,307,888	51,259,260	58,011,626	65,261,890	72,714,021	79,720,898

Source: MSR (2018); Central Statistical Organization (CSO) website.

The industry sector's contribution to total GDP reached around 35% in 2016, increasing from its share of 26% in 2010. The industry sector was separated into (i) energy, (ii) mining, (iii) processing and manufacturing, (iv) electric power, and (v) construction. In a similar table of the Asian Development Bank for

Myanmar's GDP by industrial origin (current price) (ADB, 2017), the mining and quarrying GDP is the sum of the mining and energy GDP in Table 2.4.

There was no further breakdown of processing/manufacturing into the different sub-sectors. In this regard, the share of the revenue in the sampled survey was used to break down industry sector GDP. In addition, industry GDP used to calculate the national total excludes the electricity sub-sector GDP since the energy balance table (EBT) breakdown of the industry excludes the electric power sub-sector. The calculation of total consumption was done for 2016 to be in accordance with the OGPD data representation of the Myanmar EBT (Table 2.5).

Table 2.5. Estimated Total Energy Consumption

Main Activity	Sampled Sub-sector Revenue Share, %	GDP 2016		Survey Result	Estimated Energy Consumption (Ktoe)
		mil. MK Transfers	mil. US$	ktoe/mil. US$	
Industry		2,680,655	24,370	0.11385	387
Manufacturing	100%	18,167,437	16,516	0.15099	1,247
Iron and Steel	3%	515,194	468	0.90593	212
Chemical (incl. Petrochemical)	9%	1,6353,89	1,487	0.17066	127
Non-ferrous Metals	2%	387,679	352	0.12123	21
Non-metallic equipment	19%	3,445,579	3,132	0.09849	154
Transportation equipment	22%	3,953,116	3,594	0.03138	56
Machinery	8%	1,501,906	1,365	0.04892	33
Food Processing	2%	383,650	349	1.01984	178
Beverage and Tobacco	10%	1,860,154	1,691	0.33866	286
Pulp, Paper, and Printing	5%	844,078	767	0.09945	38
Wood and Wood Products	6%	1,032,219	938	0.5598	26
Textiles and Leather	14%	2,608,473	2,371	0.09598	114
Construction		5,133,917	4,667	0.02577	60

Note: US$1.00 = 1,100 kyat (MK).

ktoe = kiloton of oil equivalent.

The estimated total energy consumption of industry based on the survey result was 1,387 ktoe. Using the fuel shares calculated from the survey as shown in Table 2.3, the estimated total energy consumption by fuel in 2016 showed that majority of the fuel consumed by the manufacturing sector was electricity followed by biomass and oil, which mainly was diesel (Table 2.6)

Table 2.6. Estimated Total Energy Consumption by Fuel (ktoe)

Main Activity	Estimated Energy Consumption (ktoe)	Coal	Gas	Electricity	Diesel	LPG	OOP	Total Oil	Biomass	CHECK total
Industry	1387	53	59	542	348	2	16	365	368	1387.23
Manufacturing/ Processing	1247	53	59	522	232	2	11	245	368	1246.83
Iron and Steel	212	6	0	196	3	0	0	3	6	212.15
Chemical (incl. Petrochemical)	127	0	24	76	7	0	0	7	20	126.86
Non-ferrous Metals	21	2	0	13	6	0	0	6	0	21.36
Non-metallic Mineral Products	154	32	14	30	67	0	11	78	0	154.25
Transportation Equipment	56	0	21	29	5	2	0	6	0	56.38
Machinery	33	0	0	16	11	0	0	11	7	33.40
Food Processing	178	4	0	36	30	0	0	30	108	177.85
Beverage and Tobacco	286	0	0	68	68	0	0	68	150	286.34
Pulp, Paper, and Printing	38	0	0	10	4	0	0	4	24	38.16
Wood and Wood Products	26	0	0	5	13	0	0	13	8	26.26
Textiles and Leather	114	8	0	41	19	0	0	19	46	113.80
Construction	60	0	0	18	43	0	0	43	0	60.14
Mining and Quarrying	80	0	0	3	73	0	5	78	0	80.27

Source: Author's calculation

The estimated total industry consumption was 73% lower than that of the EBT (Table 2.7). In addition, the shares of the fuel consumed were also different. In

Myanmar EBT 2016, majority of the fuel consumed by the industry was biomass (44%) and diesel (34%).

Also, some data was available for the sub-sector consumption, particularly natural gas consumption. Most of total consumption was entered as non-specified industry consumption because no sub-sector consumption data was available. The industrial survey was conducted to estimate the total consumption of these sub-sectors.

Table 2.7. Industry Energy Consumption by Fuel (ktoe)

INDUSTRY SECTOR	Coal	Petroleum Products	Gas/ Diesel Oil	Fuel Oil	LPG	Other Petroleum Products	Gas	Others	Electricity	Total
Total Industry	419	3,860	3,509	120	0	231	530	4,610	800	10,219
Manufacturing/ Processing	210	1,823	1,754	60	0	8	265	2,305	400	5,002
Iron and Steel	37						7			44
Chemical (incl. Petrochemical)							117			117
Non-ferrous Metals							2			2
Non-metallic Mineral Products	123						119			242
Transportation Equipment							0			0
Machinery							5			5
Food, Beverages and Tobacco							6			6
Pulp, Paper and Printing							0			0
Wood and Wood Products										
Textiles and Leather							8			8
Non-specified Industry	49	1,823	1,754	60		8	2	2,305	400	4,578
Construction		215				215				215
Mining and Quarrying										

LPG = liquefied petroleum gas.

Source: Myanmar EBT 2016.

The estimated total consumption from the current industry survey was significantly different from the OGPD data in the Myanmar EBT 2016. The differences were due to the limitation of the GDP statistics. Since no data was available on manufacturing GDP by sub-sector, shares of sub-sector revenue were used to calculate sub-sector breakdown. Multiplying the sub-sector GDP with its intensities (ktoe/million MK) will give the estimated industry consumption of the sub-sectors at the national level.

The real share of these sub-sectors' manufacturing GDP can be obtained by improving the national account statistics to include the value added for the manufacturing sub-sectors. Some surveyed samples exclude revenue data; the exact value-added ratio is also not available. These limitations of the survey and Myanmar's national account statistics affected the estimation of industry intensities.

This energy consumption survey of the industry sector is the first of its kind for the OGPD. Therefore, there will be differences between the estimated fuel consumption from the survey result compared to the EBT data collected by the OGPD. As a conclusion, the survey results can further be improved in the future, which will contribute to the breakdown of energy consumption in the industry sub-sectors.

Future improvement

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

Sales revenue is confidential in some factories surveyed; thus, it is not possible to calculate the unit energy consumption of these factories. In addition, the sample results of the unit energy consumption also exhibited outliers. Both missing sales revenue and outliers reduce the accuracy of the average unit energy consumption in each sub-sector.

In the future, before the survey, the OGPD will need to collect the list of manufacturing industries operating in Myanmar to understand the population of

the different sub-sectors. The number of samples is recommended to be more than 175 since some factories have missing sales revenue data and some have outliers.

At the national level, gross value added of the sub-sector indicates sub-sector activity. Therefore, inflating the industry survey result of the estimated energy consumption to the national level needs the breakdown of the Myanmar manufacturing GDP by the surveyed sub-sector. The current GDP structure of Myanmar excluded the gross value added of the manufacturing sub-sectors.

Another option to estimate the unit energy consumption is per production amount of each sub-sector surveyed. At the national level, this will also need the total production of the sub-sector to estimate its energy consumption. In conclusion, the national production or gross value added of the sub-sectors is very important in estimating the total energy consumption of Myanmar industries.

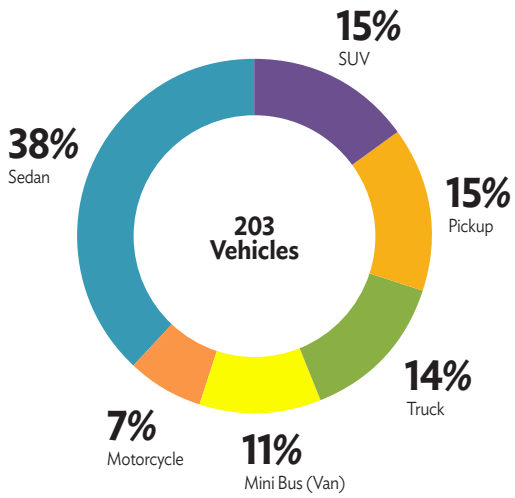
Road Transportation Sector

Survey result

The parking lot survey was conducted in several areas of Yangon. These areas were the Mahabandoola Road and Anawrahta Road (downtown areas), Junction City and Myanmar Plaza (shopping areas), Aung Mingalar Highway Bus Terminal and Dagon Ayer Highway Bus Terminal (highway bus terminals), Yangon Central Railway Station, and Yangon International Airport. Sampled vehicles totalled 203 (Figure 2.2), consisting of 77 sedans, 31 SUVs, 30 pickups, 28 trucks, 22 minibuses/vans, and 15 motorcycles.

The fuel consumed by the sampled vehicles were either gasoline, diesel, compressed natural gas (CNG), or dual. The latter was mainly consumed by taxis under the category 'sedan'. Figure 2.3 shows the fuel consumption of the sampled vehicles and their share. Overall, of the 203 vehicles sampled, 61% consumed gasoline, 33% consumed diesel, 4% CNG, and 2% dual fuel. The share of the vehicles by type and fuel share is the basis in estimating the national road transport consumption by vehicle type.

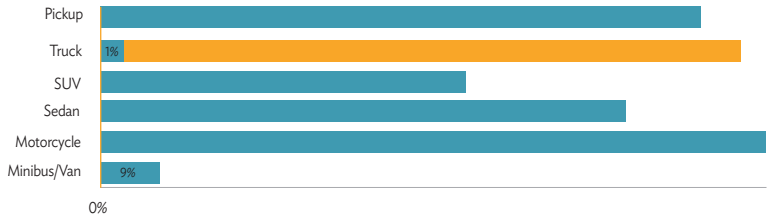
Figure 2.2. Type of Vehicles Sampled



Source: Author's calculation.

Based on the vehicles' weekly consumption and distance travelled, it is possible to calculate the average fuel economy of the vehicle and its distance travelled over the year. The fuel economy of the vehicle is the relationship between the distance travelled and the amount of fuel consumed by the vehicle.

Figure 2.3. Breakdown of Vehicles by Fuel Consumed



	Minibus/Van	Motorcycle	Sedan	SUV	Truck	Pickup
Gasoline	2	15	61	17	1	27
Diesel	19		6	14	26	2
CNG	1		6		1	1
Dual			4			

CNG = compressed natural gas, SUV = sport utility vehicle.

Source: Author's calculation.

Consumption can be expressed in terms of volume of fuel to travel a distance, or the distance travelled per unit volume of fuel consumed. In the calculation, some samples are outliers and are, thus, removed from the data. An outlier is an observation that lies at an abnormal distance from other values in a random sample from a population.

Table 2.8. Fuel Economy and Distance Travelled of Sampled Vehicles

Type of Vehicles	Average km/litre		Avergae Km/Kg	Average Km/Year			FUEL USE (Ltr)/CAR		
	Gasoline	Diesel	CNG	Gasoline	Diesel	CNG	Gasoline	Diesel	CNG
Passenger Car	9.4	7.0	17.5	12,904	9,001	29,367	1380	1278	1676
Bus	-	2.7	10.7	-	14,114	23,040	-	5186	2160
Pickup	11.5	9.7	12.3	10,159	9,570	15,288	886	990	1248
Truck	-	5.9	11.1	-	15,284	14,400	-	2571	1296
Motorcycle	23.2	-	-	3,468	-	-	150	-	-

Passenger Car includes SUV.

CNG = compressed natural gas, kg = kilogram, km = kilometre.

Source: Author's calculation.

Table 2.8 shows the calculated average fuel economy and distance travelled for the sampled vehicles according to the type of vehicle.

Inflation to national total

Based on the unit fuel consumption of the different types of vehicles obtained from the survey, total consumption of road transport was estimated as follows:

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

Where:

Fueli is the total gasoline/diesel/CNG consumption for vehicle type i

FEi is the fuel economy of vehicle type i

DISi the distance travel of vehicle type i

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

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

The total number of vehicles is the activity data for the road transport sector. The CSO provided the annual transportation statistics based on vehicle registration. CSO data showed the annual number of vehicles by type of vehicle and by area (Yangon and others). No breakdown by fuel consumed was available in the annual statistical publication of the CSO.

The consultant (MSR) was able to obtain vehicle population by type of vehicle and fuel consumed as of June 2018 (Table 2.9) from the Road Transport Administration Department of the Ministry of Transport and Communication.

Table 2.9. Vehicle Population in Myanmar 2018

Type of Vehicle	Fuel						Total
	Gasoline	Diesel	CNG	LPG	EV	HV	
Passenger car	426,626	98,933	1,364	66	449	3,226	530,664
Bus Car	585	21,555	5,456	3			27,599
(Light Duty)	142,355	191,851	3,267	104	13	5	337,595
(Heavy Duty)	447	55,754	604	3			56,808
Two-wheeler	5,738,085				3,402	32	5,741,519
Three-wheeler	97,316	458			527	1	98,302
Trailer Jeep	623	42,848					43,471
Heavy Machinery		1,792					1,792
Trailer							15,821
Others	2,452	89,761	448	2	1		92,664
Total	6,408,489	502,952	11,139	178	4,392	3,264	6,946,235

Description:

1. 'Passenger car' includes saloons, station wagons, microbuses (can carry up to 15 passengers), light vans, jeeps, and double cabs.

2. 'Bus car' includes minibuses (can carry over 15 passengers) and buses.

3. 'Light truck' includes pickups, single cabs, light trucks, vans, and trucks that can carry up to 3 tons.

4. 'Heavy truck' includes vans and trucks that can carry over 3 tons.

5. 'Others' include ambulance vehicles, fire-fighting vehicles, cranes, hearses, fuel bowsers (tankers), mobile water tanks, vehicle-carrying pipes, salvage trucks, vehicle-carrying drilling machines, dump trucks, and concrete mixer trucks.

CNG = compressed natural gas, EV = electric vehicle, HV = hybrid vehicle, LPG = liquefied petroleum gas.

Source: MSR from Road Transport Administration Department, Ministry of Transport and Communication.

Not all vehicles in the statistics were surveyed. LPG, electric, and hybrid vehicles were not surveyed. In addition, three-wheelers, trailer jeeps, heavy machinery, trailers, and others were also not surveyed. As a result, only the number of vehicles for passenger cars, buses, light duty trucks, heavy duty trucks, and two-wheelers were used in estimating total consumption. In addition, the estimation was limited only to gasoline, diesel, and CNG vehicles.

MSR and CSO data was used to estimate the number of vehicles in 2016. The resulting number of vehicles to calculate the total fuel consumption for road transport in 2016 was 6.1 million (Table 2.10), where 5.3 million were two-wheelers (motorcycles). By fuel consumed, majority of the vehicles (94%) consumed gasoline. The remaining were diesel vehicles (5.3%) and CNG vehicles (0.2%). Table 2.10 shows the number of vehicles by type and fuel consumed and their intensity (consumption per vehicle per year).

Table 2.10. Number of Vehicles and Fuel intensity per Vehicle

Vehicle Types	Number of Vehicles				Fuel Use (ltr) / Car		Fuel Use (Kg) / Car
	Total	Gasoline-fuelled	Diesel-fuelled	CNG-fuelled	Gasoline-fuelled	Diesel-fuelled	CNG
Passenger Car	508,534	411,737	95,480	1,316	1,380	1,278	1,676
Bus	26,798	568	20,932	5,298	-	5,186	2,160
Pick-Up	261,292	110,220	148,542	2,530	886	990	1,248
Truck	61,144	481	60,012	650	-	2,571	1,296
Motorcycle	5,267,952	5,267,952			150	-	-
TOTAL	6,125,719.31	5,790,958.13	324,966.90	9,794.28			

CNG = compressed natural gas, kg = kilogram, ltr = litre.

Source: Author's calculation.

Applying the formula, multiplying the number of vehicles with their intensity resulted in the total consumption of vehicles at the national level. The result showed that consumption of total petroleum products for road transport in Myanmar was around 1,889 ktoe where 70% of this total was gasoline consumption, 29% was diesel consumption, and 1% was CNG (Table 2.11). In terms of its physical unit, total gasoline consumption for road transport was 1,453,916 kl while for diesel consumption, the result was 531,983 kl. The CNG consumed by the road transport sector reached 17,650,335 kg.

Table 2.11. Estimated Total Consumption of Road Transport

Vehicle Type	Gasoline	Diesel	Ttotal Oil	CNG	Gasoline	Diesel	CNG	Total
	kl			kg	Ktoe			
Passenger Car	568,132	122,064	690,196	2,206,732	518	125	2	645
Bus		108,552	108,552	11,444,209		111	9	122
Pick-up	97,699	147,057	244,756	3,156,822	89	151	2	243
Truck		154,310	154,310	842,573		158	1	159
Motorcycle	788,086		788,086		719			719
TOTAL	1,453,916	531,983	1,985,900	17,650,335	1326	546	14	1889

Source: Author's calculation.

Table 2.12 shows the Myanmar EBT 2016 only for the road transport sector. The table includes consumption of other petroleum products for the road transport sector. This is the lubricant consumed by the vehicles. The lubricant consumption was deducted from the total consumption for comparison with the estimated total consumption from the survey.

In terms of total consumption, the estimated result of the OGPD data was 1,885 ktoe, slightly lower than the OGPD data in Table 2.12 (1889 ktoe). By fuel type, gasoline consumption from the estimation was only 0.4% lower than the OGPD data. In this regard, the major study results (fuel economy and mileage) could be useful for the analysis of gasoline vehicles.

Diesel and CNG consumption, however, differ significantly. The estimated diesel consumption was 39% higher than the OGPD data while CNG was only around one-tenth of the OGPD data. Diesel is mainly consumed by buses and trucks. Buses included minibuses that can carry over 15 passengers, trucks were heavy trucks carrying over 3 tons, and light trucks were pick-ups and those carrying less than 3 tons. In the calculation, no differentiation was made on the fuel economy and mileage of buses since the statistics on registered vehicles provide only the total number. Similarly, with trucks, the differentiation is only on the type of truck, whether it is a light or heavy truck. In addition, the vehicle intensity was multiplied by the number of vehicles. Usually for bus and truck companies, the number in operation in a year will be less than the total number. Assuming operating buses and trucks were 70% of the total number, the reduction will result in a total consumption around 7% higher than the OGPD data.

In the case of CNG, the sampled vehicles were only 13 (Figure 2.3), of which 4 were dual fuel vehicles. The fuel economy and distance travelled of the surveyed CNG passenger cars as shown in Table 2.8 were 17.5 km/kg and 29,367 km, respectively. Therefore, the intensity of the CNG passenger cars was 1,674 kg per vehicle. Compared with the study on Urban Transport Scenario of Yangon, Myanmar (Win and Dhakal, 2015), the intensity of CNG vehicles was around 5,000 kg per vehicle (Table 2.12). Clarification on the number of CNG vehicles, the fuel economy, and annual mileage of the vehicles (taxi, bus, etc.) will be necessary to calculate the national CNG consumption.

Table 2.12. Survey Table: Vehicles (km) and Fuel Efficiency by Vehicle Type

	Primary Products Receipts	Inter-product Transfers
Gasoline Passenger Vehicles	29,230	9.24
Diesel Passenger Vehicles	27,892	9.26
CNG Passenger Vehicles	54,057	11.45

CNG = compressed natural gas, kg = kilogram, km = kilometre.

Source: Survey result.

Table 2.13. Road Transport Fuel Consumption, 2016 (ktoe)

	Petroleum Products	Motor Gasoline	Gas/Diesel Oil	Other Oil Products (OOP)	Gas	Total	Total - OOP
Road	1,902	1,331	394	177	164	2,066	1,889

Source: ERIA (2016).

Future improvement

The Road Transport Administration Department, Ministry of Transport and Communication (RTADMTC) provided the registered number of vehicles by type of vehicle and by the fuel it consumed. Further data on fuel consumption such as gasoline, diesel, and CNG will be necessary. In addition, fuel economy and the annual mileage of each vehicle type will be estimated. The availability of the data will result in a more accurate estimation of the fuel consumption at the national level.

For the future, the OGPD should approach the RTADMTC and collect information on the engine size of the registered vehicles. Collecting the detailed

registered number of vehicles will make possible differentiation of the vehicle population by type, engine size, and fuel consumed.

The statistics on the number of vehicles need to be clarified – whether it is all in operation or just a cumulative number from previous years. Consequently, the RTADMTC should collect every year the number of scrapped vehicles.

Lastly, estimation of the fuel consumed by the transport sector needs to be compared with the fuel sales of oil and gas companies to the pump stations and to the gas filling stations. Comparing this sales data to that of the pump and gas filling stations will provide the fuel consumption used in the road transport sector.

2.5 Commercial Sector

The commercial sector consists of five categories of buildings (Table 2.14).

Table 2.14. Categories of Commercial Buildings and Sample Size

Category of Buildings	Sample Size
Offices	44
Hotels	29
Shopping Malls	13
Restaurants	40
Hospitals	25
Total sample size	151

Source: MSR (2018).

A useful method to evaluate the energy performance of commercial buildings is to derive a benchmark value in building energy intensity (BEI) from the survey data. BEI is expressed as kWh per m2 per year and can be determined by the following formula:

$$BEI = \frac{(TBEC - CPEC - DCEC)}{(GFA - DCA - GLA \times FVR)} \text{ x } \frac{AWH}{WOH}$$

Where:

TBEC total building energy consumption (kWh/y)
CPEC car park energy consumption (kWh/y)
DCEC data centre energy consumption (kWh/y)
GFA gross floor area ($m^{2)}$
DCA data centre area (m^2)
GLA gross lettable area (m^2)
FVR floor vacancy rate *(%)*
AWH average weekly hours (hr/week) – based on nationwide practice
WOH weighted weekly operating hours (hr/week)
BEI building energy intensity (kWh/m2/y)

The analyses discussed below were compared with similar benchmark values of BEI in Malaysia and energy use intensity (EUI) in Singapore. Typical BEI and EUI values for commercial buildings in similar climatic conditions such as Singapore and Malaysia are given in Table 2.15. The information provided in this table was extracted from publications made by the Green Building Index Sdn Bhd, Malaysia and the Building Construction Authority, Singapore, and from the author's interpretation.

Office buildings

The key data obtained in the survey were the following:

1) Total electricity consumption per year (kWh/year)
2) Energy consumption per year of other energy sources (i.e., fuel energy other than electricity)
3) Daily operational hours
4) Total GFA (in m2 – excluding car park and data centre)

A total of 44 survey data sets for office buildings were analysed. It was also noted that the operational hours of office buildings varied and the average operational hours amongst the buildings surveyed turned out to be 2,453 hours per year, or an average of 47 hours per week. The average operational hours seemed low compared with those adopted by the green building practices in Malaysia, which use a value of 2,700 hours per year. This is an average of 52 hours per week. The latter included some extended working hours beyond the official operational hours in offices where air-conditioning systems were still operational.

Nevertheless, the analysis of Myanmar survey data is based on the average value of office operational hours of 47 hours per week. After adding the consumption of other energy sources, total energy consumption was adjusted to reflect the same operational hours of 2,453 per year to rationalise the energy consumption for comparison purposes on the same basis.

Table 2.15. Comparison of Building Energy Intensity Values

Building Type	EUI for Green Mark, Singapore (kWh/m²/year)		BEI for GBI, Malaysia (kWh/m²/year)	
	EUI for Green Mark, Singapore	Green Building Entry Level	Gas/ Diesel Oil	Green Building Entry Level
Office Buildings	268 (Small) 212 (Large)	160	250	150
Hotels	267	260	N/A	200 for 3-star and below 290 for 4-star and above
Retails Buildings	366	360	345	240 for malls consisting of general retail outlets and low-energy intensity outlets. 350 for malls consisting of at least 10% (of its NLA) high-energy intensity outlets such as F&B, supermarkets, and outlets operating long hours, such as cinemas, etc.
Hospitals	345	N/A	300	200 for hospitals providing limited clinical services such as day surgery, etc. 290 for hospitals providing major clinical services (requiring high energy intensity)

BEI = building energy intensity, EUI = energy use intensity, F&B = food & beverage, kWh = kilowatt-hour, NLA = net lettable area.
Source: Green Building Index Sdn Bhd, Malaysia and BCA Green Mark, Singapore.

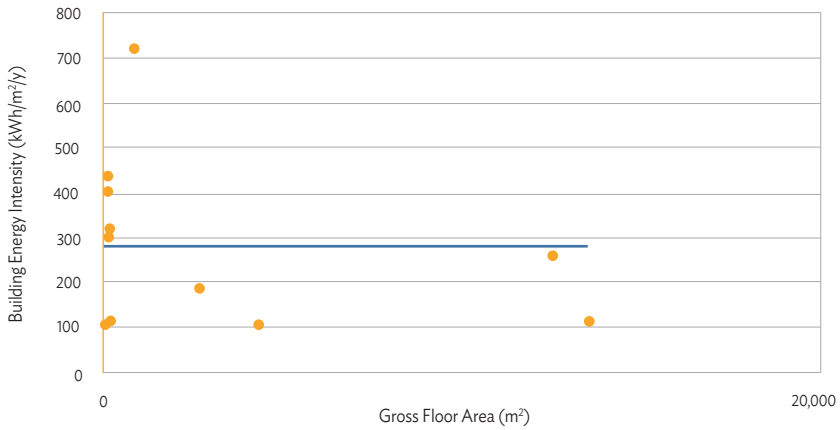
The main energy source of office buildings was electricity. However, some office buildings recorded higher consumption of diesel fuel than electricity consumption, e.g. ,3,360 litres per year of diesel fuel consumption (or 33,595 kWh per year of electricity equivalent) versus a record of 4,200 kWh of electricity consumption at the same premises. In some office buildings, the consumption of diesel fuel is almost as much as electricity consumption, e.g., 324,192 kWh yearly electricity consumption versus 24,300 litres per year of diesel fuel (or 242,960 kWh per year of electricity equivalent). Data shows that consumption of diesel fuel in office buildings is substantial at about 10% of total energy consumption.

BEI values were determined using the total energy consumption based on the rationalised operational hours and the GFA recorded in the survey. Preliminary analysis showed exceptionally low BEI value (151 kWh/m^2/year) compared with office buildings in Malaysia and Singapore, which have similar climatic conditions.

Preliminary analysis of BEI values shows an average BEI value of about 151 kWh/m2/year, which is not realistic because that of the average conventional buildings without the incorporation of energy efficiency design and installation is in the range of 250 kWh/m2/year in Malaysia and 246 kWh/m2/year in Singapore (Table 2.2). The discrepancies could be due to the accuracy of the energy consumption data and the GFAs, and the average operational hours in office buildings. It was noted that some BEI values calculated from the survey data were much less than 100 kWh/m2/year and some BEI values calculated were even near zero. Therefore, these BEI calculated values were considered outliers.

Further analysis was conducted by keeping to the range of BEI values calculated from the survey data to within 100 kWh/m2/year to 750 kWh/m2/year. The BEI values outside this range were deemed to be outliers and, hence, were excluded in the analysis. Having discarded the outliers, the final analysis was based on a small pool of 11 data sets. Figure 2.4 shows the results of this analysis.

Figure 2.4. Analysis of Building Energy Intensity for Office Buildings



Source: Author's calculation.

An average BEI value of 279 kWh/m2/year was derived from the survey data. For the purpose of this survey, the average benchmark value of energy consumption intensity for office buildings in Myanmar is 280 kWh/m2/year. This average BEI value and the national statistical information on office space are used to project national energy consumption in office buildings in the country. Table 2.16 provided by the MSR shows the government and private office spaces in and outside Yangon for 2015.

Table 2.16. Government and Private Sector Office Building Space in Myanmar

	Office Space in Yangon (m^2)	Office Space outside Yangon (m^2)	Total Office Space in Myanmar (m^2)
Government Office Buildings	5,160,726	549,192	5,709,918
Private Sector Office Buildings	1,269,314	755,608	2,024,922

Source: ADB (2015).

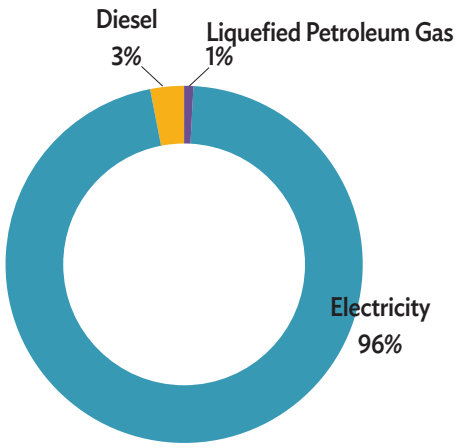
Table 2.16 shows that government office space is about four times that of private sector office space in Yangon. Comparing the total office space in the whole country, government office space is almost three times more than that of the private sector. However, the survey of energy consumption in office buildings conducted in Yangon was mainly of private sector office buildings. Therefore, the average BEI value calculated from the survey data might be biased towards private sector office buildings.

Figure 2.5 shows that the main energy source of office buildings is electricity, which takes up 96% of total energy consumption. Other energy sources are diesel and LPG.

Hotels

The key data obtained in the survey were the following:
1) Total electricity consumption per year (kWh/year)
2) Energy consumption per year of other energy sources (i.e., fuel energy other than electricity)
3) Star ratings of hotels
4) Total GFA (m2 – excluding car park and data centre)
5) Total number of hotel rooms

Figure 2.5. Average Share of Energy Sources for Office Buildings in Myanmar

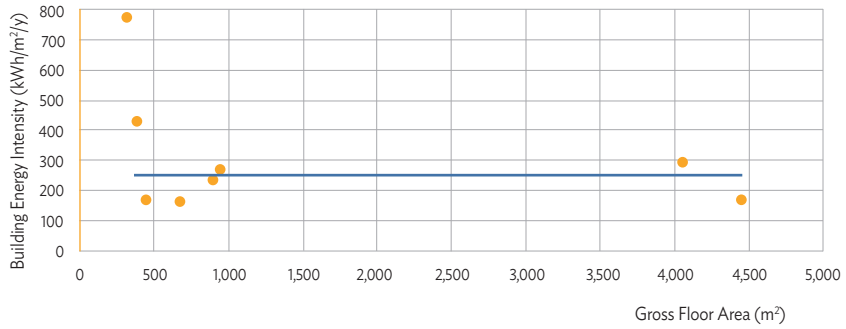


Source: Author's calculation.

The analyses of BEI values based on the survey data were conducted under two categories: 1–3 star-rated hotels and 4–5 star-rated hotels. The main energy source for both hotel categories was electricity. Total energy consumption was derived from the yearly consumption values of electricity, diesel, and LPG. Based on the GFA obtained in the survey, BEI values were calculated.

The BEI values calculated from the survey data for 1–3 star-rated hotels, whose sample size was 20, were inconsistent. Some BEI values calculated were much less than 100 kWh/m2/year; some were even almost zero, while some BEI values exceeded 700 kWh/m2/year. Some of these high BEI values calculated were in the range of 785 kWh/m2/year to 2,153 kWh/m2/year. Figure 2.5 shows the analysis of BEI values, which exclude the extreme values of low and high BEI values. The analysis of BEI values was confined to 160 kWh/m2/year to 420 kWh/m2/year. BEI values outside this range were considered outliers. This has resulted in reducing the sample size to 7 instead of 20 hotels for the analysis. The result of the analysis of 1–3 star-rated hotels is shown in Figure 2.6, which derives an average BEI value of 246 kWh/m2/year from the seven sets of data.

Figure 2.6. Analysis of Building Energy Intensity for 1–3 Star-Rated Hotels

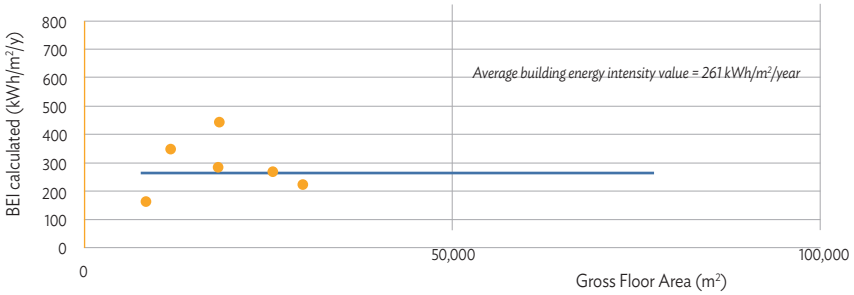


kWh = kilowatt-hour.

Source: Author's calculation.

The BEI values calculated from the survey data for 4–5 star-rated hotels were more consistent but the sample size for this category was small at six hotels only after discarding the outliers. The range of relevant BEI values calculated was kept to within 250 kWh/m2/year to 450 kWh/m2/year to enhance the derivation of more appropriate BEI values. Figure 2.7 shows that the average BEI value for 4–5 star-rated hotels is 261 kWh/m2/year.

Figure 2.7. Analysis of Building Energy Intensity for 4–5 Star–Rated Hotels



Source: Author's calculation.

Table 2.17. Statistical Information on Hotels, Motels, and Guest Houses in Myanmar

Item	States/Regions	No. of Hotels, Motels, and Guest Houses	No. of Rooms
1	Kachin State	29	856
2	Kayah State	17	368
3	Kayin State	24	880

4	Chin State	6	171
5	Sagaing Region	33	1,265
6	Tanintharyi Region	39	1,525
7	Bago Region	70	1,755
8	Magway Region	35	845
9	Mandalay Region	380	13,604
10	Mon State	52	1,683
11	Rakhine	60	1,892
12	Yangon	387	20,123
13	Shan State	314	10,259
14	Ayeyarwaddy Region	79	3,264
15	Nay Pyi Taw	65	5,488
	Union Total	1,590	63,978

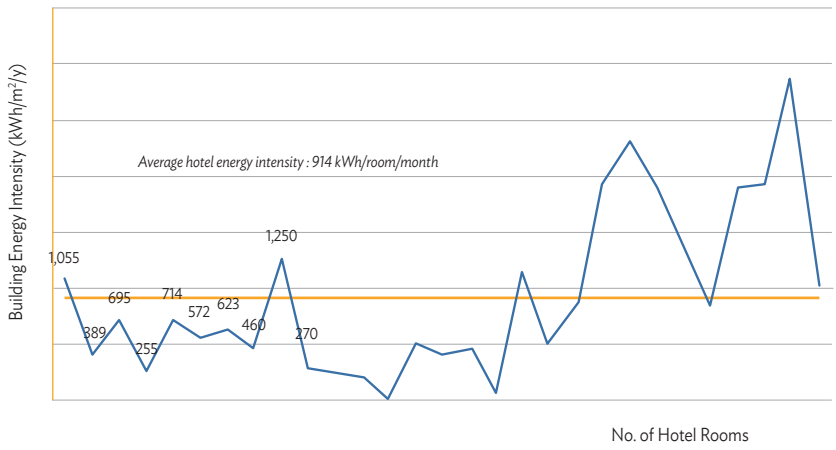
Source: MSR (2018).

Since the hotel statistical information available in Myanmar is number of hotel rooms (without being classified under hotel star rating), the use of the BEI method to estimate the projected energy consumption cannot be applied as in office buildings. Therefore, it is necessary to work out the EUI based on per room to estimate the projected energy consumption of hotels from the survey data analysis. To make a national projection of energy consumption for hotels, the total energy consumption and the corresponding number of hotel rooms were extracted and calculated based on energy consumption per hotel room per month. The monthly basis is a convenient way of assessing and comparing the level of energy consumption so it could be easily gauged. The analysis of hotel energy intensity is shown in Figure 2.8 and the average intensity value turned out to be 914 kWh/room/month, which can be used to estimate the projected national energy consumption for hotels.

Figure 2.9 shows that the main source of energy for the 1–3 star-rated hotels is electricity, which takes up 76% of total energy consumption. Diesel fuel use is substantial at about 18% and LPG is the other fuel used mainly for hotel food and beverage applications. One of the 1–3 star-rated hotels provided their energy

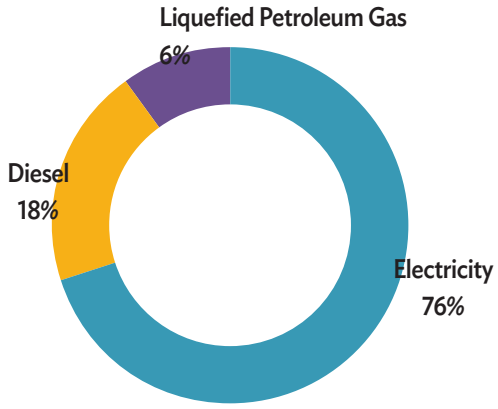
consumption data entirely on diesel without the use of electricity. This did not seem to be realistic.

Figure 2.8. Analysis of Hotel Energy Intensity



Source: Author's calculation.

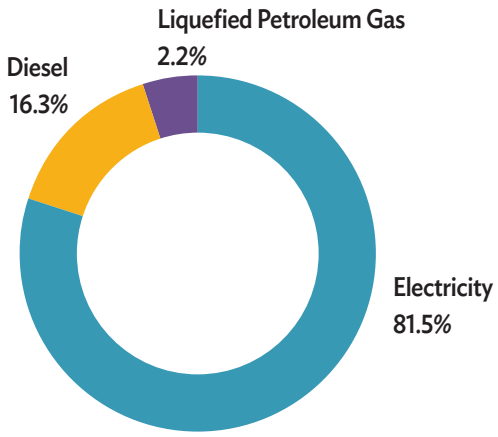
Figure 2.9. Average Share of Energy Sources for 1–3 Star-Rated Hotels in Myanmar



Source: Author's calculation.

Similarly, Figure 2.10 shows that the main energy source of the 4–5 star-rated hotels is electricity, which takes up a higher share at 81.5% of total energy consumption compared to the 1–3 star-rated hotels. Diesel fuel use is substantial at about 16.3% but LPG share is much less at 2.2% compared with the 1–3 star-rated hotels.

Figure 2.10. Average Share of Energy Sources for 4–5 Star-Rated Hotels in Myanmar



LPG = liquefied petroleum gas.
Source: Author's calculation.

Shopping malls

The key data obtained in the survey are the following:
1) Total electricity consumption per year (kWh/year)
2) Energy consumption per year of other energy sources (i.e., fuel energy other than electricity)
3) Daily operational hours
4) Total GFA (m2 – excluding car park and data centre)

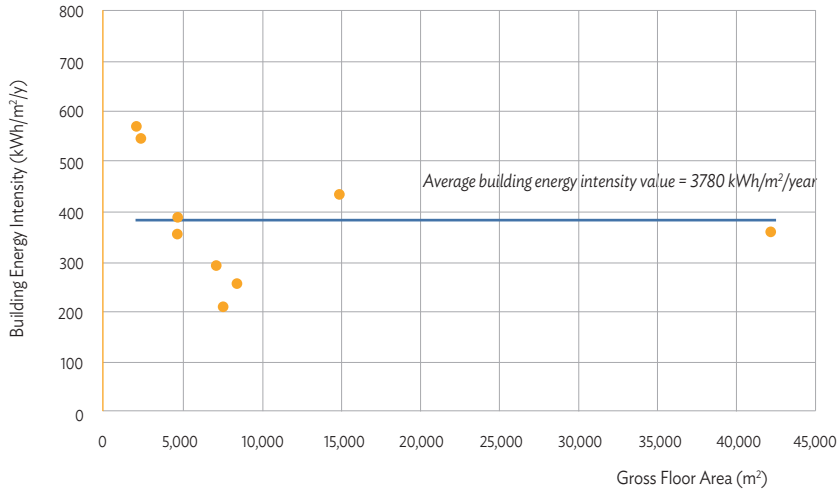
The weekly operational hours for shopping malls varied and the average operational hours amongst the shopping malls surveyed turned out to be 83 hours. This is almost 12 hours per day and is comparable to the 84 operational hours per week (or 4,368 hours per year) for green buildings (Green Building Index) in Malaysia. In other words, it is possible to directly compare the BEI

values for shopping malls in Myanmar and Malaysia as far as operational hours are concerned.

Like other commercial buildings, the main energy source for retail buildings is electricity. Other fuel recorded for consumption of shopping malls was diesel; and surprisingly, no LPG data was reported in the survey. This could be due to the method of survey adopted by the MSR, which might have targeted shopping mall owners or management without interviewing shopping mall tenants, who would likely use LPG fuel if their businesses were in the food sector.

Total energy consumption was obtained by adding up electricity and diesel fuel consumption. BEI values were calculated using the total energy consumption and the GFA recorded in the survey. In analysing the BEI values calculated, outlier values exceeding 600 kWh/m2/year and those less than 200 kWh/m2/year were discarded. As a result, the number of data sets was reduced to nine shopping malls. Figure 2.10 shows the analysis of BEI values calculated for shopping malls with BEI values of 210 kWh/m2/year to 570 kWh/m2/year. The average BEI value for shopping malls in Myanmar is 380 kWh/m2/year.

Figure 2.11. Analysis of Building Energy Intensity for Shopping Malls



Source: Author's calculation.

Figure 2.12. Average Share of Energy Sources for Shopping Malls

Source: Author's calculation.

Table 2.18. Statistical Information on Retail Space in Myanmar

Year	Modern Retail Space in Yangon	Traditional Retail Space in Yangon	Retail Space outside Yangon
2016	236,851 m^2	34,319 m^2	82,384 m^2

Source: ADB (2015).

Figure 2.12 shows that the main energy source for shopping malls in Myanmar is electricity and other fuel used is mainly diesel. It is surprising to note that besides diesel, no other fuel was recorded in the survey. Based on statistical information in Table 2.18, it is possible to use the average BEI value derived from the analysis of BEI for shopping malls as shown in Figure 2.11.

Restaurants

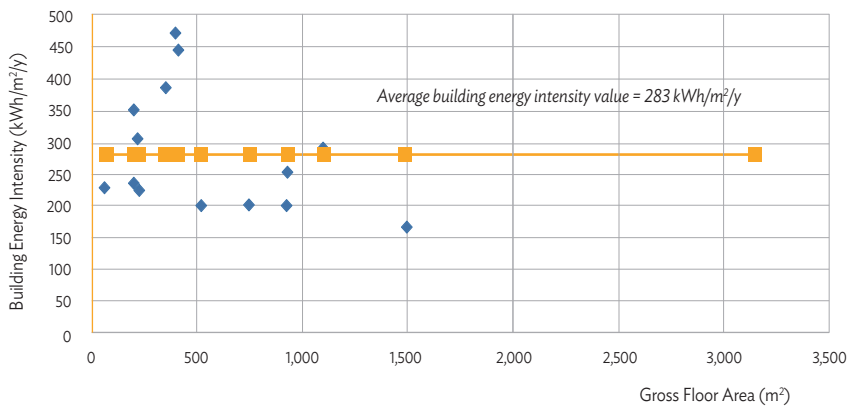
The key data obtained in the survey is the following:

1) Total electricity consumption per year (kWh/year)
2) Energy consumption per year of other energy sources (i.e., fuel energy other than electricity)
3) Daily operational hours
4) Total GFA (m2 – excluding car park and data centre)

As for shopping malls, the weekly operational hours for restaurants vary from 46 hours to 112 hours, making the average operational hours amongst the restaurants surveyed to be 81 hours or about 11.5 hours per day. Restaurants normally have rest hours. Nevertheless, the BEI values calculated were rationalised to standardise the operational hours to 81 hours so that the BEI values calculated for restaurants having different operational hours could be compared on the same operational hours.

In analysing BEI values for restaurants, the extremely low BEI value of 20 kWh/m2/year and the extremely high BEI value of 6,899 kWh/m2/year were discarded. The BEI values of two restaurants that provided energy consumption data of electricity only, with zero other fuels, including LPG, were also discarded. This is because restaurants are expected to use other fuels besides electricity. The analysis confined the range of rationalised BEI values calculated from 165 kWh/m2/year to 474 kWh/m2/year. As a result, the number of data sets was reduced to 15 restaurants. Figure 2.13 shows the result, which is an average BEI value of 283 kWh/m2/year for restaurants in Myanmar.

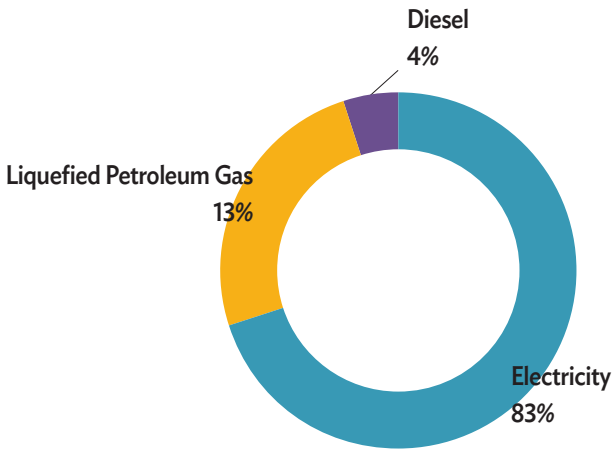
Figure 2.13. Analysis of Building Energy Intensity for Restaurants



kWh = kilowatt-hour.

Source: Author's calculation.

Figure 2.14. Average Share of Energy Sources for Restaurants



Source: Author's calculation.

Table 2.19. Statistical Information on Restaurants in Myanmar

Year	No. of Restaurants in Yangon	No. of Restaurants outside Yangon
2016	8,753	20,166

Source: ADB (2015)

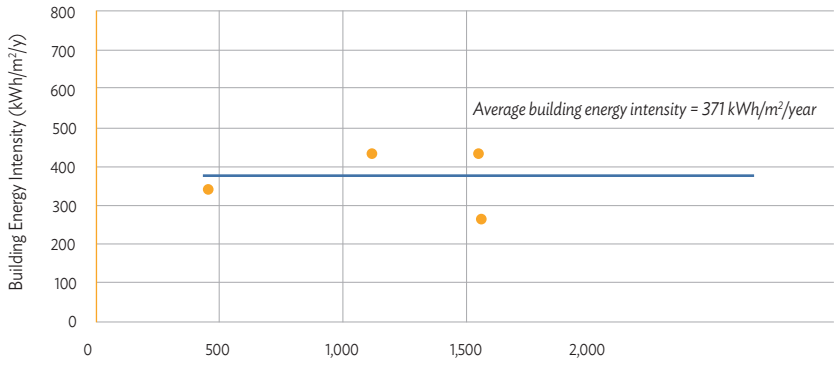
Figure 2.14 shows that the main energy source of restaurants is electricity; as expected, the consumption of LPG is substantial. LPG is mainly used for cooking purposes. There was no record of data for biomass fuel. The reason for this is probably because the energy consumption survey was conducted primarily in Yangon (Table 2.19), and that the main energy sources were electricity, LPG, and diesel (Figure 2.14).

Hospitals

The key data obtained in the survey are the following:

1) Total electricity consumption per year (kWh/year)
2) Energy consumption per year of other energy sources (i.e., fuel energy other than electricity)
3) Total GFA (m^2 – excluding car park and data centre)

Figure 2.15. Analysis of Building Energy Intensity for Hospitals



kWh = kilowatt-hour.

Source: Author's calculation.

In analysing the BEI values for hospitals, the extremely low BEI value of 1 kWh/m2/year and the extremely high BEI value of 2,452 kWh/m2/year were discarded as these values are deemed impractical and, hence, regarded as outliers. Another analysis based on energy consumption per bed per month was conducted. The result was also erratic as the range of values worked out to vary from 6 kWh/bed/month to 2,303 kWh/bed/month.

Therefore, the final analysis of hospital BEI values was confined to the range of 265 kWh/m2/year to 434 kWh/m2/year. Having discarded the outliers, the number of data sets used for the BEI analysis was reduced to 9. The result of an average BEI value of 371 kWh/m2/year is shown in Figure 2.15.

Table 2.20 was extracted from the Hospital Statistics Report 2014–2016 issued by the Ministry of Health, which provides information on number of beds and not the gross floor area of hospitals. Therefore, the BEI method to project national energy consumption of hospitals cannot be used. Since the number of hospital beds is given, it is necessary to estimate hospital energy use intensity on a per bed per month basis.

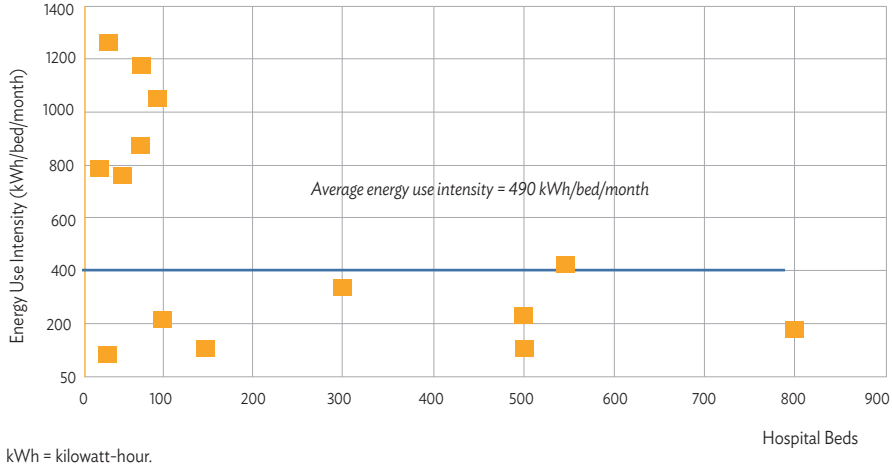
Figure 2.15 shows the analysis of hospital energy use intensity on a per bed per month basis. The per month basis is a convenient way of assessing and comparing the level of energy consumption so that it can be easily gauged. The average hospital EUI was 490 kWh/bed/month (Figure 2.16). In deriving this

Table 2.20. Government Hospital Information as of 2016

States/Region	Total No. of Government Hospitals	Available Beds
Kachin State	55	2,299
Kayah State	18	586
Kayin State	34	1,306
Chin State	28	1,072
Sagaing Region	132	4,762
Tanintharyi Region	38	1,294
Bago Region	109	3,986
Magway Region	100	3,736
Mandalay Region	108	8,456
Mon State	42	1,553
Rakhine	63	2,079
Yangon	85	12,260
Shan State	159	5,717
Ayeyarwaddy Region	121	4,675
Nay Pyi Taw	23	2,114
Union Total	1,115	55,895

Source: Ministry of Health and Sports (2018).

Figure 2.16. Analysis of Hospital Energy Use Intensity



kWh = kilowatt-hour.

Source: Author's calculation.

average EUI value, the extreme values of 4 kWh/bed/month and 2,242 kWh/bed/month were discarded and deemed to be outliers as they were impractical values. The intensity values considered to be valid for the analysis was confined to a range of 85 kWh/bed/month to 1,270 kWh/bed/month.

Residential Sector

The energy consumption survey of the residential sector was conducted in selected townships in the Yangon region. The survey questionnaire was developed by the MSR with guidance from the ERIA team. The questionnaire was designed to obtain the following data:

- Type of locality (urban, suburban, or rural)
- Type of building and occupancy details
  - -apartment or house
  - -floor area, number of bedrooms
  - -number of occupants
- Energy consumption
  - -electricity consumption per year
  - -other types of fuel consumption per year

Two hundred sets of survey data were collected from 13 townships in the Yangon area. Table 2.21 shows the breakdown in sampling areas and sample size. The sampling areas were generally classified under urban, suburban, and rural. This survey is limited as the rural areas defined in the survey might not be the same as the rural areas outside Yangon. The electricity consumption data collected was not the actual consumption over a 12-month period because yearly consumption data would have taken care of the seasonal effects. However, the actual data collection was the electricity consumption over a 1-month period, which was then converted into yearly consumption by multiplying it by 12 months. Therefore, some errors can be expected in the analysis due to the survey data.

The raw data in the 200 sets of household surveys was very scattered and needed to be treated. Treatment of the raw data is explained in the following:

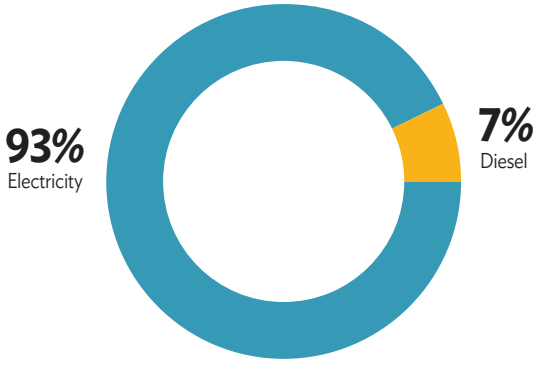
1) Total energy consumption per household was calculated by adding up the consumption of electricity and other fuels monthly.

Table 2.21. Sampling Areas and Sample Size

Districts	Locality	Township	Sample Ward	Sample Size
South Yangon	Rural	Dala	Aung Min Ga Lar Ward	15
North Yangon	Rural	Htantabin	No (1) Ward	15
North Yangon	Rural	Taikkyi	Kyan Sit Thar Ward	15
South Yangon	Rural	Hnawbi	Myo Ma (South) Ward	16
East Yangon	Suburban	Dagon Myothit (North)	No (29) Ward	15
North Yangon	Suburban	Hlinethaya	No (9) Ward	15
North Yangon	Suburban	Mingaladon	Pyi Taw Thar Ward	16
North Yangon	Suburban	Shwepyitha	No (3) Ward	15
West Yangon	Urban	Bahan	Bo Sein Hman Ward	15
West Yangon	Urban	Hline	No (7) Ward	16
West Yangon	Urban	Mayangon	No (2) Ward - Tha Maing Myo	15
East Yangon	Urban	Pazuntaung	No (7) Ward	16
East Yangon	Urban	Thingangyun	Bo Kan Nyunt Ward	16
Total number of samples				200

Source: MSR (2018)

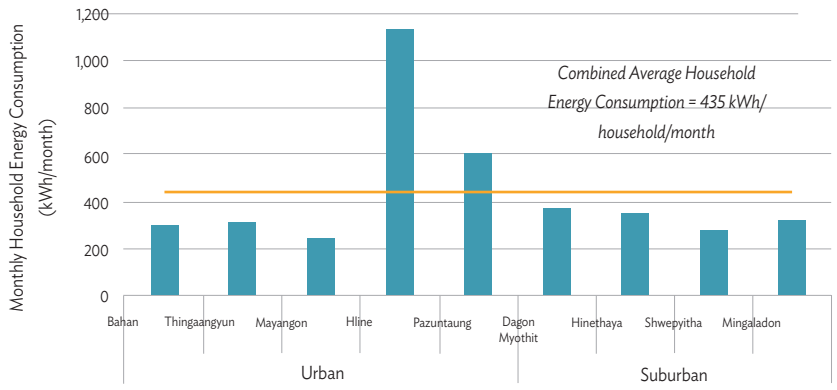
Figure 2.17. Average Share of Energy Sources for Hospitals



Source: Author's calculation.

2) Data was grouped and analysed as clusters for the respective districts under the locality categories of urban, suburban, and rural areas.

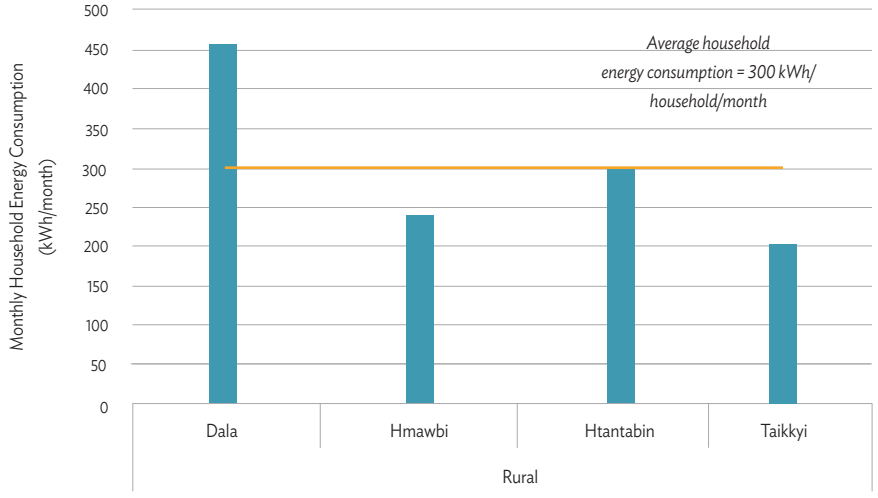
Figure 2.18. Analysis of Energy Consumption per Household per Month in Urban and Suburban Areas, including Electricity and Other Fuels



kWh = kilowatt-hour.

Source: Author's calculation.

Figure 2.19. Analysis of Energy Consumption per Household per Month in Rural Areas, including Electricity and Other Fuels



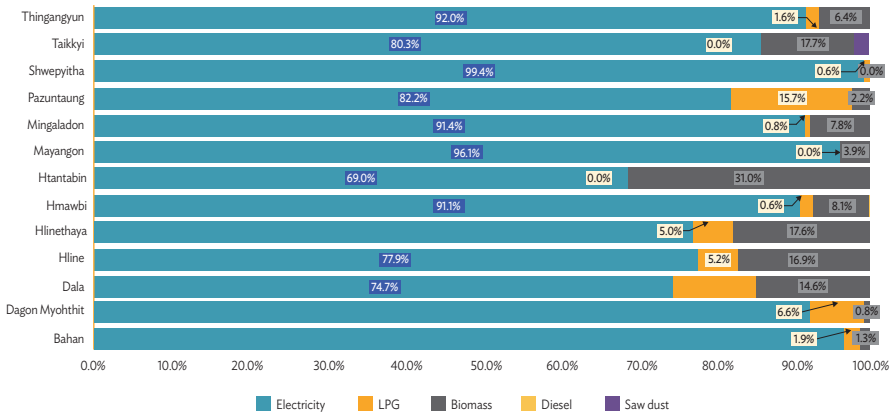
Wh = kilowatt-hour.

Source: Author's calculation.

3) Weighted average method was used to analyse the scattered data. This method considers the spread of data. It calculates the average based on the frequency of data occurred in a specific range.

Figures 2.17 and 2.18 show the results of the analysis of household energy consumption in urban, suburban, and rural areas, respectively. Combined average household consumption was calculated for the urban and suburban areas because the statistical information on the number of households is available under the urban classification only.

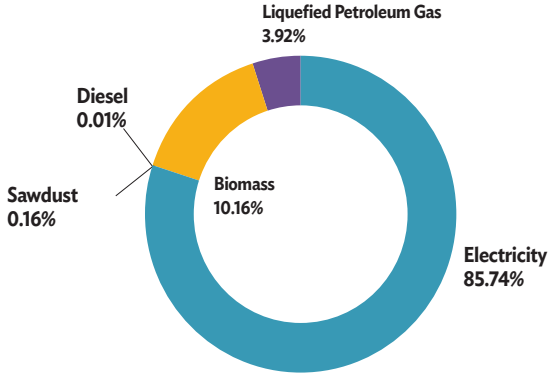
Figure 2.20. Average Share of Energy Sources for Each Township Surveyed



LPG = liquefied petroleum gas.

Source: Author's calculation.

Figure 2.21. Overall average share of energy sources for residential sector



Source: Author's calculation.

The shares of energy sources for the households that participated in the survey were analysed. Figure 2.19 shows that electricity is the main energy source for urban and rural areas in Yangon. However, as noted from the EBT, the consumption of other fuels such as fuel wood and wood waste is a much larger share than electricity. Firstly, the explanation for this discrepancy is mainly that the rural areas surveyed in Yangon are not representative of the actual rural areas in Myanmar. Secondly, there might be difficulties in keeping the consumption records of biomass fuel. Thirdly, the sampling size is small. Nevertheless, the survey results indicate that the populations are switching to the use of electricity, which is a more convenient source of energy and has become a necessity where access to electricity is available in urban, semi-urban, outer city, and some rural areas. Figure 2.20 shows the overall average share of energy sources for the residential sector in Myanmar.

Estimates of National Energy Consumption in the Commercial and Residential Sectors

Commercial sector

Based on the analyses in Sections 2.5 and 2.6, the national energy consumption in the commercial sector can be projected (Table 2.22). Subject to the availability of statistical information, the projected estimates were based on the BEI and other EUI values derived from the analysis of survey data; the total floor area obtained in the national statistical information for office and retail spaces; and the national statistics on the number of respective buildings, hotel rooms, hospital beds, and restaurants in Myanmar.

Office buildings

Based on the average BEI value estimated in Section 2.5.1 and the statistical information on office space reported for 2015, it is possible to estimate the projected energy consumption of office buildings in Myanmar (Table 2.22).

Table 2.22. Estimation of Projected Energy Consumption of Office Buildings in Myanmar

	Office space as of 2015 (m^2)	Average BEI ($kWh/m^2/y$)	Projected Total Energy Consumption (GWh)	Projected Total Energy Consumption (ktoe)
Goverment Office Buildings	5,709,918	280	1,599	137
Private Sector Office Buildings	2,024,922	280	567	49
Projected Total Consumption			2,166	186

Source: BEI = building energy intensity, GWh = gigawatt-hour, ktoe = kilo ton of oil equivalent.

Source: ADB (2015).

Hotels

The estimation of projected energy consumption of hotels is different from the method used for office buildings. The difference is due to the statistical information available for hotels regarding number of rooms, instead of floor area, without star rating classification. It is necessary to estimate the average EUI per room of 1–3 and 4–5 star-rated hotel data to project the energy consumption of hotels nationwide from the survey data analysis (Table 2.23).

Table 2.23. Estimation of Projected Energy Consumption of Hotels in Myanmar

	No. of hotel rooms[a] (as of 2016)	Average Energy Use Intensity (EUI) on per hotel room basis[b] (kWh/room/month)	Projected National Energy Consumptionb (GWh/year)	Projected National Energy Consumptionb (ktoe/year)
Yangon	20,123	914	221	19
Outside Yangon	43,855	914	481	41
Total Projected Consumption			702	60

Sources: [a] Ministry of Hotels & Tourism (2017).[b] Author's calculation.

Shopping malls

The statistical information on shopping malls is available in floor area. Therefore, the BEI method was used to estimate the projected energy consumption of shopping malls in Myanmar (Table 2.24).

Table 2.24. Estimation of Projected Energy Consumption of Shopping Malls in Myanmar

	Retail Space (m^2)	Average BEI Baseline value ($kWh/m^2/year$)	Projected National Energy Consumption (GWh/year)	Projected National Energy Consumption (ktoe/year)
Yangon	271,170	380	103	9
Outside Yangon	82,384	380	31	3
Total Projected Consumption			134	12

BEI = building energy intensity, GWh = gigawatt-hour, kWh = kilowatt-hour, ktoe = kilo ton of oil equivalent.

Sources: [a] ADB (2015). [b] Author's calculation.

Restaurants

The statistical information in number of restaurants was extracted from the Myanmar Energy Master Plan, which was made available by the MSR. However, to use the BEI method, it was necessary to assume an approximate floor area of a typical restaurant. At the third Working Group meeting, the members agreed that a typical floor area of 150 m2 would be used as basis for the estimation (Table 2.25).

Table 2.25. Estimation of Projected Energy Consumption of Restaurants in Myanmar

	Estimated Floor Area of Restaurants Assuming 150 m^2 each (as of 2016)	Average BEI Baseline value[b] ($kWh/m^2/year$)	Projected National Energy Consumption (GWh/year)	Projected National Energy Consumption (GWh/year)
Yangon	8,753x150= 1,312,950 m^2	283	372	32
Outside Yangon	20,166x150 = 3,024,900 m^2	283	600	52
Total Projected Consumption			972	84

BEI = building energy intensity, GWh = gigawatt-hour, kWh = kilowatt-hour.

Sources: [a] ADB (2015). [b] Author's calculation (the assumption of floor area of 150 m^2 per restaurant was made by the author)

Hospitals

The statistical information available for hospitals is the number of hospital beds in government hospitals. Thus, it was necessary to derive the EUI on a per hospital bed basis from the survey data. The number of private hospital beds was not available. To estimate the projected energy consumption of private hospitals, the number of beds was estimated from the number of private hospitals in the Hospital Statistics Report 2014–2016 and the number of government hospital beds.

Table 2.26. Estimation of Projected Energy Consumption of Hospitals in Myanmar

	No. of Hospital Beds (as of 2016)	Average Energy Use Intensity (kWh/bed/month)	Projected National Energy Consumption (GWh/year)	Projected National Energy Consumption (GWh/year)
Government Hospitals	55,895	490	329	28
Private Hospitals	11,179	490	66	6
Total Projected Consumption			134	12

Notes: [a] Ministry of Health and Sports (2018).[b] Information on the number of beds of private hospitals was not available. Based on the 187 private hospitals compared with 1,115 public hospitals, which is about 20% (in terms of the number of hospitals), the number of private hospital beds was assumed to be also 20% of public hospital beds.

GWh = gigawatt-hour, kWh = kilowatt-hour.

Source: Author's calculation.

Projected national energy consumption for the commercial sector

Table 2.27 summarises the projected energy consumption of each of the five sub-sectors in the commercial sector – namely, office buildings, hotels, shopping malls, restaurants, and hospitals. The projected national energy consumption from the energy consumption survey is compared with the national 2016 EBT (made available in July 2018).

Table 2.27. Projected National Energy Consumption based on Survey Data and EBT Energy Consumption for the Commercial Sector

	Projected National Energy Consumption Based on Survey Data (GWh/year)	Projected National Energy Consumption Based on Survey Data (ktoe/year	Total Energy Consumption based on 2016 Energy Balance Table (ktoe/year)
Office	2,166	186	329
Hotels	702	60	66
Shopping Malls	134	12	
Restaurants	972	84	
Hospitals	395	34	
Total	4,369	376	294

EBT = energy balance table, GWh = gigawatt-hour, ktoe = kilo ton of oil equivalent.

Sources: [a] Author's calculation. [b] ERIA (2016).

Table 2.25 shows that the total energy consumption for the commercial sector projected from the survey data is 376 ktoe, which is greater than the corresponding value of 294 ktoe from the 2016 EBT. The 294 ktoe from the 2016 EBT comprises 260 ktoe of electricity consumption and 34 ktoe of petroleum products consumption. The sources of error could be due to the following:

1) The survey sampling size was small. The actual analyses were based on an even smaller pool of data as some of the data analysed was outliers.

2) The surveys were mainly conducted in Yangon, which might not be representative of the consumption trending in Myanmar, e.g., the electricity consumption recorded in EBT is 260 ktoe (or 88.4% of the total commercial energy consumption), and the balance is 34 ktoe of petroleum product consumption (or 11.6% of the total commercial energy consumption). However, the survey data shows that in addition to electricity and diesel as energy sources, LPG is also a substantial source of energy for the commercial sector.

3) Energy consumption records and building information such as gross floor area might not have been kept properly and might not be readily available and reported during the surveys.

4) Human errors might have contributed to the discrepancies, due to the following:

a) Inexperienced enumerators who were not familiar with the technical nature and requirements of the energy consumption survey, e.g., interpretation of gross floor area, overlooking shopping mall tenants for source of LPG data, etc. The lack of direct training of the enumerators by ERIA experts might have contributed to this source of errors.
b) Respondents who were not fully cooperative might have given inaccurate data.
c) Respondents might not be familiar with the technical nature and requirements of energy consumption survey.

5) The survey coverage and the EBT for the commercial sector might have different boundaries.

6) The projected estimates rely on the accuracy of the survey data and the building statistics available from the published sources. There could be a mismatch in terms of the year for which the building statistics and the EBT data were compiled.

Nevertheless, the comparison of the projected national energy consumption (376 ktoe) for the commercial sector and the corresponding EBT value (294 ktoe) is within a discrepancy range of 28%, which is reasonable.

Residential sector

Based on the analyses in Section 2.6, the projected national energy consumption can be derived as given in Table 2.26. The projected estimates were based on the average national baseline energy consumption for household under two categories: urban–suburban and rural areas. The projected national residential energy consumption was derived from the analysis of the survey data and the national statistics on the number of households.

The number of households based on the Myanmar Population Census 2014 was 3,049,433 in urban areas and 7,828,399 in rural areas as reported by the MSR. However, to derive the updated number of households, the Working Group used the population growth rates presented at its third meeting[1] in making adjustments to tally with the population growth. The population in 2015 was

[1] Refers to the Third Working Group meeting of ERIA Research Project FY2017 held in Bangkok, 18–20 April 2018.

reported to be 52.4 million. Based on the reported 4.4 persons per household in the 2014 census, the total number of households in 2015 was derived and tabulated in Table 2.26. As a result, the total energy consumption for the residential sector projected from the survey data is 4,151 ktoe/year, which is less than the corresponding 2015 EBT value of 7,720 ktoe. The difference between these two values is substantial. The 7,720 ktoe of residential energy consumption comprises 574 ktoe of electricity (or 7.44% of the total residential energy consumption), 2 ktoe of coal products (or 0.02%), and 7,144 ktoe of biomass (or 92.54%).

Main discrepancy between 2015 EBT value and the projected value is the electricity consumption. The electricity consumption of 574 ktoe tabulated in the EBT represents 7.44% while the projected estimates of energy consumption from the survey data constitute mainly electricity consumption at 85.74% for the residential sector. The percentage share of biomass in the survey data is only 10.16% only. In other words, based on the survey results, a large part of the biomass energy consumption by the residential sector was not captured.

Table 2.28. Projected National Energy Consumption Based on Survey Data and EBT Energy Consumption for the Residential Sector

	Urban	Rural	Total
No. of households	3,338,530	8,570,561	11,909,091
Average household energy consumption (kWh/household/month)	435	300	N/A
Projected yearly energy consumption	17,427 GWh or 1,498 ktoe	30,854 GWh or 2,653 ktoe	47,187 GWh or 4,151 ktoe
Energy Balance Table			7,720 ktoe

EBT = energy balance table, GWh = gigawatt-hour, ktoe = kilo ton of oil equivalent, N/A = not applicable.

Sources: [a] MSR (2018). [b] Author's calculation. [c] ERIA (2015).

Therefore, there is discrepancy in the breakdowns of the projected energy consumption values and the EBT breakdown values. The reasons for this discrepancy could be due to the following:

1) The survey areas being confined to Yangon would reflect a much higher share of electricity use due to the relatively better infrastructures in Yangon.
2) The rural areas in Yangon referred to in the survey are not representative of the rural areas in Myanmar. Hence, the use of biomass, including firewood

and wood waste, are not reflected in the survey data. The EBT shows a much larger share of other fuels including biomass (92.54%).

3) The survey sample size was small.

4) There might be difficulties in keeping yearly records of biomass fuel, which might have caused the lack of reporting or under-reporting of the consumption of biomass fuels.

5) The survey coverage and the EBT for the commercial sector might have different boundaries.

6) Human errors due to the following:

a) Inexperienced enumerators who were not familiar with the technical nature of energy consumption surveys. The lack of direct training of the enumerators by ERIA experts might have contributed to this source of errors.

b) The yearly energy consumption data collected was based on the consumption for a particular month or months.

c) Respondents were unwilling to fully cooperate and give accurate data voluntarily.

d) Respondents might not be familiar with the technical nature and requirements of energy consumption survey.

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Chapter 3
Energy Balance Table

Energy balance is an accounting framework for compiling and reconciling data on all energy products entering, exiting, transformed, and used within the national territory of a country during a reference period. It is usually expressed in a common unit to enable the estimation of total energy supply, forecasting, and the study of substitution and conservation.

This chapter will firstly introduce the layout of Myanmar's energy balance table (EBT), including the scope of energy products and energy flow. Then, it will explain the estimation method for missing data. Lastly, it will present the Myanmar EBT from 2000 through 2016.

Basic Concept of Energy Balance Table

Energy balance is an accounting framework for compiling and reconciling data on the supply and demand of all energy products within the national territory of a given country during a reference period (usually a year). It expresses all forms of energy in a common accounting unit and shows the relationship between the inputs to and the outputs from energy transformation processes. It should be as complete as possible so that all energy flows are accounted for.[1]

The energy balance is a matrix showing the relationship between energy products (represented in columns) and energy flows (represented in rows). A column refers to a group of energy products in its primary or secondary form.

[1] Concept and Definition. http://unstats.un.org/unsd/energy/balance/2013/03.pdf.

Each cell in this column shows a flow of energy involving this group of products as defined by the row name.

A main purpose of an energy balance is to reflect the relationships between the primary production of energy (and other energy flows imported and/or exported by the national territory), its transformation, and final consumption. Therefore, the energy balance contains three main blocks of rows as follows:

- Upper sector (primary energy supply) is intended to show flows representing energy indigenous production in, and importing and exporting through, the national territory, as well as stock changes to provide information on the amount of energy available in the national territory during the reference period. The supply flows consist of production of primary energy products and imports of both primary and secondary energy products. The flows removing energy from the national territory are exports of primary and secondary energy products and international bunkers. The aggregate of the balance, which is the Total Energy Supply, is computed as: [2]

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

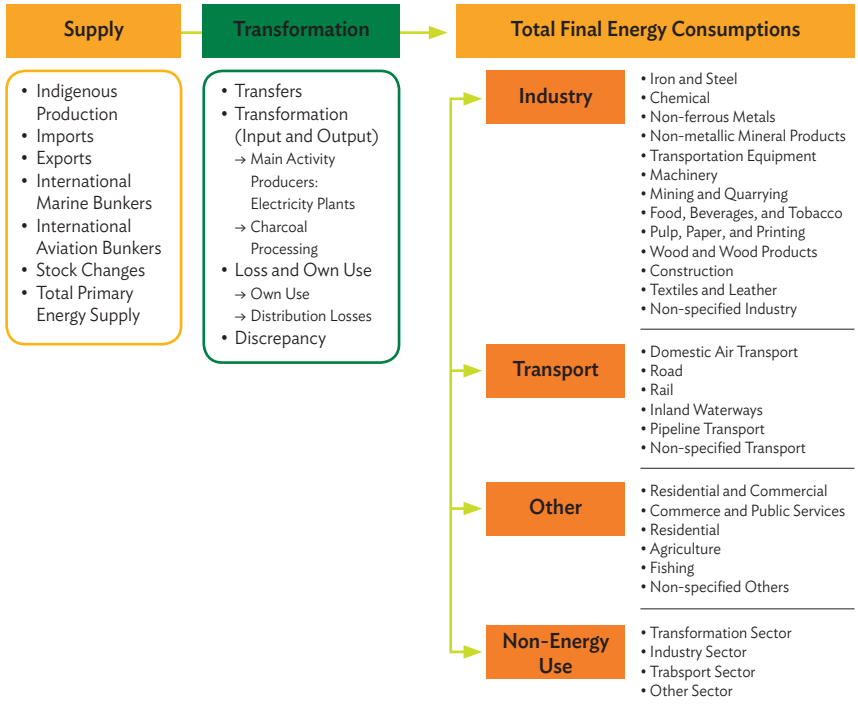
- Middle sector (energy transfer and transformation) is intended to show the flows of how energy is transformed, transferred, and used by energy industries for own use and losses in distribution and transmission. Power generation and petroleum refinery processes are a major activity in this sector.
- Lower sector (final energy consumption) is intended to show the flows of how energy is being consumed by the final sectors. The flows reflect the final energy consumption and non-energy use of energy products. Thus, it excludes deliveries of fuel and other energy products for use in transformation processes (covered in the middle block) and the use of energy products for energy needs of the energy industries (also covered in the middle block). Final energy consumers are grouped into three main categories:

[2] Because of the sign convention in energy balances, where quantities that contribute to the supply receive positive signs whilst those that are removed receive negative signs, these parts can be added up straight.

1. manufacturing, construction, and non-fuel mining industries;
2. transport; and
3. other (agriculture; forestry and fishing; commerce; and public services, households, and other consumers).

Figure 3.1 shows a simplified diagram of the energy flow in an EBT.

Figure 3.1. Energy Flow in the Energy Balance



Source: Economic Research Institute for ASEAN and East Asia (ERIA) (2018).

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

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

> *Statistical Difference = Total Primary Energy Supply + Transfers + Transformation + Energy Industries Own Use + Losses – Final Consumption*

The EBT can be presented in both detailed and aggregated formats. The degree of detail depends on the policy concern, data and resource availability, and the underlying classifications used. Usually, a simplified format is used for countries of small size and/or for which the types of energy flows are few and far between, and, as a result, can be summarised without much information loss. The detailed definition of energy products and energy flows is shown in Annex 1. The development of the Myanmar EBT 2000–2016 is provided in section 3.4. The structuring of an energy balance depends on the country's energy production and consumption patterns and the level of detail that the country requires.

Methodology

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

Data collection format

The primary energy data required for the development of the Myanmar EBT 2000–2016 was discussed in Chapter 1. The data is then entered in the reporting format for each of the energy products, which in the case of Myanmar consist of coal; petroleum products; biomass (fuelwood, charcoal, bagasse); hydro; solar; and electricity (including imported electricity). The format used is the Asia-Pacific Economic Cooperation and Association of Southeast Asian Nations (APEC-ASEAN)[3] joint questionnaire developed to assemble the main statistics of each product and provide a check on the completeness of the data

because the questionnaire will balance the supply and use of the respective products. The joint questionnaire consists of five questionnaires, each for the energy products (coal, oil, gas, oil, electricity, and renewables). The content of the questionnaire basically consists of the supply data, transformation and energy industry own use, and final consumption (including non-energy use).

After data has been completely entered in the APEC–ASEAN joint format, which for Myanmar excludes the natural gas questionnaire, the data is then used to generate the EBT through an interface programme provided by ERIA for the Myanmar Energy Statistics project.

Unit and conversion

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

The unit in the APEC–ASEAN joint questionnaire is the physical unit and differs between the products. The unit in the oil questionnaire is in thousands of metric tons (kt), whilst primary data are mainly in kilolitres. Specific gravities data requirement is included in the oil questionnaire as well as the NCV to convert into an energy unit (kilocalorie). If there is a refinery in the country, refinery intake data is also requested in the questionnaire in kilo tons.

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

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

The Myanmar EBT 2000–2016 adopted the energy unit of ton of oil equivalent (toe). One unit of toe is defined as 107 kl (41.868 GJ). There are two heat values: one is NCV and the other is gross calorific value (GCV). The differences between NCV and GCV are:

- For coal and oil – the NCV is less than about 5% of GCV.
- For gas – the NCV is around less than 10% of GCV.

The calorific content of the different energy products in Myanmar is shown in Table 3.1.

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

- Hydro – 100%
- Nuclear – 33%
- Geothermal – 10%
- Solar/wind/tide – 100%

Table 3.1. Naphtha Supply and Consumption

Energy Products	Original Unit	Calorific Content (ton of oil equivalent)
Sub-bituminous Coal	metric ton	0.4513
Lignite	metric ton	0.2842
BKB/PB	metric ton	0.4943
Crude Oil	metric ton	1.0101
Motor Gasoline	metric ton	1.0579
Aviation Gasoline	metric ton	1.0579
Naphtha	metric ton	1.0579
Kerosene Type Jet Fuel	metric ton	1.0531
Kerosene	metric ton	1.0459
Gas/Diesel Oil	metric ton	1.0268
Fuel Oil	metric ton	0.9648
Liquefied Petroleum Gas	metric ton	1.1295
White Spirit SBP	metric ton	0.9600

Lubricants	metric ton	0.9600
Bitumen	metric ton	0.9600
Paraffin Waxes	metric ton	0.9600
Petroleum Coke	metric ton	0.7761
Other Petroleum Products	metric ton	0.9600
Natural Gas	1,000 cubic metres	0.8684
Fuelwood and Wood Waste	metric ton	0.3725
Bagasse	metric ton	0.2300
Charcoal	metric ton	0.7045
Other Biomass	metric ton	0.3319
Electricity	megawatt-hour	0.0860

BKB/PB = brown coal briquette.

Source: ERIA (2018).

Estimation Method for Missing Data

Due to the limitation of existing energy statistics, some of the information needed to compile the EBT is estimated. This section explains the estimation methods for the above-mentioned missing data.

Coal

Main activity producer – Electricity Plants: The transformation input of sub-bituminous coal and lignite in electricity plants from 2014 to 2016 is estimated with coal-fired electricity production and average efficiency of coal-fired electricity plants from 2000 to 2013 (17.8%).

Coal transformation – brown coal briquette (BKB/PB) plants: 100% transformation efficiency is assumed for BKB production.

Iron and steel – The coal consumption of the FeNi Factory is assumed to be half sub-bituminous coal and half lignite in 2012.

Crude oil and petroleum products

Stock at opening and closing – The missing opening stock is assumed to be equal to the stock at closing of the previous year. The missing closing stock is assumed to be equal to the stock at the opening of next year. If the above data is not available, the missing opening stock is assumed to be equal to the

stock at closing deducting supply and adding consumption, whilst the missing closing stock is assumed to be equal to the stock at opening adding supply and deducting consumption.

Main activity producer – electricity plants: The transformation input of diesel in electricity plants in 2000–2006 and 2009–2016 is estimated with oil-fired electricity production and average efficiency of oil-fired electricity plants from 2007 to 2008 (27.7%).

Industry sector – not elsewhere specified: Fuel oil consumption can only be disaggregated by sales to government agencies and the private sector. The amount consumed by the private sector is assumed to go to 'not elsewhere specified' (industry). The missing petroleum coke consumption in 2011 is estimated with gross refinery output and stock change.

Transport sector – road: Motor gasoline and diesel oil reported under 'not elsewhere specified' (transport) is reclassified as road.

Other sector – residential: All liquefied petroleum gas (LPG) consumption before 2014 is classified as residential sector, due to the lack of disaggregated data.

Other sector – others: Aviation gasoline is used for military purposes, and classified as 'not elsewhere specified' (others). The missing paraffin waxes consumption in 2004, 2009, and 2013–2016 is estimated with gross refinery output, imports, and stock change.

Gas

Loss and own use – oil and gas extraction: Missing oil and gas extraction consumption from 2000 to 2010 is estimated with the average own use rate (about 2%) over total gas production in 2011–2016 and deducted from 'not elsewhere specified' (others).

Industry sector – The consumption of the non-metallic minerals industry in 2012–2014 was misclassified as construction industry and is reclassified. Besides, the gas consumption of the industry sector is disaggregated according to its consumption structure in 2012–2014.

Hydro

Indigenous production – The generation of hydroelectricity provided by the Ministry of Electricity and Energy (MOEE) does not include micro hydro and exported hydro power. They are added back to hydroelectricity generation.

Geothermal, solar, etc.

Indigenous production – Solar photovoltaic (PV) and wind electricity generation is not included in the data provided by the MOEE. They are added to total electricity generation.

Biomass

Indigenous production and consumption of fuelwood – The reported other biomass is added to fuelwood and wood waste. Fuelwood consumption is assumed to be 30% for industry, 30% for commercial, and 40% for residential.

Transformation of charcoal – The input–output ratio between fuelwood and charcoal is assumed to be 4 to 1.

Electricity

Own use of main activity producer – The own use of electricity plants is disaggregated with assumed own use rate, which is 5.0% for coal-fired plant, 3.5% for oil-fired plant, 2.0% for gas-fired plant, 0.5% for hydro, and 0% for solar PV and wind.

Energy Balance Table 2000–2016

Table 3.2. Myanmar Energy Balance Table, 2000

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	241		420		4,508	163			6,989			12,321
2. Imports			654	751								1,405
3. Exports	-181				-3,159							-3,340
4. International Marine Bunkers				-0								-0
5. International Aviation Bunkers				-18								-18
6. Stock Changes			-6	-9								-15
7. Total Primary Energy Supply	60		1,068	724	1,349	163			6,989			10,353
8. Transfers												
9. Total Transformation Sector			-1,068	883	-807	-163			-143	440		-857
9.1 Main Activity Producer				-11	-807	-163				440		-541
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-1,068	894								-174
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-143			-143
9.9 Other Transformation												
10. Loss and Own Use				-7	-93					-159		-259
11. Discrepancy	-0			-1	-52							-53
12. Total Final Energy Consumption	60			1,599	398				6,846	281		9,184
13. Industry Sector	60			629	396				2,054	111		3,250
13.1 Iron and Steel	29				11							39
13.2 Chemical (incl. Petrochemical)					154							154
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	29				203							232
13.5 Transportation Equipment					1							1
13.6 Machinery					4							4
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					10							10
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					5							5
13.13 Other Industry	2			629					2,054	111		2,796
14. Transport Sector				930	2							931
14.1 Domestic Air Transport				47								47
14.2 Road				882	2							884
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				40					4,792	170		5,002
15.1 Residential and Commercial				28					4,792	162		4,983
15.1.1 Commerce and Public Services				12					2,054	45		2,111
15.1.2 Residential				16					2,738	117		2,872
15.2 Agriculture												
15.3 Fishing												
15.4 Others				13						7		20
16. of which Non-energy Use				13	139							152
17. Electricity Output in GWh			36		3,190	1,892						5,118
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.3. Myanmar Energy Balance Table, 2001

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	286		597		7,180	173			7,151			15,387
2. Imports			544	594								1,137
3. Exports	-240		-169		-5,967							-6,375
4. International Marine Bunkers				-3								-3
5. International Aviation Bunkers				-18								-18
6. Stock Changes			35	-16								19
7. Total Primary Energy Supply	46		1,007	557	1,214	173			7,151			10,147
8. Transfers												
9. Total Transformation Sector			-996	790	-714	-173			-175	403		-866
9.1 Main Activity Producer				-10	-714	-173				403		-493
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-996	799								-197
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-175			-175
9.9 Other Transformation												
10. Loss and Own Use				-11	-148					-142		-300
11. Discrepancy	0		-10	-32	-102				0			-143
12. Total Final Energy Consumption	46			1,304	250				6,976	262		8,837
13. Industry Sector	46			513	248				2,093	99		2,998
13.1 Iron and Steel	16				7							22
13.2 Chemical (incl. Petrochemical)					97							97
13.3 Non-ferrous Metals					1							1
13.4 Non-metallic Mineral Products	29				127							157
13.5 Transportation Equipment					1							1
13.6 Machinery					3							3
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					3							3
13.9 Pulp, Paper, and Printing					7							7
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					3							3
13.13 Other Industry	1			513					2,093	99		2,705
14. Transport Sector				761	2							763
14.1 Domestic Air Transport				52								52
14.2 Road				709	2							711
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				30					4,883	163		5,076
15.1 Residential and Commercial				27					4,883	156		5,065
15.1.1 Commerce and Public Services				10					2,093	48		2,151
15.1.2 Residential				17					2,790	107		2,914
15.2 Agriculture												
15.3 Fishing												
15.4 Others				3						7		11
16. of which Non-energy Use				5	87							92
17. Electricity Output in GWh			31		2,650	2,008						4,689
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.4. Myanmar Energy Balance Table, 2002

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	253		828		8,755	182			7,318			17,336
2. Imports			475	481								956
3. Exports	-199		-170		-7,265							-7,633
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-15								-15
6. Stock Changes			-19	44								25
7. Total Primary Energy Supply	54		1,115	507	1,491	182			7,318			10,667
8. Transfers												
9. Total Transformation Sector			-1,067	980	-828	-182			-204	436		-864
9.1 Main Activity Producer				-9	-828	-182				436		-582
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-1,067	989								-78
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-204			-204
9.9 Other Transformation												
10. Loss and Own Use				-11	-180					-136		-327
11. Discrepancy	0		-48	60	-130				0			-118
12. Total Final Energy Consumption	54			1,536	353				7,114	300		9,356
13. Industry Sector	54			639	351				2,134	122		3,301
13.1 Iron and Steel	17				9							26
13.2 Chemical (incl. Petrochemical)					137							137
13.3 Non-ferrous Metals					1							1
13.4 Non-metallic Mineral Products	34				180							214
13.5 Transportation Equipment					1							1
13.6 Machinery					4							4
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					9							9
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					5							5
13.13 Other Industry	3			639					2,134	122		2,898
14. Transport Sector				848	2							850
14.1 Domestic Air Transport				61								61
14.2 Road				787	2							789
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				49					4,980	178		5,206
15.1 Residential and Commercial				46					4,980	171		5,196
15.1.1 Commerce and Public Services				29					2,134	47		2,210
15.1.2 Residential				17					2,846	123		2,986
15.2 Agriculture												
15.3 Fishing												
15.4 Others				3						7		10
16. of which Non-energy Use				3	123							126
17. Electricity Output in GWh			29		2,928	2,111						5,068
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.5. Myanmar Energy Balance Table, 2003

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	418		941		9,138	178			7,540			18,214
2. Imports				676								676
3. Exports	-333				-7,486							-7,818
4. International Marine Bunkers				-3								-3
5. International Aviation Bunkers				-13								-13
6. Stock Changes			15	7								23
7. Total Primary Energy Supply	85		956	668	1,652	178			7,540			11,080
8. Transfers												
9. Total Transformation Sector			-975	902	-951	-178			-321	467		-1,057
9.1 Main Activity Producer				-10	-951	-178				467		-672
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-975	912								-63
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-321			-321
9.9 Other Transformation												
10. Loss and Own Use				-6	-161					-136		-302
11. Discrepancy	0		19	62	-200				-0	0		-120
12. Total Final Energy Consumption	85			1,626	340				7,219	331		9,601
13. Industry Sector	85			597	338				2,166	136		3,321
13.1 Iron and Steel	22				9							31
13.2 Chemical (incl. Petrochemical)					132							132
13.3 Non-ferrous Metals					1							1
13.4 Non-metallic Mineral Products	60				173							234
13.5 Transportation Equipment					1							1
13.6 Machinery					4							4
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					4							4
13.9 Pulp, Paper, and Printing					9							9
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					4							4
13.13 Other Industry	2			597					2,166	136		2,901
14. Transport Sector				975	2							977
14.1 Domestic Air Transport				70								70
14.2 Road				905	2							907
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				54					5,053	195		5,302
15.1 Residential and Commercial				51					5,053	188		5,292
15.1.1 Commerce and Public Services				34					2,166	50		2,250
15.1.2 Residential				17					2,888	139		3,043
15.2 Agriculture												
15.3 Fishing												
15.4 Others				3						7		10
16. of which Non-energy Use				2	119							121
17. Electricity Output in GWh			31		3,320	2,075						5,426
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.6. Myanmar Energy Balance Table, 2004

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	448		1,004		10,473	207			7,595			19,728
2. Imports				691								691
3. Exports	-361		-58		-8,685							-9,104
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-17								-17
6. Stock Changes			-13	-74								-87
7. Total Primary Energy Supply	87		934	598	1,788	207			7,595			11,210
8. Transfers												
9. Total Transformation Sector	-40		-918	804	-1,080	-207			-177	482		-1,136
9.1 Main Activity Producer	-40			-10	-1,080	-207				482		-855
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-918	814								-104
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-177			-177
9.9 Other Transformation												
10. Loss and Own Use				-6	-183					-146		-335
11. Discrepancy	0		-15	13	-135				-0			-137
12. Total Final Energy Consumption	47			1,409	391				7,419	336		9,602
13. Industry Sector	47			548	387				2,226	133		3,341
13.1 Iron and Steel	22				10							33
13.2 Chemical (incl. Petrochemical)					151							151
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	23				199							222
13.5 Transportation Equipment					1							1
13.6 Machinery					4							4
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					10							10
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					5							5
13.13 Other Industry	1			548					2,226	133		2,908
14. Transport Sector				817	4							821
14.1 Domestic Air Transport				56								56
14.2 Road				761	4							765
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				44					5,193	203		5,440
15.1 Residential and Commercial				41					5,193	196		5,430
15.1.1 Commerce and Public Services				28					2,226	53		2,307
15.1.2 Residential				13					2,968	143		3,123
15.2 Agriculture												
15.3 Fishing												
15.4 Others				3						7		10
16. of which Non-energy Use				2	136							137
17. Electricity Output in GWh	60		33		3,107	2,408						5,608
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.7. Myanmar Energy Balance Table, 2004

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	534		1,072		10,758	258			7,740			20,361
2. Imports				830								830
3. Exports	-281		-165		-9,066							-9,513
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-11								-11
6. Stock Changes			5	6								11
7. Total Primary Energy Supply	252		912	823	1,691	258			7,740			11,676
8. Transfers												
9. Total Transformation Sector	-154		-876	760	-1,001	-258			-183	522		-1,189
9.1 Main Activity Producer	-154			-10	-1,001	-258				522		-901
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-876	770								-106
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-183			-183
9.9 Other Transformation												
10. Loss and Own Use				-6	-186					-147		-339
11. Discrepancy	-0		-36	-138	-206							-381
12. Total Final Energy Consumption	99			1,439	298				7,557	374		9,767
13. Industry Sector	99			626	263				2,267	151		3,405
13.1 Iron and Steel	23				7							30
13.2 Chemical (incl. Petrochemical)					102							102
13.3 Non-ferrous Metals					1							1
13.4 Non-metallic Mineral Products	62				135							197
13.5 Transportation Equipment					1							1
13.6 Machinery					3							3
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					3							3
13.9 Pulp, Paper, and Printing					7							7
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					3							3
13.13 Other Industry	14			626					2,267	151		3,058
14. Transport Sector				768	35							803
14.1 Domestic Air Transport				55								55
14.2 Road				713	35							749
14.3 Rail												
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				45					5,290	223		5,558
15.1 Residential and Commercial				43					5,290	216		5,549
15.1.1 Commerce and Public Services				26					2,267	60		2,353
15.1.2 Residential				17					3,023	156		3,195
15.2 Agriculture												
15.3 Fishing												
15.4 Others				2						8		10
16. of which Non-energy Use				1	92							93
17. Electricity Output in GWh	244		33		2,786	3,001						6,064
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.8. Myanmar Energy Balance Table, 2006

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	593		1,007		11,316	286			8,014			21,216
2. Imports				856								856
3. Exports	-233		-113		-9,580							-9,925
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-14								-14
6. Stock Changes			-40	12								-28
7. Total Primary Energy Supply	360		855	853	1,735	286			8,014			12,104
8. Transfers												
9. Total Transformation Sector	-229		-861	835	-910	-286			-233	530		-1,154
9.1 Main Activity Producer	-229			-9	-910	-286				530		-903
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-861	843								-17
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-233			-233
9.9 Other Transformation												
10. Loss and Own Use				-6	-233					-156		-395
11. Discrepancy			6	-49	-48				-0	-0		-91
12. Total Final Energy Consumption	131			1,632	545				7,781	375		10,464
13. Industry Sector	131			781	462				2,334	159		3,868
13.1 Iron and Steel	29				12							42
13.2 Chemical (incl. Petrochemical)					180							180
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	63				237							301
13.5 Transportation Equipment					2							2
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					6							6
13.9 Pulp, Paper, and Printing					12							12
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					6							6
13.13 Other Industry	39			781					2,334	159		3,313
14. Transport Sector				812	83							894
14.1 Domestic Air Transport				57								57
14.2 Road				721	83							804
14.3 Rail				34								34
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				39					5,447	215		5,701
15.1 Residential and Commercial				37					5,447	210		5,694
15.1.1 Commerce and Public Services				25					2,334	71		2,430
15.1.2 Residential				13					3,112	139		3,264
15.2 Agriculture												
15.3 Fishing												
15.4 Others				2						5		7
16. of which Non-energy Use				1	162							163
17. Electricity Output in GWh	401		28		2,410	3,325						6,164
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.9. Myanmar Energy Balance Table, 2007

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	504		1,023		11,718	311			8,250			21,806
2. Imports				945								945
3. Exports	-103		-143		-9,820							-10,066
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-13								-13
6. Stock Changes			7	-14								-7
7. Total Primary Energy Supply	401		886	917	1,899	311			8,250			12,664
8. Transfers												
9. Total Transformation Sector	-213		-866	763	-1,015	-311			-211	550		-1,303
9.1 Main Activity Producer	-213			-10	-1,015	-311				550		-999
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-866	773								-93
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-211			-211
9.9 Other Transformation												
10. Loss and Own Use				-6	-241					-169		-415
11. Discrepancy	0		-20	-48	-7				0	-0		-75
12. Total Final Energy Consumption	188			1,625	637				8,039	382		10,870
13. Industry Sector	188			817	519				2,412	161		4,096
13.1 Iron and Steel	29				14							42
13.2 Chemical (incl. Petrochemical)					202							202
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	91				266							357
13.5 Transportation Equipment					2							2
13.6 Machinery					6							6
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					7							7
13.9 Pulp, Paper, and Printing					14							14
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					7							7
13.13 Other Industry	68			817					2,412	161		3,458
14. Transport Sector				776	118							894
14.1 Domestic Air Transport				56								56
14.2 Road				688	118							806
14.3 Rail				32								32
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				32					5,627	221		5,880
15.1 Residential and Commercial				31					5,627	216		5,874
15.1.1 Commerce and Public Services				22					2,412	74		2,508
15.1.2 Residential				9					3,215	142		3,366
15.2 Agriculture												
15.3 Fishing												
15.4 Others				1						5		6
16. of which Non-energy Use				1	182							183
17. Electricity Output in GWh	436		34		2,310	3,619						6,398
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.10. Myanmar Energy Balance Table, 2008

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	274		916		9,966	350			8,497			20,003
2. Imports				705								705
3. Exports	-19				-8,056							-8,075
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-13								-13
6. Stock Changes			-15	-56								-71
7. Total Primary Energy Supply	255		901	635	1,910	350			8,497			12,548
8. Transfers												
9. Total Transformation Sector	-111		-833	717	-977	-350			-209	569		-1,193
9.1 Main Activity Producer	-111			-13	-977	-350				569		-881
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-833	730								-103
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-209			-209
9.9 Other Transformation												
10. Loss and Own Use				-6	-205					-165		-376
11. Discrepancy	0		-68	-21	23					0		-66
12. Total Final Energy Consumption	144			1,325	751				8,288	404		10,912
13. Industry Sector	144			553	603				2,486	164		3,950
13.1 Iron and Steel	22				16							38
13.2 Chemical (incl. Petrochemical)					235							235
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	103				310							412
13.5 Transportation Equipment					2							2
13.6 Machinery					7							7
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					8							8
13.9 Pulp, Paper, and Printing					16							16
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					8							8
13.13 Other Industry	19			553					2,486	164		3,222
14. Transport Sector				739	148							887
14.1 Domestic Air Transport				50								50
14.2 Road				655	148							803
14.3 Rail				34								34
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				33					5,801	241		6,075
15.1 Residential and Commercial				31					5,801	236		6,068
15.1.1 Commerce and Public Services				22					2,486	81		2,589
15.1.2 Residential				9					3,315	155		3,479
15.2 Agriculture												
15.3 Fishing												
15.4 Others				2						5		7
16. of which Non-energy Use				1	212							213
17. Electricity Output in GWh	220		40		2,291	4,071						6,622
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.11. Myanmar Energy Balance Table, 2009

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	209		879		10,804	452			8,709			21,052
2. Imports				502								502
3. Exports	-14		-95		-9,188							-9,297
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-13								-13
6. Stock Changes			38	30								67
7. Total Primary Energy Supply	195		822	517	1,616	452			8,709			12,310
8. Transfers												
9. Total Transformation Sector	-93		-806	653	-566	-452			-165	599		-830
9.1 Main Activity Producer	-93			-9	-566	-452				599		-522
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-806	663								-143
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-165			-165
9.9 Other Transformation												
10. Loss and Own Use				-6	-222					-169		-398
11. Discrepancy			-16	-38	-206							-260
12. Total Final Energy Consumption	102			1,126	621				8,543	429		10,822
13. Industry Sector	102			480	457				2,563	159		3,761
13.1 Iron and Steel	21				12							33
13.2 Chemical (incl. Petrochemical)					178							178
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	58				235							292
13.5 Transportation Equipment					2							2
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					6							6
13.9 Pulp, Paper, and Printing					12							12
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					6							6
13.13 Other Industry	23			480					2,563	159		3,225
14. Transport Sector				619	164							783
14.1 Domestic Air Transport				52								52
14.2 Road				531	164							695
14.3 Rail				36								36
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				27					5,980	270		6,278
15.1 Residential and Commercial				25					5,980	265		6,271
15.1.1 Commerce and Public Services				18					2,563	92		2,673
15.1.2 Residential				8					3,417	173		3,598
15.2 Agriculture												
15.3 Fishing												
15.4 Others				2						5		7
16. of which Non-energy Use				1	160							161
17. Electricity Output in GWh	250		30		1,428	5,256						6,964
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.12. Myanmar Energy Balance Table, 2010

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	313		937		10,920	532		0	8,924			21,627
2. Imports				1,619								1,619
3. Exports					-8,988							-8,988
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-19								-19
6. Stock Changes			7	30								36
7. Total Primary Energy Supply	313		944	1,629	1,933	532		0	8,924			14,275
8. Transfers												
9. Total Transformation Sector	-131		-891	755	-1,013	-532		-0	-166	742		-1,237
9.1 Main Activity Producer	-131			-10	-1,013	-532		-0		742		-945
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-891	765								-126
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-166			-166
9.9 Other Transformation												
10. Loss and Own Use				-6	-224					-199		-429
11. Discrepancy			-53	-77	-20					-0		-150
12. Total Final Energy Consumption	182			2,301	675				8,758	543		12,458
13. Industry Sector	182			1,004	502				2,627	197		4,511
13.1 Iron and Steel					13							13
13.2 Chemical (incl. Petrochemical)					196							196
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	164				257							421
13.5 Transportation Equipment					2							2
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					7							7
13.9 Pulp, Paper, and Printing					13							13
13.10 Wood and Wood Products												
13.11 Construction												
13.12 Textiles and Leather					7							7
13.13 Other Industry	18			1,004					2,627	197		3,846
14. Transport Sector				1,268	173							1,441
14.1 Domestic Air Transport				60								60
14.2 Road				1,172	173							1,345
14.3 Rail				36								36
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				29					6,131	346		6,506
15.1 Residential and Commercial				27					6,131	341		6,498
15.1.1 Commerce and Public Services				15					2,627	112		2,754
15.1.2 Residential				12					3,503	228		3,743
15.2 Agriculture												
15.3 Fishing												
15.4 Others				3						6		8
16. of which Non-energy Use				1	176							177
17. Electricity Output in GWh	391		33		2,012	6,189		0				8,625
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.13. Myanmar Energy Balance Table, 2011

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	309		849		11,426	649		0	9,537			22,771
2. Imports	21			1,537								1,559
3. Exports	-11				-8,970							-8,981
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-27								-27
6. Stock Changes			-32	-223								-255
7. Total Primary Energy Supply	320		817	1,286	2,456	649		0	9,537			15,065
8. Transfers												
9. Total Transformation Sector	-153		-835	781	-1,283	-649		-0	-158	899		-1,398
9.1 Main Activity Producer	-153			-12	-1,283	-649		-0		899		-1,197
9.2 Auto Producers												
9.3 Gas Processing												
9.4 Refineries			-835	793								-42
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-158			-158
9.9 Other Transformation												
10. Loss and Own Use				-5	-197					-250		-452
11. Discrepancy			19	4	-140				-0	13		-104
12. Total Final Energy Consumption	167			2,066	836				9,380	662		13,111
13. Industry Sector	167			818	660				2,785	233		4,664
13.1 Iron and Steel	31				18							49
13.2 Chemical (incl. Petrochemical)					257							257
13.3 Non-ferrous Metals					3							3
13.4 Non-metallic Mineral Products	107				339							446
13.5 Transportation Equipment					2							2
13.6 Machinery					7							7
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					9							9
13.9 Pulp, Paper, and Printing					17							17
13.10 Wood and Wood Products												
13.11 Construction				52								52
13.12 Textiles and Leather					9							9
13.13 Other Industry	28			766					2,785	233		3,813
14. Transport Sector				1,212	176							1,388
14.1 Domestic Air Transport				74								74
14.2 Road				1,100	176							1,276
14.3 Rail				38								38
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				36					6,595	429		7,060
15.1 Residential and Commercial				34					6,595	422		7,051
15.1.1 Commerce and Public Services				16					2,785	132		2,933
15.1.2 Residential				18					3,810	290		4,118
15.2 Agriculture												
15.3 Fishing												
15.4 Others				2						7		9
16. of which Non-energy Use				75	232							307
17. Electricity Output in GWh	312		38		2,556	7,544		4				10,455
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.14. Myanmar Energy Balance Table, 2012

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	305		829	12	11,477	668		0	9,627			22,919
2. Imports	2			1,442								1,443
3. Exports			-141		-8,900							-9,041
4. International Marine Bunkers				-2								-2
5. International Aviation Bunkers				-36								-36
6. Stock Changes			62	84								146
7. Total Primary Energy Supply	306		750	1,501	2,577	668		0	9,627			15,430
8. Transfers												
9. Total Transformation Sector	-131		-697	626	-1,430	-668		-0	-170	943		-1,527
9.1 Main Activity Producer	-131			-16	-1,409	-668		-0		943		-1,281
9.2 Auto Producers												
9.3 Gas Processing					-21							-21
9.4 Refineries			-697	642								-54
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-170			-170
9.9 Other Transformation												
10. Loss and Own Use				-5	-238					-233		-476
11. Discrepancy	-5		-54	-148	-336				-0	0		-542
12. Total Final Energy Consumption	171			1,974	573				9,457	710		12,885
13. Industry Sector	171			1,094	393				2,795	331		4,784
13.1 Iron and Steel	27				15							42
13.2 Chemical (incl. Petrochemical)					197							197
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	142				150							292
13.5 Transportation Equipment					2							2
13.6 Machinery					4							4
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					6							6
13.9 Pulp, Paper, and Printing					12							12
13.10 Wood and Wood Products												
13.11 Construction				78								78
13.12 Textiles and Leather					5							5
13.13 Other Industry	2			1,016					2,795	331		4,144
14. Transport Sector				847	165							1,013
14.1 Domestic Air Transport				73								73
14.2 Road				738	165							903
14.3 Rail				36								36
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				32	14				6,662	379		7,088
15.1 Residential and Commercial				32	14				6,662	372		7,080
15.1.1 Commerce and Public Services				16	14				2,795	141		2,967
15.1.2 Residential				16					3,866	231		4,113
15.2 Agriculture												
15.3 Fishing												
15.4 Others				1						7		8
16. of which Non-energy Use				105	177							283
17. Electricity Output in GWh	265		51		2,883	7,766		4				10,969
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.15. Myanmar Energy Balance Table, 2013

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	235		846	8	11,853	973		0	9,372			23,288
2. Imports	16			1,910								1,926
3. Exports	-24		-238		-9,159					-218		-9,639
4. International Marine Bunkers				-3								-3
5. International Aviation Bunkers				-78								-78
6. Stock Changes			3	19								22
7. Total Primary Energy Supply	227		611	1,856	2,694	973		0	9,372	-218		15,516
8. Transfers												
9. Total Transformation Sector	-59		-557	477	-1,500	-973		-0	-180	1,268		-1,525
9.1 Main Activity Producer	-59			-19	-1,488	-973		-0		1,268		-1,272
9.2 Auto Producers												
9.3 Gas Processing					-12							-12
9.4 Refineries			-557	496								-61
9.5 Coal Transformation												
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-180			-180
9.9 Other Transformation												
10. Loss and Own Use				-5	-268					-223		-496
11. Discrepancy	0		-54	-109	-271				0	-0		-434
12. Total Final Energy Consumption	168			2,219	654				9,193	827		13,061
13. Industry Sector	168			1,261	475				2,704	349		4,958
13.1 Iron and Steel	25				9							34
13.2 Chemical (incl. Petrochemical)					153							153
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	90				280							370
13.5 Transportation Equipment					1							1
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					15							15
13.10 Wood and Wood Products												
13.11 Construction				110								110
13.12 Textiles and Leather					6							6
13.13 Other Industry	53			1,152					2,704	349		4,258
14. Transport Sector				881	178							1,060
14.1 Domestic Air Transport				47								47
14.2 Road				797	178							976
14.3 Rail				37								37
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector				77	1				6,489	478		7,044
15.1 Residential and Commercial				40	1				6,489	469		6,998
15.1.1 Commerce and Public Services				13	1				2,704	146		2,863
15.1.2 Residential				27					3,784	324		4,135
15.2 Agriculture												
15.3 Fishing												
15.4 Others				37						9		46
16. of which Non-energy Use				186	138							324
17. Electricity Output in GWh	136		61		3,228	11,310		4				14,739
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.16. Myanmar Energy Balance Table, 2014

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	181		810	10	16,499	886		1	10,012			28,398
2. Imports	150			3,679								3,828
3. Exports	-6		-243		-13,238					-126		-13,613
4. International Marine Bunkers				-0								-0
5. International Aviation Bunkers				-84								-84
6. Stock Changes			-31	-772	-7							-810
7. Total Primary Energy Supply	325		536	2,833	3,254	886		1	10,012	-126		17,720
8. Transfers												
9. Total Transformation Sector	-34	1	-561	489	-2,129	-886		-1	-182	1,345		-1,958
9.1 Main Activity Producer	-34			-20	-2,116	-886		-1		1,345		-1,712
9.2 Auto Producers												
9.3 Gas Processing					-13							-13
9.4 Refineries			-561	509								-52
9.5 Coal Transformation	-2	2										0
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-182			-182
9.9 Other Transformation												
10. Loss and Own Use				-5	-387					-250		-641
11. Discrepancy	0		25	-208	-164				0	0		-346
12. Total Final Energy Consumption	290	1		3,110	573				9,830	970		14,773
13. Industry Sector	290			1,782	391				2,886	454		5,803
13.1 Iron and Steel	51				10							61
13.2 Chemical (incl. Petrochemical)					140							140
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	53				217							269
13.5 Transportation Equipment					1							1
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					6							6
13.10 Wood and Wood Products												
13.11 Construction				215								215
13.12 Textiles and Leather					6							6
13.13 Other Industry	186			1,568					2,886	454		5,094
14. Transport Sector				1,254	181							1,436
14.1 Domestic Air Transport				56								56
14.2 Road				1,161	181							1,342
14.3 Rail				37								37
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector		1		73	1				6,944	516		7,535
15.1 Residential and Commercial		1		43	1				6,944	505		7,493
15.1.1 Commerce and Public Services				12	1				2,886	151		3,049
15.1.2 Residential		1		31					4,058	354		4,444
15.2 Agriculture												
15.3 Fishing												
15.4 Others				31						11		42
16. of which Non-energy Use				302	126							429
17. Electricity Output in GWh	70		65		5,193	10,298		14				15,639
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.17. Myanmar Energy Balance Table, 2015

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	159		659	14	17,110	915		1	9,101			27,960
2. Imports	114			4,712								4,826
3. Exports	-6		-150	-34	-13,712					-107		-14,008
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-41								-41
6. Stock Changes			-29	163	4							138
7. Total Primary Energy Supply	268		481	4,812	3,402	915		1	9,101	-107		18,873
8. Transfers												
9. Total Transformation Sector	-2	2	-432	391	-2,402	-915		-1	-183	1,481		-2,061
9.1 Main Activity Producer				-17	-2,385	-915		-1		1,481		-1,837
9.2 Auto Producers												
9.3 Gas Processing					-17							-17
9.4 Refineries			-432	409								-24
9.5 Coal Transformation	-2	2										
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-183			-183
9.9 Other Transformation												
10. Loss and Own Use				-5	-470					-222		-697
11. Discrepancy	-0		-48	-437	-32				-0	0		-518
12. Total Final Energy Consumption	267	2		4,760	498				8,918	1,153		15,597
13. Industry Sector	267			2,791	330				2,624	354		6,366
13.1 Iron and Steel	28				5							33
13.2 Chemical (incl. Petrochemical)					160							160
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	92				142							235
13.5 Transportation Equipment					0							0
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					5							5
13.9 Pulp, Paper, and Printing					3							3
13.10 Wood and Wood Products												
13.11 Construction				154								154
13.12 Textiles and Leather					7							7
13.13 Other Industry	147			2,637	2				2,624	354		5,764
14. Transport Sector				1,892	167							2,059
14.1 Domestic Air Transport				97								97
14.2 Road				1,758	167							1,925
14.3 Rail				37								37
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector		2		78	1				6,293	799		7,172
15.1 Residential and Commercial		2		47	1				6,293	790		7,131
15.1.1 Commerce and Public Services				23	1				2,624	216		2,864
15.1.2 Residential		2		23					3,669	574		4,268
15.2 Agriculture												
15.3 Fishing												
15.4 Others				31						9		41
16. of which Non-energy Use				283	144							426
17. Electricity Output in GWh			55		6,518	10,639		11				17,223
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid, TJ = terajoule.

Source: Author.

Table 3.18. Myanmar Energy Balance Table, 2016

Unit: kilotons of oil equivalent

	Coal	Coal Products	Crude Oil and NGL	Petroleum Products	Gas	Hydro	Nuclear	Geothermal, Solar etc.	Others	Electricity	Heat	Total
1. Indigenous Production	209		607	11	16,466	1,043		1	9,069			27,406
2. Imports	208			3,966								4,174
3. Exports	-4		-146	-173	-12,834					-205		-13,361
4. International Marine Bunkers				-1								-1
5. International Aviation Bunkers				-89								-89
6. Stock Changes			-0	357	-1							355
7. Total Primary Energy Supply	414		461	4,070	3,631	1,043		1	9,069	-205		18,484
8. Transfers												
9. Total Transformation Sector	-7	2	-418	400	-2,747	-1,043		-1	-141	1,742		-2,213
9.1 Main Activity Producer	-5			-19	-2,730	-1,043		-1		1,742		-2,056
9.2 Auto Producers												
9.3 Gas Processing					-17							-17
9.4 Refineries			-418	419								0
9.5 Coal Transformation	-2	2										-0
9.6 Petrochemical Industry												
9.7 Biofuel Processing												
9.8 Charcoal Processing									-141			-141
9.9 Other Transformation												
10. Loss and Own Use				-5	-431					-216		-652
11. Discrepancy	0		-43	-261	-23				-0	-0		-327
12. Total Final Energy Consumption	407	2		4,204	430				8,928	1,321		15,292
13. Industry Sector	407			2,037	265				2,633	400		5,743
13.1 Iron and Steel	37				7							44
13.2 Chemical (incl. Petrochemical)					117							117
13.3 Non-ferrous Metals					2							2
13.4 Non-metallic Mineral Products	123				119							242
13.5 Transportation Equipment					0							0
13.6 Machinery					5							5
13.7 Mining and Quarrying												
13.8 Food, Beverages, and Tobacco					6							6
13.9 Pulp, Paper, and Printing					0							0
13.10 Wood and Wood Products												
13.11 Construction				215								215
13.12 Textiles and Leather					8							8
13.13 Other Industry	49			1,823	2				2,305	400		4,578
14. Transport Sector				2,065	164							2,230
14.1 Domestic Air Transport				128								128
14.2 Road				1,902	164							2,066
14.3 Rail				36								36
14.4 Inland Waterways												
14.5 Pipeline Transport												
14.6 Other Transport												
15. Other Sector		2		102	0				6,294	921		7,320
15.1 Residential and Commercial		2		70	0				6,294	911		7,278
15.1.1 Commerce and Public Services				34	0				2,633	260		2,928
15.1.2 Residential		2		35					3,661	651		4,350
15.2 Agriculture												
15.3 Fishing												
15.4 Others				32						10		42
16. of which Non-energy Use				424	105							529
17. Electricity Output in GWh	10		61		8,052	12,125		9				20,258
18. Heat Output in TJ												

GWh = gigawatt-hour, NGL = natural gas liquid TJ = terajoule.

Source: Author.

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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.

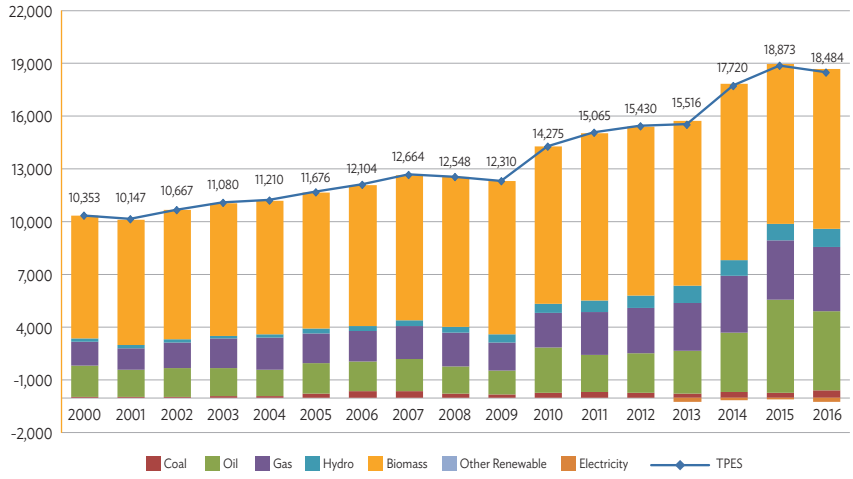
Hydro growth was slightly slower than coal, at an average rate of 12.3% per year. Hydro supply plays a major role in providing the electricity needed to meet the increasing domestic demand as more houses are being electrified and more commercial buildings are constructed. Moreover, electricity from hydro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

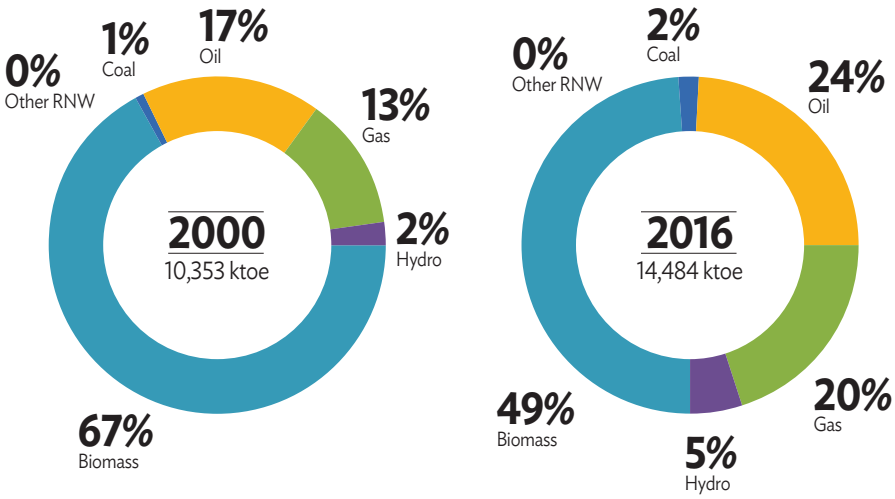
Figure 4.1. Total Primary Energy Supply



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.

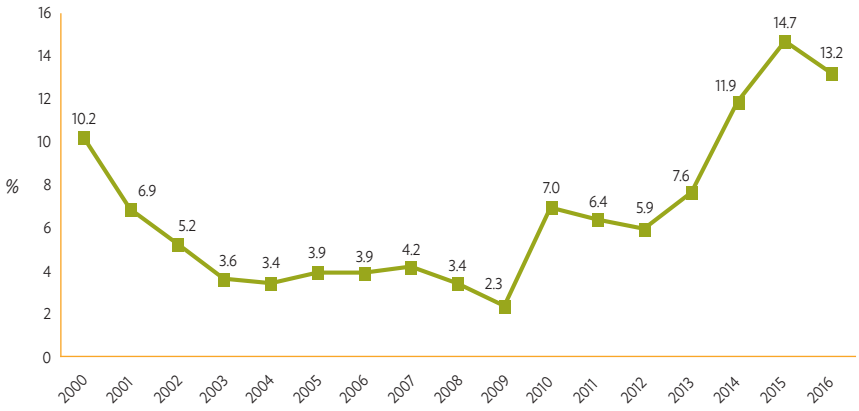
Myanmar exported gas to Thailand. The indigenous production of natural gas was the second largest in the total indigenous production of the country in 2000. Its production increased significantly at an average rate of 8.4% per year – from 4,500 ktoe in 2000 to almost 16,500 ktoe in 2016.

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

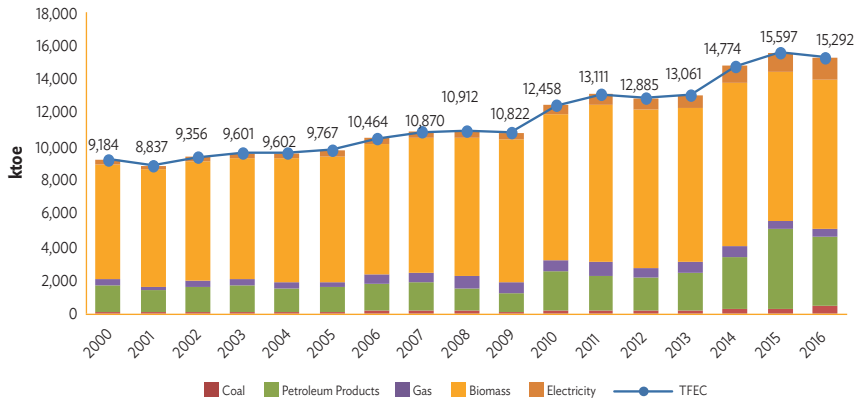


Source: Author's calculation.

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

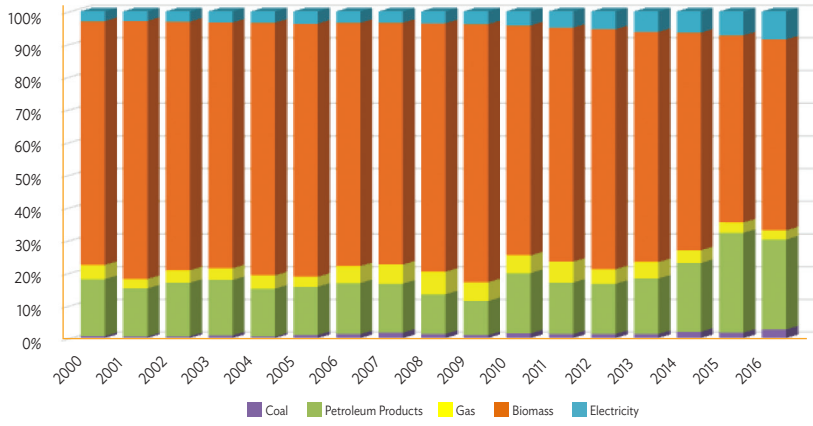


TFEC = total final energy consumption.

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.

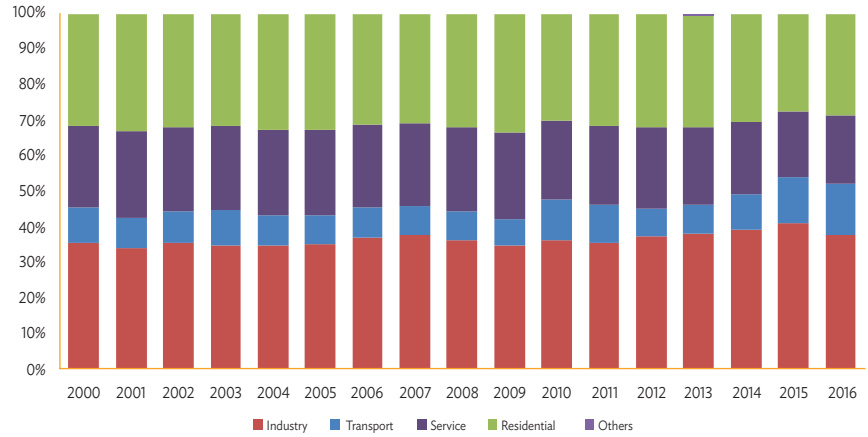
Source: Author's calculation.

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.

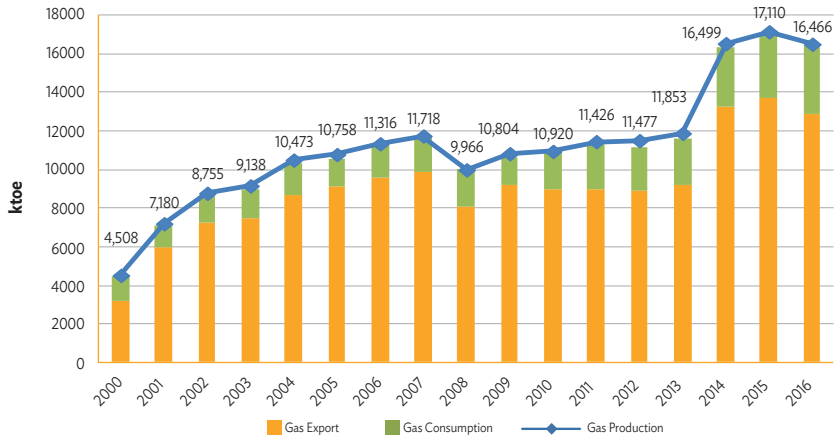
Supply and Consumption by Energy Product

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**

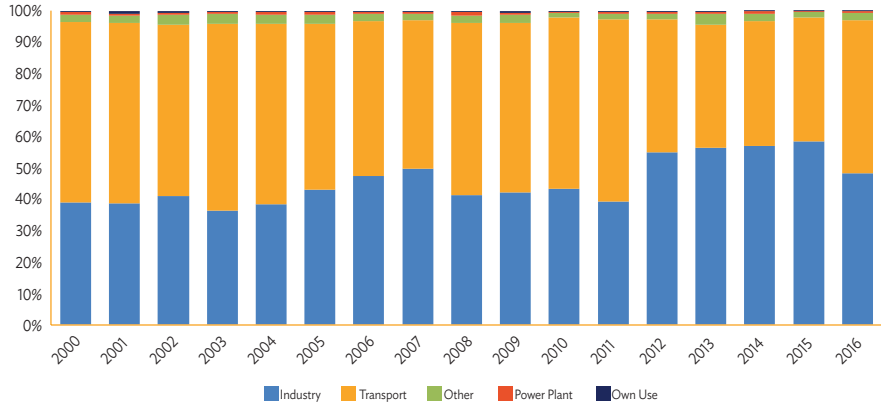
AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent.

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.

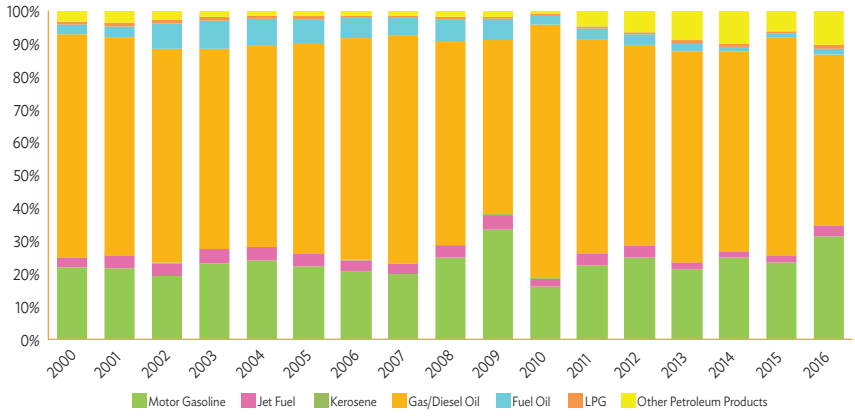
LPG share in the total petroleum product consumption of Myanmar remained at around 1% in 2000–2016 since it was used only for cooking in the residential and services sectors (restaurants, cafeterias, etc.). Although the share of LPG

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**

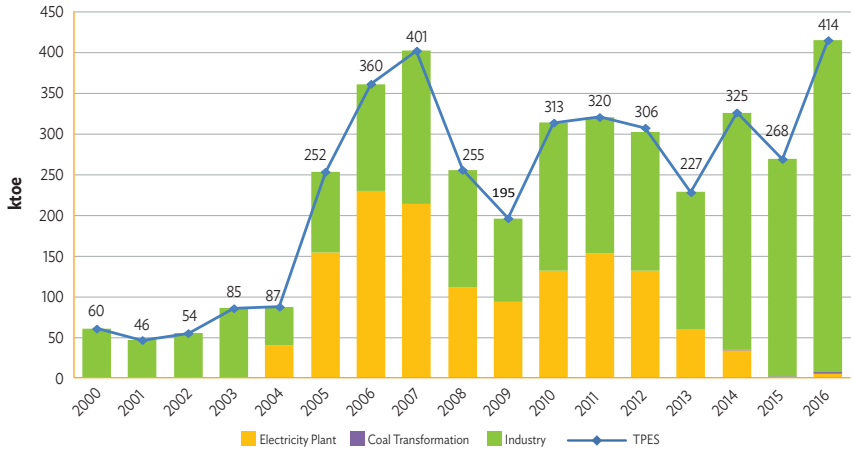
AAGR = average annual growth rate, ktoe = kilo ton of oil equivalent.

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.

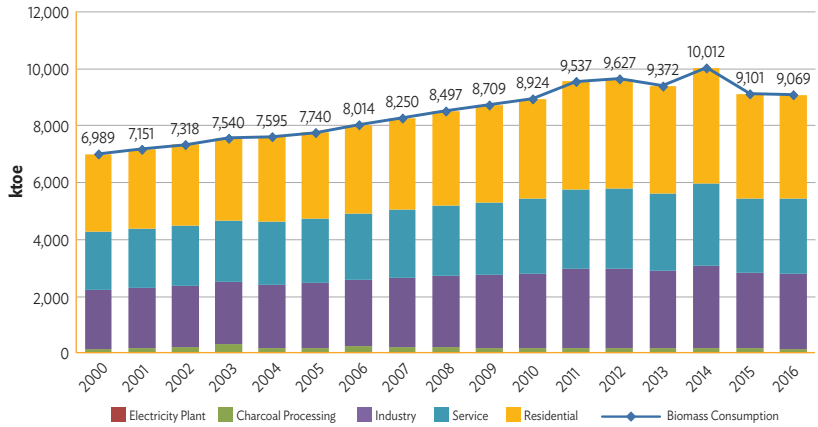
Biomass

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)

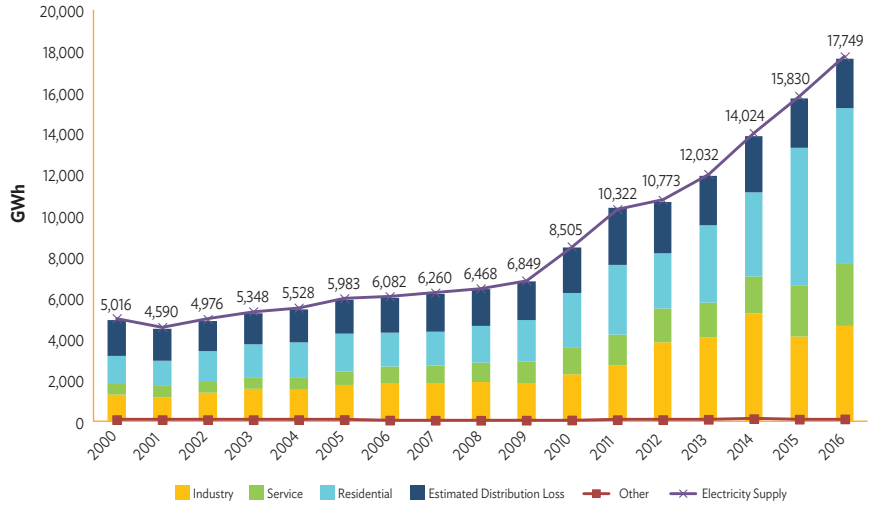
Year	Domestic Electricity Consumption	Industry	Service	Residential	Other	Estimated Distribution Loss	Electricity Supply
2000	3,268	1,295	527	1,361	85	1,748	5,016
2001	3,041	1,148	564	1,245	85	1,550	4,590
2002	3,484	1,417	552	1,431	84	1,492	4,976
2003	3,850	1,577	578	1,612	83	1,498	5,348
2004	3,909	1,549	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**

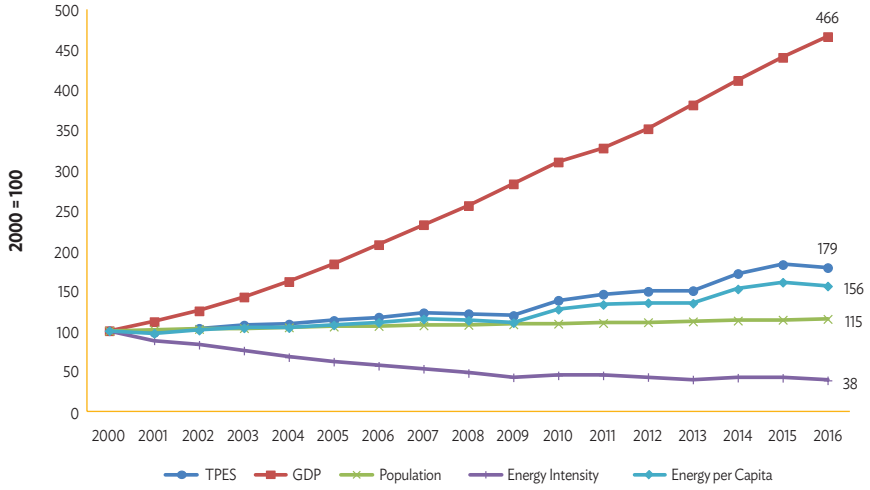
AAGR = average annual growth rate, GDP = gross domestic product, ktoe = kiloton of oil equivalent, POP = population , toe = ton of oil equivalent, TPES = total primary energy supply.

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.

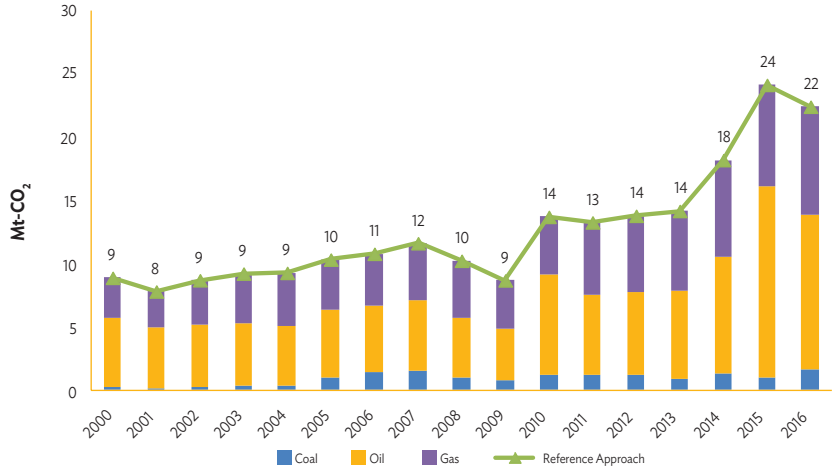
Energy and CO_2 emissions

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).

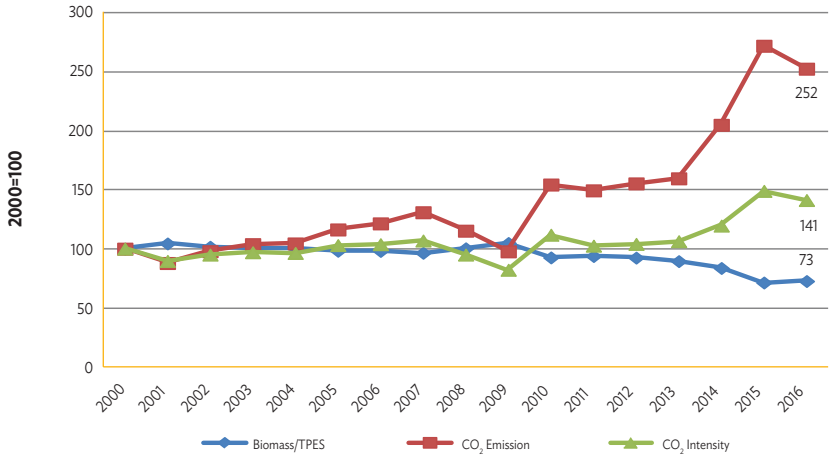
Table 4.12. Energy and CO_2 Emission Indicators

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.

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Chapter 5
Conclusions and Policy Implications

Conclusions

To produce the Myanmar Energy Statistics 2000–2016, the Economic Research Institute for ASEAN and East Asia (ERIA) and the Oil and Gas Planning Department (OGPD) conducted the following research activities:

1) Collect existing energy data and assess quality of the data.
2) Conduct energy demand surveys for the final energy consumption sector, which consists of the industry, road transport, residential, and commercial sub-sectors.
3) Collect sales data of petroleum products from oil-importing companies in Myanmar.
4) Estimate missing data.
5) Produce Myanmar's energy balance tables (EBTs) for 2000–2016 based on existing data and the estimated data from the survey results and other information.
6) Analyse the EBTs to evaluate the energy demand–supply situation of Myanmar.

Available existing energy data for both supply and demand sides are abundant but the quality of some data is not good, so that ERIA/OGPD revised the inconsistent data. ERIA/OGPD also faced missing data, which is on sub-bituminous coal and lignite consumption for power generation, opening and closing stocks of crude oil and petroleum products, disaggregation of own use to

each type of power plant, etc. Some data was estimated, and some was treated as zero.

ERIA/OGPD selected a local consultant, the Myanmar Survey Research (MSR), to conduct the energy demand survey. The survey was successful, but the quality of its results was not good because this was the first time for Myanmar to conduct such a survey. However, ERIA/OGPD found several meaningful results:

1) Energy consumption of the industry sector can be separated into 13 industrial sub-sectors, but GDP can be separated into only a few industrial sub-sectors.
2) Gasoline consumed for road transport activities, which is estimated based on the survey results, is the same as gasoline demand in transport activities of OGPD data.
3) The results of the commercial survey might indicate reasonable building energy intensity after removing the outliers.
4) The household survey suggests that biomass share from existing data is a bit high. This indicates that households in Myanmar are aggressively shifting from biomass to conventional energy, such as liquefied petroleum gas or electricity.

The sales data from oil companies in Myanmar has not been completed. The sales data would be useful, so ERIA should encourage the OGPD to complete this survey.

The EBTs of Myanmar are successfully produced based on existing and estimated energy data using the computer software presented by ERIA to analyse the data. According to the analysis, Myanmar has been an oil- and natural gas–producing country. Natural gas is an important energy source for the country; it is for domestic consumption, mainly power generation, and for export. But share of domestic oil has been declining and its share of 2016 was around 10% of total oil supply.

Policy Implications

Myanmar's EBT 2000–2016, as prepared by ERIA/OGPD, yields the following key findings:

1) The total final energy consumption (TFEC) and the total primary energy supply (TPES) for 2000–2016 grew 2.7% and 3.2%, respectively. For the TFEC, biomass was the dominant energy source, followed by petroleum products and electricity. But electricity marked the highest growth, 10.2%, followed by coal and petroleum products. For the TPES, biomass was still dominant in 2016, followed by gas, petroleum products, and hydro. But hydro marked the highest growth rate, 12.3%, followed by coal, gas, and petroleum products.

2) CO_2 emission from combusting energy (fossil fuel) also largely increased to about 21 CO_2 million tons in 2016 from 9 CO_2 million tons in 2000, which grew 5.7% per year. Major energy sources that emitted CO_2 in Myanmar were oil and gas. In 2000–2016, oil and gas increased 6.0% and 6.4%, respectively. Consequently, the growth rate of CO_2 was much higher than the TPES in 2000–2016.

3) Hydropower generation is clean in terms of CO_2 emission, but it faces seasonal fluctuation. On the other hand, gas power generation can achieve stable electricity supply, but it emits CO_2. Consequently, they are complementary. Since both are national energy sources, they will surely contribute to maintain energy supply security.

4) Energy intensity, defined as TPES/GDP, improved by 65% in 2000–2016. Also, elasticity defined as TPES per GDP was 0.3 (3.22/10.09) in the same period. The reason for this lower elasticity is that electricity and petroleum demand increased rapidly but biomass demand decreased, so that biomass absorbed the increase of electricity and petroleum products.

The policy implications of the key findings mentioned are as follows:

1) The TFEC increased 3.2% per year in 2000–2016 but, without biomass, was 6.5% per year in the same period. GDP elasticity was still less than 1 (6.5/10.1) but energy consumption in the industry and the transport sectors (especially road subsector) marked 3.6% and 5.6% per year, respectively. Consequently, energy efficiency and conservation (EEC) policies, such

as energy management system and standard and labelling (S&L), will be implemented in both sectors.

2) The dominant electricity consumer was the residential sector, so that efficient use of appliances is essential and EEC policies, such as media campaigns and S&L, will be effective.

3) Myanmar's import dependency ratio (%), defined as import/total supply, had been less than 10% until 2013 but it jumped to 15% in 2015. The rapid increase of petroleum consumption across the sector brought about this result. Internal use of domestic energy, such as natural gas and hydropower generation, will be essential for Myanmar. On the other hand, both energy sources are important as export goods. Since the use of hydropower generation and natural gas is good for maintaining energy security yet causes Myanmar to lose income from the export of electricity by hydro and natural gas, this is controversial issue.

4) Thermal efficiency of natural gas power generation, which is the second-largest power source, was very low, 20%–25%, in 2000–2016 due to the existing old-type power plants. Replacement of existing plants with combined cycle gas turbines and allocation of the saved gas for export will be recommended.

These energy statistics should be updated every year so that the OGPD/ Ministry of Electricity and Energy will continue to release Myanmar's EBTs through collecting updated original energy data and estimating it.

Annex 1
Definitions of Myanmar's Energy Balance Table

Column: Energy Products

Column 1: Coal includes all coal, i.e., solid fossil fuel consisting of carbonised vegetal matter such as hard coal (coking coal, other bituminous coal, sub-bituminous coal); anthracite; lignite; and peat.

Column 2: Coal products include those derived directly or indirectly from the various classes of coal by carbonisation or pyrolysis processes, or by the aggregation of finely divided coal or by chemical reactions with oxidising agents, including water, such as coke, coke oven gas, blast furnace gas, oxygen steel furnace gas, patent fuel, coal tar, and brown coal briquette/peat briquette (BKB/PB).

Column 3: Crude oil and natural gas liquid comprise crude oil, natural gas liquids, refinery feedstocks, and additives as well as other hydrocarbons (including emulsified oils, synthetic crude oil, mineral oils extracted from bituminous minerals such as oil shale, bituminous sand, etc., and oils from coal liquefaction).

Column 4: Petroleum products comprise motor gasoline, aviation gasoline, naphtha, jet fuel, kerosene, gas/diesel oil, fuel oil, liquefied petroleum gas, refinery gas, ethane, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke, and other petroleum products.

Column 5: Gas includes natural gas (excluding natural gas liquids) and gas works gas. The latter appears as a positive figure in the 'gas works' row but is not part of production.

Column 6: Hydro shows the energy content of the electricity produced in hydropower plants. Hydro output excludes output from pumped storage plants.

Column 7: Nuclear show the primary heat equivalent of the electricity produced by a nuclear power plant with an average thermal efficiency of 33%.

Column 8: Geothermal, solar, etc. show production of geothermal, solar, wind, and tide/wave/ocean energy and the use of these energy forms for electricity and heat generation. Unless the actual efficiency of the geothermal process is known, the quantity of geothermal energy entering electricity generation is inferred from the electricity production at geothermal plants assuming an average thermal efficiency of 10%. For solar, wind and tide/wave/ocean energy, the quantities entering electricity generation are equal to the electrical energy generated. Other uses shown in this column relate to geothermal and solar thermal heat.

Column 9: Other (combustible renewables and waste) comprises solid biomass, liquid biomass, biogas, industrial waste and municipal waste. Biomass is defined as any plant matter used directly as fuel or converted into fuels (e.g., charcoal) or electricity and/or heat. Included here are fuelwood and wood waste, bagasse, charcoal, other biomass, and biogas.

Municipal waste comprises wastes produced by the residential, commercial, and public service sectors that are collected by local authorities for disposal in a central location to produce heat and/or power. Hospital waste is included in this category.

Column 10: Electricity shows final consumption and trade in electricity, which is accounted at the same heat value as electricity in final consumption (i.e., 1 MWh = 0.086 toe.)

Column 11: Heat shows the disposition of heat produced for sale. Most of the heat included in this column results from the combustion of fuels although small amounts are produced from electrically powered heat pumps and boilers. Any heat extracted from ambient air by heat pumps is shown as production.

Column 12: Total equals the total of Columns 1 to 11.

Row: Energy Flow

Row 1: Indigenous production is the production of primary energy, i.e., hard coal, lignite/brown coal, peat, crude oil, natural gas liquid, natural gas, combustible renewables and waste, nuclear, hydro, geothermal, solar, and the heat from heat pumps that is extracted from the ambient environment. Indigenous production is calculated after removal of impurities (e.g., sulphur from natural gas).

Row 2/3: Imports and exports comprise amounts having crossed the national territorial boundaries of the country, whether customs clearance has taken place.

For coal: Imports and exports comprise the amount of fuels obtained from or supplied to other countries, whether an economic or customs union exists between the relevant countries. Coal in transit should not be included.

For oil and gas: Quantities of crude oil and oil products imported or exported under processing agreements (i.e., refining on account) are included. Quantities of oil in transit are excluded. Crude oil, natural gas liquid, and natural gas are reported as coming from the country of origin; refinery feedstocks and oil products are reported as coming from the country of last consignment. Re-exports of oil imported for processing within bonded areas are shown as exports of product from the processing country to the destination.

For electricity: Amounts are considered as imported or exported when they have crossed the national territorial boundaries of the country. If electricity is 'wheeled' or transited through a country, the amount is shown as both an import and an export.

Row 4: International marine bunkers cover those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined based on the port of departure and

port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded.

Row 5: International aviation bunkers include deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split should be determined based on the departure and landing locations and not by the nationality of the airline. For many countries, this incorrectly excludes fuel used by domestically owned carriers for their international departures.

Row 6: Stock changes reflect the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries, and large consumers. A stock build is shown as a negative number, and a stock draw as a positive number.

Row 7: Total primary energy supply (TPES) is made up of indigenous production (Row 1) + imports (Row 2) – exports (Row 3) - international marine bunkers (Row 4) - international aviation bunkers (Row 5) ± stock changes (Row 6).

Row 8: Transfers include inter-product transfers, products transferred, and recycled products (e.g., used lubricants which are reprocessed).

Row 9: Total transformation sector. Transformation is the process where the movement of part or all the energy content of a product entering a process to one or more different products leaving the process (e.g., coking coal to coke, crude oil to petroleum products, and heavy fuel oil to electricity). Total transformation sector is the sum of transformation input (negative number) and transformation output (positive number) of various energy industries.

Row 9.1: Main activity producer generates electricity and/or heat for sale to third parties as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid. Columns 1 through 9 show the use of primary and secondary fuels to produce electricity and/or heat as negative entries. Heat from chemical processes used to generate electricity will appear in Column 11. Gross electricity and/or heat produced (including power stations' own consumption) appears as a positive quantity

in the electricity and heat column. Transformation losses appear in the total column as a negative number.

Row 9.2: Auto producer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned. Columns 1 through 9 show the use of primary and secondary fuels to produce electricity and/or heat as negative entries. Heat from chemical processes used for electricity generation will appear in Column 11. Gross electricity and/or heat produced (including power stations' own consumption) appears as a positive quantity in the electricity and heat column. Transformation losses appear in the total column as a negative number.

Row 9.3: Gas processing is treated similarly to electricity generation, with the quantity produced appearing as a positive figure in the gas column, inputs as negative entries in the coal, petroleum products and gas columns, and conversion losses appearing in the total column.

Row 9.4: Refineries show the use of primary energy for the manufacture of finished petroleum products and the corresponding output. Thus, the total reflects transformation losses. In certain cases, the data in the total column are positive numbers. This can be due either to problems in the primary refinery balance, or to the fact that the International Energy Agency uses regional net calorific values for petroleum products.

Row 9.5: Coal transformation contains losses in transformation of coal from primary to secondary fuels and from secondary to tertiary fuels (hard coal to coke, coke to blast furnace gas, lignite to BKB, etc.). It is often difficult to correctly account for all inputs and outputs in energy transformation industries, and to separate energy that is transformed from energy that is combusted. As a result, in certain cases, the data in the total column are positive numbers, indicating a problem in the underlying energy data.

Row 9.6: Petrochemical Industry includes backflows from the petrochemical sector. Backflows from oil products that are used for non-energy purposes (i.e., white spirit and lubricants) are not included here, but in non-energy use.

Row 9.7: Biofuel Processing records the transformation input and output of biofuel plants, of which the input is recorded as negative and the output as positive.

Row 9.8: Charcoal Processing records the transformation of fuelwood or other vegetal matter to produce charcoal. The quantity of fuelwood or other vegetal matter input is recorded as negative, while the output of charcoal is recorded as positive number.

Row 9.9: Other Transformation covers non-specified transformation not shown elsewhere, such as the blending of other gases with natural gas.

Row 10: Loss and Own Use. Losses includes distribution and transmission losses in gas distribution, electricity transmission, and coal transport. Own use contains the primary and secondary energy consumed by transformation industries for heating, pumping, traction, and lighting purposes [ISIC4 Divisions 10-12, 23 and 40]. These quantities are shown as negative figures. Included here are, for example, own use of energy in coal mines, own consumption in power plants (which includes net electricity consumed for pumped storage) and energy used for oil and gas extraction.

Row 11: Discrepancy includes the sum of the unexplained statistical differences for individual fuels, as they appear in the basic energy statistics. It also includes the statistical differences that arise because of the variety of conversion factors in the coal and oil columns.

Row 12: Total final energy consumption (TFEC) is the sum of consumption by the different end-use sectors. Backflows from the petrochemical industry are not included in final consumption.

Row 13: Industry sector consumption is specified in the following sub-sectors (energy used for transport by industry is not included here but is reported under transport):

Row 13.1: Iron and steel industry [ISIC Group 271 and Class 2731];
Row 13.2: Chemical (incl. Petrochemical) industry [ISIC Division 24] excluding petrochemical feedstocks;

Row 13.3: Non-ferrous metals basic industries [ISIC Group 272 and Class 2732];
Row 13.4: Non-metallic minerals such as glass, ceramic, cement, etc. [ISIC Division 26];
Row 13.5: Transport equipment [ISIC Divisions 34 and 35];
Row 13.6: Machinery comprises fabricated metal products, machinery, and equipment other than transport equipment [ISIC Divisions 28 to 32];
Row 13.7: Mining (excluding fuels) and quarrying [ISIC Divisions 13 and 14];
Row 13.8: Food, beverages, and tobacco [ISIC Divisions 15 and 16];
Row 13.9: Paper, pulp, and printing [ISIC Divisions 21 and 22];
Row 13.10: Wood and wood products (other than pulp and paper) [ISIC Division 20];
Row 13.11: Construction [ISIC Division 45];
Row 13.12: Textile and leather [ISIC Divisions 17 to 19];
Row 13.13: Other industry (any manufacturing industry not included above) [ISIC Divisions 25, 33, 36 and 37].

Note: The other industry row is also used when breaking down industrial sub-sectors is difficult. This number should be treated with caution.

Rows 14: Transport sector includes all fuels used for transport [ISIC Divisions 60 to 62] except international marine bunkers and international aviation bunkers. It includes transport in the industry sector and covers domestic aviation, road, rail, pipeline transport, domestic navigation, and non-specified transport. Domestic aviation includes deliveries of aviation fuels to aircraft for domestic aviation – commercial, private, agriculture, etc. It includes use for purposes other than flying, e.g., bench testing of engines, but not airline use of fuel for road transport.

The domestic/international split should be determined based on departure and landing locations and not by the nationality of the airline. Fuel used for ocean, coastal, and inland fishing (included under fishing), and military consumption (included in other sectors non-specified) are excluded from the transport sector.

Rows 15: Other sectors cover residential, commercial, and public services [ISIC Divisions 41, 50–52, 55, 63–67, 70–75, 80, 85, 90–93, 95, and 99]; agriculture [ISIC Divisions 01 and 02]; fishing [ISIC Division 05]; and others. Others include military fuel use for all mobile and stationary consumption (e.g., ships, aircraft,

road and energy used in living quarters) regardless of whether the fuel delivered is for the military of that country or for another.

Row 16: Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Non-energy use is shown separately in final consumption under the heading non-energy use.

Row 17: Electricity generated shows the total number of gigawatt-hours generated by thermal power plants separated into electricity plants and combined heat and power (CHP) plants, as well as production by nuclear and hydro (excluding pumped storage production), geothermal, etc. (see, however, the notes on Rows 10 and 11). Electricity produced by heat from chemical processes is shown in the heat column.

Row 18: Heat generated shows the total amount of terajoules generated by power plants separated into CHP plants and heat plants. Heat produced by electric boilers is shown in the electricity column. Heat produced by heat pumps, heat from chemical processes, and heat from non-specified combustible fuels is shown in the heat column.

Annex 2
Petroleum Products Sales Questionnaire Definitions

Definition of Fuels

1. Liquefied Petroleum Gas or LPG

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

2. Naphtha

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

3. Motor Gasoline

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

4. Kerosene-type Jet Fuel

This is a blend of kerosene suited to flight conditions with particular specifications, such as freezing point. The specifications are set down by a small number of national standards committees, most notably, Absorption Spectroscopic Methods–ASTM (United States), UK Ministry of Defend-Defend

Standard MOD (United Kingdom), and Russian Gasoil Specification-GOST (Russian Federation).

5. Other Kerosene

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

6. Diesel Oil

Diesel oils are middle distillates, predominantly of carbon number range C11 to C25 and with a distillation range of 160°C to 420°C. This product comprises road diesel and heating or other gas oil.

7. Fuel Oil

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

8. Lubricants

Lubricants are oils, produced from crude oil, mainly used to reduce friction between sliding surfaces and during metal-cutting operations.

9. Bitumen

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

10. Other Products

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

Definition of Flows

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

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

3. Own use
Own use by petroleum import companies

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

5. Total Sales
= 1± 2 – 3

6. Sell to Power Producers
=6+7

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

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

9. Sell to Large-Scale Industrial Users (13 subsectors)
=10+11+12+13+14+15+16+17+18+19+20+21+22

10. Iron and Steel
ISIC Group 241 and Class 2431 (NACE Groups 24.1, 24.2, 24.3 and Classes 24.51 and 24.52). To avoid double counting, oil used in blast furnaces should be reported in the energy or transformation sector.

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

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

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

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

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

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

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

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

19. Construction

ISIC Division 41, 42 and 43 (NACE Division 41, 42, and 43)

20. Textiles and Leather

ISIC Divisions 13, 14, and 15 (NACE Divisions 13, 14, and 15)

21. Not Elsewhere Specified (Industry)

If the economy's industrial classification of oil consumption does not correspond to the above ISIC (or NACE) codes, please estimate the breakdown by industry and include in Not Elsewhere Specified only consumption in sectors which are not covered above. ISIC Division 22, 31, and 32. For NACE, it covers Divisions 22, 31, and 32 -Industry).

22. Sell to Large-Scale Transport User

=23+24+25+26+27

23. Taxi, Bus, Road Freight, etc.

- Report oil for use in road vehicles.
- Include fuel used by agricultural vehicles on highways and lubricants for use in road vehicles.
- Exclude motor gasoline and diesel used in stationary engines (see Not Elsewhere Specified – Other sectors); diesel oil for non-highway use in tractors (see Agriculture/Forestry – Other sectors); military use (see Not Elsewhere Specified – Other sectors); and gasoil used in engines at construction sites (see Construction – Industry sector).

24. International Civil Aviation

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

25. Domestic Air Transport

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

26. Inland Waterways

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

27. International Marine Bunker

Bunkers cover the quantities of fuels delivered to sea-going ships of all flags. Consumption of warships should be included in Final Consumption under the Other sectors, Not Elsewhere Specified. Consumption by ships engaged in fishing and in transport in inland and coastal waters is not included.

28. Sell to Other Large-Scale Users

=29+30+31+32+33+34

29. Commercial Services Such as Mall, Hotel, School, Hospital, Office building

ISIC Divisions and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84 (exclude Class 8422), 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96, and 99. Oil consumed by businesses and offices in the public and private sectors. Oil use at railways, bus stations, shipping piers, and airports should be reported in this category and not shown in the Transport sector.

30. Public Services Such as Central and Local Governments

Sales of petroleum products to central and local governments

31. Residential

Report fuels consumed by all households including 'households with employed persons' (ISIC and NACE Divisions 97 and 98).

32. Agriculture

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

33. Fishing

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

34. Petroleum Wholesaler

Sales of petroleum products to petroleum wholesaler

35. Sell to Gas Station

=36+37

36. Company-Owned Stations

Delivery of petroleum products to owned service stations

37. Company Franchises

Delivery of petroleum products to franchised service stations

Corporation/Company:
Year:

Petroleum Product Sales Questionnaire

Contact Person:

Tel:
Email:

Quantity Description	LPG	Naphta	Motor Gasoline	Keresone Type Jet Fuel	Other Keresone	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products (specify)
	Ton	KL	KL	KL	KL	KL	KL	KL	Specify	Specify
Import										
Blending										
Own Use										
Stock (in the end of the year)										
Total Sales										
Sell to Power producers										
EDC										
IPP, Rural, etc										
Sales to Large-Scale Industrial Users										
Iron and Steel										
Chemical (incl. Petrochemical)										
Non-ferrous Metals										
Transportation Equipment										
Machinery										
Mining and Quarrying										
Food, Beverages, and Tobacco										
Pulp, Paper, and Printing										
Wood and Wood Products										
Construction										
Textiles and Leather										
Not Elsewhere Specified (Industry)										
Sell to Large-Scale Transport Users										
Taxi, Bus, Road Freight, etc.										
International Civil Aviation										
Domestic Air Transport										
Inland Waterways										
International Marine Bunker										
Sell to Other Large-Scale Users										
Commercial Service such as mall, hotel, school, hospital, office building										
Public Services such as central and local governments										
Residential										
Agriculture										
Fishing										
Petroleum Wholesale										
Sell to Gas Station										
Company-Owned Stations										
Company Franchise										