Cambodia National Energy Statistics 2016

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Foreword

Cambodia has been experiencing high economic growth during the past 5 years and this trend will continue at least to 2020, according to economic experts. In this regard, the country's energy consumption could increase significantly. Unfortunately, no official energy statistics are available to monitor and evaluate this growth. Although an international organisation has been estimating energy balance tables for Cambodia historically, they seem to be underestimated. Accurate and reliable energy statistics such as energy balance tables are necessary to analyse the relationship between economic growth and energy consumption in Cambodia. This publication represents the first official energy statistics in Cambodia and contributes to the formulation of appropriate energy policies for the Ministry of Mines and Energy, Cambodia.

The Ministry of Mines and Energy requested the Economic Research Institute for ASEAN and East Asia (ERIA) to support the General Department of Petroleum (GDP) and the General Department of Energy (GDE) to prepare accurate energy statistics in Cambodia. ERIA kindly accepted this offer and in November 2015 set up a project team consisting of international experts to work in collaboration with the staff of GDP and GDE. The GDP and GDE shared the existing energy data with ERIA, and ERIA supported GDP and GDE in conducting three surveys: (1) demand–supply survey of petroleum products of petroleum companies, (2) energy consumption survey in the industry sector, and (3) energy consumption survey in buildings. During the project period, ERIA also conducted capacity building training, such as for basic understanding of energy statistics.

Lastly, the Ministry of Mines and Energy would like to express its great appreciation to ERIA for its technical and financial support for publishing the Cambodia Energy Statistics.

Suy Sem
Minister of Mines and Energy, Cambodia
September 2016

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Special acknowledgement is also given to Mr Shigeru Kimura, Special Advisor to the ERIA President on Energy Affairs, for his excellent leadership of this project.

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Abbreviations and Acronyms

BEI	building energy intensity
CO_2	carbon dioxide
EAC	Electricity Authority of Cambodia
EDC	Electricité du Cambodge (Electricity of Cambodia)
EEI	energy efficiency indicator
ERIA	Economic Research Institute for ASEAN and East Asia
GDE	General Department of Energy
GDP	gross domestic product
GWh	gigawatt-hour
IEA	International Energy Agency
IPP	independent power producer
kt	kiloton
ktoe	thousand ton of oil equivalent
LPG	liquefied petroleum gas
MME	Ministry of Mines and Energy
PPP	purchasing power parity
TFEC	total final energy consumption
TPES	total primary energy supply

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Chapter 1

Primary Energy Data

Cambodia's energy structure is simple. Fossil fuels, such as coal and petroleum products, are imported, while biomass is mostly produced domestically. Electricity production depends on hydro and coal with some import from Viet Nam, Thailand, and the Lao People's Democratic Republic (Lao PDR). In this chapter, currently available primary energy data in Cambodia are introduced. The data collection flow of the existing data is shown in Annex 2.

1.1 Coal

Two types of coal data exist in Cambodia. These are the coal consumption for power generation and for the industry sector. The data are managed by Electricité du Cambodge (EDC) and the General Department of Energy (GDE), Ministry of Mines and Energy (MME).

1.1.1 Coal consumption for power generation

EDC collects coal consumption data from the coal power plants (managed by independent power producers or IPPs) and GDE maintains the data (Table 1.1). Coal consumption for power generation increased largely in 2014 and 2015 due to the operation of new coal power plants (Sihanoukville 100 MW coal power plant and the first 270 MW coal power plants of the CIIDG Erdos Hongjun Electric Power Co. Ltd.).

Table 1.1. Coal Consumption Data for Power Generation

Year	Generation Coal Consumption (kt)
2008	25.51
2009	30.62
2010	35.04
2011	40.09
2012	58.13
2013	91.89
2014	563.32
2015	1,002.82

kt = kiloton.
Source: Electricité du Cambodge.

1.1.2 Coal consumption in the industry sector

GDE maintains the coal consumption data of the industry sector as shown in Table 1.2. Due to the operation of the new cement plant in 2015, coal consumption has largely increased. However, other industries also consume coal in their production activities, so it is difficult to break down the coal consumption by the different industries. In this publication, the coal consumption of the industry sector is all allocated to the cement subsector (non-metallic mineral product subsector).

Table 1.2. Coal Consumption Data for Power Generation, Industry Sector

Year	Industry Coal Consumption (kt)
2010	10.19
2011	11.89
2012	13.02
2013	13.43
2014	18.93
2015	26.67

kt = kiloton.
Source: General Department of Energy, MME.

1.2 Oil

There are several types of oil (petroleum products, including additives) data in Cambodia. These are (i) oil import data prepared by the Customs Office, (ii) fuel consumption for power generation, and (iii) oil sales data collected from oil import companies in Cambodia. In preparing the Cambodia Energy Statistics, oil sales data have been newly collected from the oil import companies.

1.2.1 Oil import data of the Customs Office

The Customs Office oil import data as shown in Table 1.3 covers the following petroleum products:

- Jet A-1: kerosene type jet fuel
- Gasoline: motor gasoline
- DO: gas/diesel oil
- KO: other kerosene
- FO: fuel oil (residual oil)
- Lubricant: lubricant
- LPG: liquid petroleum gas

- Base oil: materials for lubricant
- Naphtha: materials for motor gasoline
- MTBE: additives for motor gasoline

Table 1.3. Import Data of Petroleum Products (Customs Data)

Unit: kt

Year	Jet A-1	Gasoline	DO	KO	FO	Lubricant	LPG	Base Oils	Naphtha	MTBE
2007	48.73	238.40	492.53	32.62	293.95	11.41	47.34	0.00	0.00	0.00
2008	44.31	293.22	456.10	0.00	310.09	0.00	43.29	0.00	0.00	0.00
2009	35.19	313.61	677.06	28.95	269.94	14.25	56.95	3.29	0.00	0.00
2010	46.35	384.09	762.08	30.59	244.07	14.22	65.11	2.52	0.00	0.00
2011	54.60	398.52	814.54	12.07	228.78	14.17	71.94	3.46	0.00	0.00
2012	68.99	387.73	897.64	6.26	213.74	14.77	84.68	3.25	0.00	0.00
2013	79.21	392.01	918.44	4.40	165.93	16.90	98.69	1.95	0.00	0.00
2014	91.66	426.83	1005.48	0.00	89.28	11.69	112.12	0.00	0.00	0.00
2015	96.95	481.07	1073.25	0.00	35.59	46.65	162.33	0.00	18.09	8.10

DO = gas/diesel oil, FO = fuel oil (residual oil), KO = other kerosene, LPG = liquid petroleum gas, MTBE = additives for motor gasoline.
Source: Cambodia Customs Office.

1.2.2 Oil consumption for power generation

EDC collects petroleum fuel consumption data from oil power plants (IPPs) and GDE maintains the data (Table 1.4). Diversification of power sources in Cambodia has been shifting from oil-based power plants to hydropower and coal power plants.

1.2.3 Petroleum sales data from oil import companies

Through the survey of the oil import companies in Cambodia conducted by the General Department of Petroleum, the following historical data from 2010 to 2015 were collected. Presented in this report are only the sales data for the years 2010, 2014, and 2015 (Tables 1.5–1.7). Thirteen oil import companies participated and cooperated in this survey.

The sales data of the companies were differentiated into three main categories as follows:

Table 1.4. Petroleum Consumption for Power Generation

Unit: kt

Year	Generation	
	Heavy Fuel Oil (HFO)	Diesel
2003	22.06	9.83
2004	23.46	13.41
2005	33.45	10.71
2006	48.35	6.54
2007	64.73	4.93
2008	79.55	5.81
2009	90.07	5.33
2010	170.96	6.05
2011	183.61	6.06
2012	174.91	8.95
2013	107.72	3.30
2014	61.81	2.10
2015	43.03	1.46

Source: Electricité du Cambodge.

- Sales to large-scale industrial users
- Sales to other large-scale users including:
  - Commercial services
  - Public services
  - Residential
  - Agriculture
  - Fishing
  - International civil aviation
  - Domestic air transport
  - Inland waterways
  - International marine bunker
- Sales to gas stations covering:
  - Sales to company-owned stations
  - Sales to company franchises

Due to missing important sectors such as the power generation sector and grey definitions of subsectors such as the commercial sector, the survey questionnaires could be revised further to collect more accurate petroleum sales data.

Table 1.5. Petroleum Sales Data in 2010

Petroleum Product Sales Questionnaire

Corporation/Company: All Contact Person: Tel:

Year: 2010 Email:

Quantity Descriptions	LPG	Naphtha	Motor Gasoline	Kerosene Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products
	ton	kl	kl	kl	kl	kl	kl	kl	ton	kl
Import	35,216.670	-	416,844.456	54,194.264	32,430.191	788,866.334	193,914.851	285,729.897	1,687.820	-
Blending	-	-	-	-	-	-	-	-	-	-
Own Use	-	-	238.811	-	-	1,743.290	-	17.295	-	-
Stock (at the end of the year)	235.120	-	9,102.505	5,447.945	251.068	20,621.793	10,383.192	497.005	-	-
Total Sales	34,484.830	-	405,972.126	50,769.142	28,050.027	654,147.072	177,642.334	283,903.036	1,687.820	-
Sell to Large-Scale Industial Users	-	-	9,623.250	-	-	45,384.825	78,085.874	56,248.063	1,687.820	-
Iron and Steel	-	-	-	-	-	-	-	-	-	-
Chemical (incl. Petrochemical)	-	-	-	-	-	-	-	-	-	-
Non-ferrous Metals	-	-	-	-	-	-	-	-	-	-
Transportation Equipment	-	-	19.690	-	-	2,493.710	-	64.950	-	-
Machinery	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	-	-	-	-	-	-	-	-	-	-
Food, Beverages, and Tobacco	-	-	43.520	-	-	3,895.920	-	93.620	-	-
Pulp, Paper, and Printing	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-

Petroleum Product Sales Questionnaire

Construction	-	-	3.440	-	-	34,531.960	-	55,837.310	1,687.820	-
Textiles and Leather	-	-	-	-	-	5,799.050	-	29.070	-	-
Not Elsewhere Specified (Industry)	-	-	9,556.600	-	-	20,351.105	78,085.874	223.113	-	-
Sell to Other Large-Scale Users	34,484.830	-	236,942.213	48,093.263	26,869.529	420,944.922	80,213.530	225,280.246	-	-
Commercial Services	26,125.080	-	164,094.449	-	26,869.529	259,758.678	7,775.530	1,310.400	-	-
Public Services	2,458.750	-	70,954.294	-	-	108,983.969	-	168,174.226	-	-
Residential	5,901.000	-	-	-	-	3,857.650	-	10.040	-	-
Agriculture	-	-	-	-	-	32,626.000	-	55,785.580	-	-
Fishing	-	-	-	-	-	-	-	-	-	-
International Civil Aviation	-	-	-	47,533.909	-	-	-	-	-	-
Domestic Air Transport	-	-	-	559.354	-	-	-	-	-	-
Inland Waterways	-	-	-	-	-	-	-	-	-	-
International Marine Bunker	-	-	-	-	-	-	72,438.000	-	-	-
Sell to Gas Station	-	-	160,886.456	2,675.879	1,180.498	167,729.841	19,342.930	2,374.717	-	-
Company-Owned Stations	-	-	106,554.611	2,675.879	59.025	46,236.299	12,912.930	376.352	-	-
Company Franchises	-	-	54,331.845	-	1,121.473	121,493.542	6,430.000	1,998.365	-	-

kl = kilolitre, LPG = liquid petroleum gas.

Source: General Department of Petroleum, MME.

Table 1.6. Petroleum Sales Data in 2014

Petroleum Product Sales Questionnaire

Corporation/Company: All Contact Person: Tel:

Year: 2014 Email:

Quantity Descriptions	LPG	Naphtha	Motor Gasoline	Kerosene Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products
	ton	kl	kl	kl	kl	kl	kl	kl	ton	kl
Import	63,137.706	-	514,411.612	99,787.355	-	1,026,528.353	66,193.693	616,403.805	4,434.060	-
Blending	-	-	-	-	-	-	-	-	-	-
Own Use	200.000	-	1,391.969	-	-	14,594.971	-	116.088	-	-
Stock (at the end of the year)	1,778.642	-	14,135.967	9,062.404	-	26,827.540	6,889.536	500.667	-	-
Total Sales	63,366.780	-	523,909.718	96,751.395	206.037	971,324.432	65,264.589	614,807.157	4,434.060	-
Sell to Large-Scale Industial Users	1,160.000	-	1,695.329	-	-	82,860.358	36,400.220	121,882.121	4,434.060	-
Iron and Steel	-	-	-	-	-	-	-	-	-	-
Chemical (incl. Petrochemical)	-	-	-	-	-	-	-	-	-	-
Non-ferrous Metals	-	-	-	-	-	-	-	-	-	-
Transportation Equipment	-	-	10.840	-	-	3,513.620	-	98.920	-	-
Machinery	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	-	-	-	-	-	-	-	-	-	-
Food, Beverages, and Tobacco	-	-	9.220	-	-	2,125.430	-	45.920	-	-
Pulp, Paper, and Printing	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	51,084.780	-	121,535.230	4,434.060	-
Textiles and Leather	-	-	-	-	-	2,218.200	-	18.890	-	-

Not Elsewhere Specified (Industry)	-	-	1,675.269	-	-	23,918.328	36,400.220	183.161	-	-
Sell to Other Large-Scale Users	61,706.780	-	302,780.899	93,927.295	206.037	618,027.116	16,942.000	489,284.395	-	-
Commercial Services	56,996.080	-	228,813.874	-	206.037	411,923.657	11,662.000	1,590.876	-	-
Public Services	1,385.500	-	72,027.962	-	-	136,540.582	5,280.000	366,213.179	-	-
Residential	3,325.200	-	-	-	-	2,958.300	-	26.060	-	-
Agriculture	-	-	25.510	-	-	50,844.390	-	121,454.280	-	-
Fishing	-	-	-	-	-	-	-	-	-	-
International Civil Aviation	-	-	-	91,762.047	-	-	-	-	-	-
Domestic Air Transport	-	-	20.083	2,165.248	-	41.562	-	-	-	-
Inland Waterways	-	-	-	-	-	-	-	-	-	-
International Marine Bunker	-	-	-	-	-	-	-	-	-	-
Sell to Gas Stations	500.000	-	219,433.480	2,824.000	-	270,436.968	11,922.369	3,640.630	-	-
Company-Owned Stations	300.000	-	92,079.005	2,824.000	-	62,489.580	1,968.000	518.370	-	-
Company Franchises	200.000	-	127,354.475	-	-	207,947.388	9,954.369	3,122.260	-	-

kl = kilolitre, LPG = liquid petroleum gas.

Source: General Department of Petroleum, MME.

Table 1.7. Petroleum Sales Data in 2015

Petroleum Product Sales Questionnaire

Corporation/Company: All Contact Person: Tel:

Year: 2015 Email:

Quantity Descriptions	LPG	Naphtha	Motor Gasoline	Kerosene Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products (MTBE)
	ton	kl	kl	kl	kl	kl	kl	kl	ton	kl
Import	77,973.424	37,159.843	662,619.440	120,912.571	-	1,253,012.746	37,529.150	397,206.988	3,493.110	15,423.412
Blending	-	-	-	-	-	-	-	-	-	-
Own Use	220.000	-	967.077	-	-	16,845.247	-	122.832	-	-
Stock (at the end of the year)	3,207.191	-	16,955.112	8,301.391	-	24,343.733	3,640.833	570.919	-	-
Total Sales	79,547.111	-	666,856.888	105,559.472	-	1,110,415.296	33,794.101	396,857.124	3,493.110	-
Sell to Large-Scale Industrial Users	1,380.000	-	3,552.589	-	-	88,417.784	17,565.601	78,179.657	3,493.110	-
Iron and Steel	-	-	-	-	-	-	-	-	-	-
Chemical (incl. Petrochemical)	-	-	-	-	-	-	-	-	-	-
Non-ferrous Metals	-	-	-	-	-	-	-	-	-	-
Transportation Equipment	-	-	17.840	-	-	3,390.630	-	98.120	-	-
Machinery	-	-	-	-	-	-	-	-	-	-
Mining and Quarrying	-	-	-	-	-	-	-	-	-	-
Food, Beverages, and Tobacco	-	-	42.810	-	-	2,526.810	-	66.620	-	-
Pulp, Paper, and Printing	-	-	-	-	-	-	-	-	-	-
Wood and Wood Products	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	49,065.180	-	77,811.660	3,493.110	-

Petroleum Product Sales Questionnaire

Textiles and Leather	-	-	-	-	-	1,977.900	-	16.370	-	-
Not Elsewhere Specified (Industry)	1,380.000	-	3,491.939	-	-	31,457.264	17,565.601	186.887	-	-
Sell to Other Large-Scale Users	16,515.236	-	395,151.479	105,559.472	-	712,078.441	5,376.000	314,683.650	-	-
Commercial Services	11,366.786	-	305,024.658	-	-	565,503.924	2,208.000	1,682.441	-	-
Public Services	1,514.250	-	88,176.217	-	-	126,331.224	3,168.000	235,286.089	-	-
Residential	3,634.200	-	-	-	-	602.150	-	25.830	-	-
Agriculture	-	-	26.160	-	-	3,913.950	-	77,689.290	-	-
Fishing	-	-	-	-	-	-	-	-	-	-
International Civil Aviation	-	-	-	98,566.470	-	-	-	-	-	-
Domestic Air Transport	-	-	30.974	6,993.002	-	8.568	-	-	-	-
Inland Waterways	-	-	-	-	-	-	-	-	-	-
International Marine Bunker	-	-	-	-	-	-	-	-	-	-
Sell to Gas Stations	655.000	-	268,157.810	-	-	309,919.061	10,852.500	3,993.827	-	-
Company-Owned Stations	400.000	-	116,305.179	-	-	55,397.336	1,375.000	444.636	-	-
Company Franchises	255.000	-	151,852.631	-	-	254,521.725	9,477.500	3,549.191	-	-

kl = kilolitre, LPG = liquid petroleum gas.

Source: General Department of Petroleum, MME.

1.3 Electricity

1.3.1 Power generation by sources

The Electricity Authority of Cambodia (EAC) and/or EDC collects power generation data from all the stakeholders and GDE maintains the data. The data collected so far to generate hydropower, coal power, petroleum power, and biomass power are shown in Table 1.8.

Table 1.8 Power Generation by Source

Unit: GWh

Year	Hydro	Coal	Diesel/HFO	Wood & Biomass
2003	40.51	-	595.38	-
2004	28.42	-	714.81	-
2005	43.54	-	835.71	0.12
2006	50.61	-	1,034.82	1.68
2007	49.71	-	1,294.36	5.25
2008	46.28	23.36	1,409.94	4.53
2009	47.43	28.03	1,152.65	6.49
2010	31.73	32.08	898.73	5.82
2011	51.52	46.50	908.61	11.91
2012	517.37	37.42	856.56	11.75
2013	1,015.54	168.75	578.99	6.68
2014	1,851.60	863.02	326.97	16.79
2015	2,000.38	2,376.49	227.62	40.47

GWh = gigawatt-hour, HFO = heavy fuel oil.

Source: Electricity Authority of Cambodia and Electricity Authority of Cambodia.

1.3.2 Import of electricity

Cambodia still imports electricity due to seasonal factors. Hydropower generation usually declines during the dry seasons due to the lack of water. Therefore, Cambodia needs to import electricity from neighbouring countries such as Viet Nam, Thailand, and the Lao PDR. Currently, the increase in generation from coal power plants contributes to the decrease in electricity imports. Table 1.9 shows the total electricity import of Cambodia.

1.3.3 Electricity consumption by final users

EDC covers electricity sales to the final users in Cambodia (Table 1.10). In the case of electricity data, the numbers can be considered as consumption data because there is usually no electricity storage. The final users consist of the residential, commercial, industry, and other sectors.

Table 1.9. Electricity Import

Year	Import (GWh)
2003	58.28
2004	59.49
2005	82.25
2006	107.98
2007	167.41
2008	374.25
2009	842.40
2010	1,546.44
2011	1,829.79
2012	2,104.32
2013	2,281.63
2014	1,803.04
2015	1,541.00

GWh = gigawatt-hour.
Source: Electricity Authority of Cambodia.

Table 1.10. Electricity Consumption by Final Users

Unit: GWh

Year	Residential	Commercial	Industrial	Other	Total
2003	292.17	229.86	76.46	0.55	599.04
2004	325.19	270.74	105.93	0.46	702.31
2005	365.84	348.03	143.76	0.72	858.36
2006	388.83	449.22	215.98	3.13	1,057.16
2007	458.25	548.91	338.61	3.35	1,349.12
2008	575.40	694.41	389.62	4.96	1,664.40
2009	682.03	778.15	388.59	4.72	1,853.50
2010	869.08	892.89	489.88	2.19	2,254.04
2011	854.16	1,082.45	629.87	6.26	2,572.74
2012	1,079.28	1,275.90	900.32	10.31	3,265.81
2013	1,186.58	1,539.47	820.04	6.50	3,552.59
2014	1,323.08	1,639.29	1,054.35	127.39	4,144.12
2015	1,527.15	2,530.31	1,136.84	7.18	5,201.49

GWh = gigawatt-hour.
Source: Electricité du Cambodge.

1.4 Biomass

1.4.1 Production

Biomass in Cambodia consists of firewood and biogas based on animal dung. Biomass is mainly consumed in rural areas and the production figures are shown in Table 1.11.

Table 1.11. Biomass Production

Unit: ton

Year	Firewood	Biogas
2007	4,272,869	621.57
2008	4,459,457	1,265.29
2009	4,583,360	1,413.93
2010	4,644,997	2,023.60
2011	4,856,076	2,608.41
2012	5,053,881	2,270.61
2013	5,262,683	602.65
2014	5,520,148	881.54
2015	5,681,802	-

Source: General Department of Energy, MME.

1.4.2 Transformation process

Biomass (excluding biogas) are used in two transformation processes: one is for power generation and the other is for charcoal production. Biomass consumption data for these processes as shown in Table 1.12 are collected by EAC and GDE.

Table 1.12. Firewood Consumption for Transformation Processes

Unit: ton

Year	Electricity	Charcoal
2007	6,304	2,280,673
2008	5,438	2,380,875
2009	7,783	2,445,854
2010	6,983	2,479,230
2011	14,288	2,588,155
2012	14,096	2,693,994
2013	8,016	2,808,858
2014	20,148	2,940,000
2015	48,562	2,984,159

Source: General Department of Energy, MME.

Electricity generation by biomass is already shown in Table 1.8 so that only charcoal production is shown in Table 1.13. GDE collects the charcoal production data.

Table 1.13. Charcoal Production

Year	Charcoal Product (ton)
2007	260,648
2008	272,100
2009	279,526
2010	283,341
2011	295,789
2012	307,885
2013	321,012
2014	336,000
2015	341,047

Source: General Department of Energy, MME.

1.4.3 Final consumption

Biomass (firewood and biogas) and charcoal are mainly used in the residential sector, especially in the rural areas. A small quantity of firewood is still being consumed in some industries, such as for heating the boiler or burner. Table 1.14 shows the biomass consumption by the final sectors.

Table 1.14. Final Consumption of Biomass

Unit: ton

Year	Firewood		Charcoal	Biogas
	Residential	Industrial	Residential	Residential
2007	1,380,816	605,077	260,648	621.57
2008	1,441,482	631,661	272,100	1,265.29
2009	1,480,823	648,900	279,526	1,413.93
2010	1,501,030	657,755	283,341	2,023.60
2011	1,566,978	686,653	295,789	2,608.41
2012	1,631,058	714,733	307,885	2,270.61
2013	1,700,601	745,207	321,012	602.65
2014	1,780,000	780,000	336,000	881.54
2015	1,806,735	842,347	341,047	881.54

Sources: General Department of Energy; National Biodigester Programme Cambodia.

1.5 Estimation of Missing Data

Clearly, substantial energy data are available for preparing the Cambodia energy balance table historically from 2010 to 2014 and, in some cases, also up to 2015. Nonetheless, some energy data are still missing. In this case, estimation of missing data is indispensable. The following are examples of the estimation under this project (details are shown in Chapter 2):

- Coal import: Coal import estimated based on coal consumption data.
- Final consumption of petroleum products: Petroleum import data between the Customs Office and petroleum companies are not the same due to different definitions of the products. As such, the customs data are the control data for total consumption. The final consumption of petroleum products is estimated from the petroleum companies' data.
- Separation of the jet fuel imports for domestic flights and international flights is based on Cambodia's air transport statistics (international aviation bunker).
- The international standard heat value is applied for converting the physical value into its heat value. The unit for the energy balance table is the heat value (e.g. tons of oil equivalent, TOE).
- Electricity for own use is separated at generation sites into coal, petroleum, hydro, and biomass power generation.

Chapter 2

Energy Balance Table

The energy balance table provides data on the supply and demand flow of all energy products as well as on the production, import, export, transformation, and consumption within the national territory. It is also widely used in the estimation of total energy supply, forecasting, and the study of substitution and conservation.

This chapter will (i) introduce the concept of the Cambodia energy balance table, (ii) explain the estimation method for missing data, and (iii) present the Cambodia energy balance table from 2010 to 2015.

2.1 Basic Concept of the Energy Balance Table

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

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

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

- **Upper sector (primary energy supply)** is intended to show flows representing energy imports and exports in the national territory, as well as stock changes to provide information on the amount of energy available in the national territory during the reference period. The supply flows consist of production of primary energy products and imports of both primary and secondary energy products. The flows removing energy from the national territory are exports of primary and secondary energy

products and international bunkers. The aggregate of the balance, which is the total energy supply, is computed as:[1]

$$Total\ Primary\ Energy\ Supply$$
$$= Indigenous\ Production\ (row\ 1) + Imports\ (row\ 2) + Exports\ (row\ 3) + International\ Marine\ Bunkers\ (row\ 4) + International\ Aviation\ Bunkers\ (row\ 5) + Stock\ Changes\ (row\ 6)$$

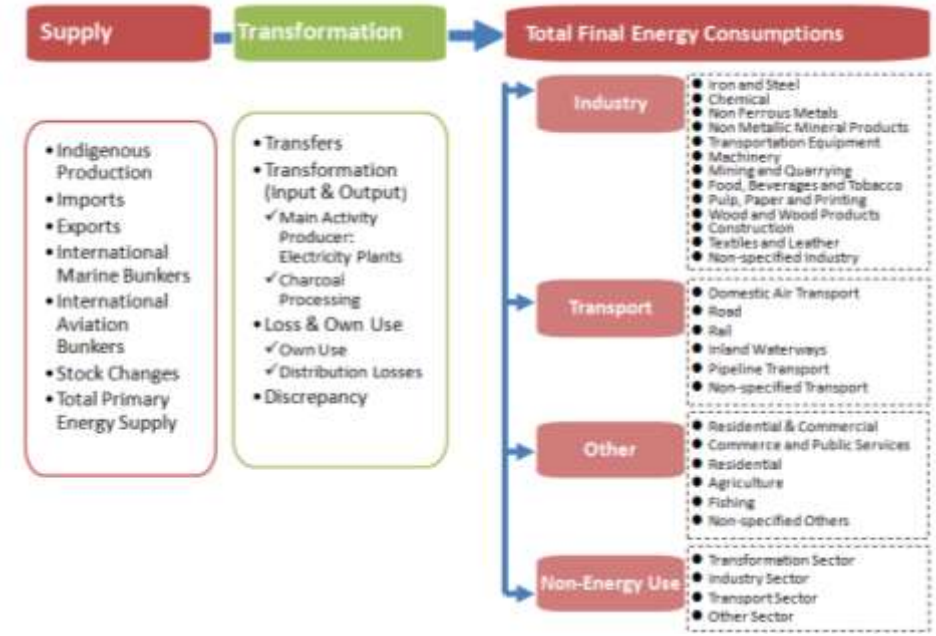
- **Middle sector (energy transfer and transformation)** is intended to show the flows of how energy is transformed, transferred, used by energy industries for own use, and lost in distribution and transmission. The power generation and petroleum refinery processes are a major activity in this sector.
- **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:
    (i) Manufacturing, construction, and non-fuel mining industries
    (ii) Transport
    (iii) Other (agriculture, forestry and fishing, commerce and public services, households, and other consumers).

A simplified diagram of the energy flow in an energy balance table is shown in Figure 2.1.

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

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

Figure 2.1. Energy Flow in the Energy Balance



Source: As constructed by this study's Working Group.

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

$$Statistical\ Difference = Total\ primary\ Energy\ Supply + Transfers + Transformation + Energy\ Industries\ Own\ Use + Losses - Final\ Consumption$$

The energy balance table 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 in the development of the Cambodia Energy Balance Table 2010–2015 is provided in Annex 6. The structuring of an energy balance table depends on the country's energy production and consumption patterns and the level of detail that the country requires.

2.2 Methodology

The methodology for creating energy balances, defining and grouping energy products, as well as the statistical terminology are harmonised with internationally established standards. The data for the energy balances are based on the individual

data collected for commodity (products) balances for coal, petroleum, gas, electricity, and renewables. The data are usually expressed in physical units of the products so that, for each product, the completeness of the data can be observed from the commodity balance. The data in the commodity balance are combined to produce the energy balance.

2.2.1 Data collection format

The primary energy data required for the development of the Cambodia Energy Balance Table 2010–2015 has already been discussed in Chapter 1. These data are then entered in the reporting format for each energy product, which in the case of Cambodia consists of coal; petroleum products; biomass (firewood, charcoal, biogas, and others); hydro; and electricity (including imported electricity). The format used is the questionnaire jointly developed by the Asia-Pacific Economic Cooperation (APEC) forum and the Association of Southeast Asian Nations (ASEAN) to assemble the main statistics of each product and provides a check on the completeness of the data because the questionnaire will balance the supply and use of the respective products. The APEC–ASEAN joint questionnaire consists of five questionnaires, one each for the energy products (coal, oil, gas, oil, electricity, and renewables). The questionnaire basically contains the supply data, transformation, energy industry own use, and final consumption (including non-energy use).

After completely entering the data in the APEC–ASEAN joint format, which for Cambodia excludes the natural gas questionnaire, the data are then used to generate the energy balance table through an interface programme developed by ERIA for the Cambodia Energy Statistics project.

2.2.2 Unit and conversion

All entries in the energy balance table are expressed in one energy unit: kilocalorie (kcal), gigajoule (GJ), kiloton of oil equivalent (ktoe), and so on. Net calorific values are generally used in building energy balances since most current technologies are still not able to recover the latent heat, which would thus not be treated as part of a fuel's energy-providing capability. However, providing both gross and net calorific values while making clear which one is used in the energy balance is considered good practice. This allows the monitoring of technological advances with respect to recovering latent heat (DECC, n.d.).

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 thousand metric tons (kt), whereas the primary data are mainly in kilolitres (kl) and barrels.

Data requirements for a specific gravity are included in the oil questionnaire as well as the net calorific value to convert into an energy unit (kcal). If there is a refinery in the country, refinery intake data (in kilotons) are also requested in the questionnaire.

The unit of the coal questionnaire is also kilotons except for the gases produced from coal (coke oven gas, etc.), which are measured in gross kilocalories. For other coal products, the calorific value data is also requested in the coal questionnaire. The unit of the new and renewable questionnaire is kilotons for solid biomass (fuelwood, woodwaste, bagasse, charcoal, other biomass, industrial waste, municipal solid waste, and liquid biofuels). Other new and renewable energy is given either in kilocalories or gigawatt-hours (GWh). Additional calorific values of the products are 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 of the data to kilocalories is also requested in the questionnaire. The existing installed capacity (in megawatts, MW) is also included in the questionnaire.

The Cambodia Energy Balance Table 2010–2015 adopted the energy unit of tons of oil equivalent (toe), where 1 toe is defined as 10^7 kcal (41.868 GJ). There are two heat values: one is net calorific value and other is gross calorific value. The difference between the two is:

- **Coal and oil:** Net calorific value is less than about 5 percent of gross calorific value.
- **Gas:** Net calorific value is less than about 10 percent of gross calorific value

The calorific content of the different energy products in Cambodia is shown in Table 2.1.

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

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

Table 2.1. Calorific Content of Energy Products in Cambodia

Energy Products	Original Unit	Calorific Content (ton of oil equivalent)
Sub-bituminous coal	metric ton	0.4958
Additives/Oxygenates	metric ton	1.2064
Motor gasoline	metric ton	1.0442
Naphtha	metric ton	1.0539
Kerosene type jet fuel	metric ton	1.0038
Kerosene	metric ton	1.0599
Gas/Diesel oil	metric ton	1.0116
Fuel oil	metric ton	1.0073
LPG	metric ton	0.6635
Lubricants	metric ton	0.9600
Bitumen	metric ton	1.0000
Fuelwood & woodwaste	metric ton	0.3702
Charcoal	metric ton	0.7000
Electricity	MWh	0.0860

LPG = liquid petroleum gas, MWh = megawatt-hour.
Source: ERIA.

2.3 Treatment of Missing Data

2.3.1 Principles for missing data source selection

The priority data sources for the Cambodia energy balance table are identified as follows:

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

Considering the time constraint in publishing the Cambodia energy statistics, the energy statistics compilation should adopt the best available data source received before March 2016.

2.3.2 Estimation method for missing data

Due to limited energy statistics, some of the information needed for the compilation of the energy balance table is estimated. Furthermore, the 2015 version of above-mentioned existing energy statistics had not been fully released at the time of production of the energy balance table. Therefore, the estimation method is applied to the preliminary numbers of the existing energy statistics in 2015. This section will explain the estimation method for the above-mentioned missing data.

2.3.2.1 Coal

Imports

The data for coal imports are generally available from the Customs Office. In the case of Cambodia, Customs Office data prior to 2014 are not available. However, data on the consumption of coal for power generation and the cement industry are available. Since the type of coal consumed is not clarified, it is simply classified as coal in the energy balance table. Given the lack of data sources, the coal imports for 2010–2013 are estimated as the sum of coal consumption in both the power plants and the cement industry.

For 2014, the reported import data of power plants and the cement industry to the General Department of Energy (GDE) are adopted. As for 2015, as import data have not yet been reported, the coal imports are again estimated as the total consumption of the power plants and the cement industry.

Stock change

As defined, stock change reflects the difference between the opening levels on the first day of the year and closing levels on the last day of the year of stocks in the national territory held by producers, importers, energy transformation industries, and large consumers. Since data sources are lacking, the stock change is estimated by deducting consumption from the imports.

Industry sector consumption

As described in Chapter 1, GDE maintains the coal consumption data of the industry sector. However, there is no breakdown of coal consumption by the different industries. For the purpose of the energy balance table, the coal consumption of the industry sector is all allocated to the cement industries (non-metallic mineral product subsector). However, the unit coal consumption of one cement company is abnormally higher than its peers. Therefore, its coal consumption is adjusted with the peer average unit coal consumption.

Calorific content

Further clarification is needed to classify the type of coal imported. Based on the information available from Electricité du Cambodge (EDC) and GDE, the calorific content for coal in the energy balance table is measured as the weighted average calorific value of coal imports from electricity plants and cement factories in 2014; and this value is adopted for all years (2010–2015).

2.3.2.2 Petroleum products

Disaggregation of aggregated data

Some petroleum companies only provided aggregated data of total sales or sector subtotals. The total sales are recorded in company-owned stations, while the sector subtotals do not specify the respective sectors.

Imports

Imports of motor gasoline, kerosene-type jet fuel, kerosene, diesel oil, fuel oil, liquid petroleum gas (LPG), and lubricants adopt the General Department of Customs and Excise of Cambodia (GDCE) data. Due to the unavailability of GDCE data, for the imports of additives (MTBE) and bitumen, the reported data of petroleum companies are adopted.

International aviation bunkers/stock/final consumption

The sales structure of reported data from petroleum companies is applied to estimate the international aviation bunkers, stock, and final consumption of motor gasoline, kerosene type jet fuel, kerosene, diesel oil, fuel oil, LPG, and lubricants. As for additives and bitumen, the reported data from petroleum companies are adopted.

2.3.2.3 Hydro

Indigenous production

Gross electricity generation data are available only for the years 2010–2014. In the case of 2015, only net electricity generation data are available. Therefore, gross electricity generation is estimated using the 99.4 percent net power generation rate of a typical hydropower plant.

Own use and transformation input of main activity producer

The own use and transformation output to grid of hydropower plants are estimated using the net power generation rate of EDC from 2010 to 2014.

2.3.2.4 Biomass

Consumption of fuelwood

Data for fuelwood consumption are available for 2010–2014. The lack of 2015 data is overcome by estimating the consumption of fuelwood in the residential sector,

industry, electricity generation, and charcoal production with the 2015 data for population, gross domestic product (GDP), and electricity generation from biomass. The unit consumption for the above sectors in 2014 is adopted to estimate their consumption in 2015.

Indigenous production and consumption of biogas

The biogas supply and consumption data provided by GDE is estimated using the biodigester installation number each year. However, they should be estimated with the accumulated installation of biodigesters in Cambodia. The data are revised and updated with the data from the National Biodigester Programme in Cambodia.

2.3.2.5 Electricity

The missing data for electricity are the own use, transformation output, and distribution loss. In this case, the following approach is used.

Own use and transformation output

The own use and transformation output to grid of independent power producers (IPPs) and off-grid factories are estimated using the net power generation rate of EDC. As for 2015, only the net electricity generation data are available and gross electricity generation of coal-fired and oil-fired units is estimated using the 93 percent net power generation rate. In the case of hydro, as explained previously, the estimation used the 99.4 percent net power generation rate of a typical hydropower plant.

Distribution loss

The distribution loss is estimated using total electricity supply minus electricity sales and estimated own use.

2.4 Cambodia Energy Balance Table 2010–2015

The energy balance tables for each of the years 2010 –2015 are shown in Tables 2.2–2.7.

Table 2.2. Cambodia Energy Balance Table, 2010

Unit: ktoe

	1. Coal	3. Crude Oil & NGL	4. Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas/Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	9. Others	10. Electricity	12. Total
1. Indigenous Production												3	1,723		1,726
2. Imports	22		1,558	401		47	32	771	246	43	18			133	1,713
3. Exports															
4. International Marine Bunkers															
13.1 International Aviation Bunkers			-41			-41									-41
5. Stock Changes			-48	-9		-5	0	-20	-13	0	-1				-48
6. Total Primary Energy Supply	22		1,469	392		1	32	751	233	43	17	3	1,723	133	3,350
7. Transfers															
8. Total Transformation Sector	-17		-178					-6	-172			-3	-722	83	-837
8.1 Main Activity Producer	-17		-178					-6	-172			-3	-3	83	-118
8.8 Charcoal Processing													-719		-719
9. Loss & Own Use			-2	0				-2			0	0		-22	-24
10. Discrepancy	0		-39	0		2	-8	-102	73	-1	-3	0	0	0	-39
11. Total Final Energy Consumption	5		1,249	392		3	24	641	133	42	14		1,001	194	2,449
12. Industry Sector	5		192					66	124		3		244	42	483
13. Transport Sector			952	392		3		543		3	11				952
13.2 Domestic Air Transport			3			3									3
13.3 Road			949	392				543		3	11				949
14. Other Sector			105				24	32	10	39			758	152	1,014
14.1 Residential & Commercial			73				24		10	39			758	152	982
14.1.1 Commerce and Public Services			56				14		10	32				77	133
14.1.2 Residential			17				9			7			758	75	849
14.2 Agriculture			32					32							32
14.4 Non-specified Others														0	0
15. Of Which Non-energy Use			14								14				14
16 Electricity Output in GWh	32	899	0									32	6		968

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Table 2.3. Cambodia Energy Balance Table, 2011

Unit: ktoe

		1. Coal	3. Crude Oil & NGL	4. Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas / Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	9. Others	10. Electricity	12. Total
1.	Indigenous Production												4	1,803		1,807
2.	Imports	26		1,608	416		55	13	824	230	48	22			157	1,791
3.	Exports															
4.	International Marine Bunkers															
13.1	International Aviation Bunkers			-46			-46									-46
5.	Stock Changes	0		2	1		0	0	-5	5	0	0				2
6.	Total Primary Energy Supply	26		1,563	418		9	13	819	236	48	22	4	1,803	157	3,554
7.	Transfers															
8.	Total Transformation Sector	-20		-191					-6	-185			-4	-756	88	-884
	8.1 Main Activity Producer	-20		-191					-6	-185			-4	-5	88	-133
	8.8 Charcoal Processing													-751		-751
9.	Loss & Own Use			-2	0				-2			0	0		-24	-26
10.	Discrepancy	0		90	-27		-5	54	-34	102	1	-2	0	0	0	90
11.	Total Final Energy Consumption	6		1,460	390		4	67	777	153	49	19		1,047	221	2,733
12.	Industry Sector	6		204					69	129		6		254	54	518
13.	Transport Sector			1,090	390		4		670		11	13				1,090
	13.2 Domestic Air Transport			4			4									4
	13.3 Road			1,086	390				670		11	13				1,086
14.	Other Sector			166				67	38	24	38			792	167	1,126
	14.1 Residential & Commercial			128				67		24	38			792	167	1,087
	14.1.1 Commerce and Public Services			61				7		24	30				93	154
	14.1.2 Residential			67				59			8			792	73	933
	14.2 Agriculture			38					38							38
	14.4 Non-specified Others														1	1
15.	Of Which Non-energy Use			19								19				19
16	Electricity Output in GWh	47	909										52	12		1,019

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Table 2.4. Cambodia Energy Balance Table, 2012

Unit: ktoe

	1. Coal	3. Crude Oil & NGL	4. Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas / Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	9. Others	10. Electricity	12. Total
1. Indigenous Production												44	1,878		1,922
2. Imports	35		1,681	405		69	7	908	215	56	20			181	1,897
3. Exports															
4. International Marine Bunkers															
13.1 International Aviation Bunkers			-58			-58									-58
5. Stock Changes	0		-5	-6		-2	0	1	2	-1	0				-5
6. Total Primary Energy Supply	35		1,618	399		10	7	909	218	55	21	44	1,878	181	3,757
7. Transfers			0												
8. Total Transformation Sector	-29		-185					-9	-176			-43	-787	122	-922
8.1 Main Activity Producer	-29		-185					-9	-176			-43	-5	122	-140
8.8 Charcoal Processing													-782		-782
9. Loss & Own Use			-2	0				-2			0	-2		-22	-26
10. Discrepancy	0		109	22		-6	-2	1	98	-1	-3	0	0	0	109
11. Total Final Energy Consumption	6		1,539	421		4	5	899	139	54	17		1,091	281	2,917
12. Industry Sector	6		197					77	116		4		265	77	546
13. Transport Sector			1,250	421		4		778		34	13				1,250
13.2 Domestic Air Transport			4			4									4
13.3 Road			1,247	421				778		34	13				1,247
14. Other Sector			92				5	44	23	20			826	203	1,121
14.1 Residential & Commercial			48				5		23	20			826	203	1,077
14.1.1 Commerce and Public Services			44				3		23	17				110	153
14.1.2 Residential			4				2			3			826	93	923
14.2 Agriculture			44					44							44
14.4 Non-specified Others														1	1
15. Of Which Non-energy Use			17								17				17
16 Electricity Output in GWh	37	857										517	12		1,423

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Table 2.5. Cambodia Energy Balance Table, 2013

Unit: ktoe

	1. Coal	3. Crude Oil & NGL	4. Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas / Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	9. Others	10. Electricity	12. Total
1. Indigenous Production			0									87	1,955		2,043
2. Imports	52		1,676	409		80	5	929	167	65	21			196	1,925
3. Exports															
4. International Marine Bunkers															
13.1 International Aviation Bunkers			-68			-68									-68
5. Stock Changes	0		-8	1		0	0	-4	-3	-2	0				-8
6. Total Primary Energy Supply	52		1,601	410		12	4	925	164	64	21	87	1,955	196	3,892
7. Transfers															
8. Total Transformation Sector	-46		-112					-3	-109			-84	-818	152	-907
8.1 Main Activity Producer	-46		-112					-3	-109			-84	-3	152	-92
8.8 Charcoal Processing													-815		-815
9. Loss & Own Use			-17	-2				-15		0	0	-3		-43	-63
10. Discrepancy	0		44	9		-9	-1	-9	58	0	-2	0	0	0	44
11. Total Final Energy Consumptions	7		1,516	417		3	3	897	113	64	19		1,137	306	2,966
12. Industry Sector	7		177					74	98	1	4		276	71	530
13. Transport Sector			1,259	417		3		782		42	15				1,259
13.2 Domestic Air Transport			3			3		0							3
13.3 Road			1,256	417				782		42	15				1,256
14. Other Sector			81				3	42	15	21			861	235	1,177
14.1 Residential & Commercial			39				3		15	21			861	234	1,135
14.1.1 Commerce and Public Services			34				1		15	18				132	167
14.1.2 Residential			5				2			3			861	102	969
14.2 Agriculture			42					42							42
14.4 Non-specified Others														1	1
15. of which Non-Energy Use			19								19				19
16 Electricity Output in GWh	169	579	0									1,016	7		1,770

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Table 2.6. Cambodia Energy Balance Table, 2014

Unit: ktoe

	Coal	Crude Oil & NGL	Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas/ Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	Hydro	Others	Electricity	Total
1. Indigenous Production												159	2,051		2,211
2. Imports	303		1,735	446		92		1,017	90	74	16			155	2,193
3. Exports															
4. International Marine Bunkers															
13.1 International Aviation Bunkers			-85			-85									-85
5. Stock Changes	-15		0	0		-3	0	2	-1	1	0				-15
6. Total Primary Energy Supply	289		1,650	446		5	0	1,019	89	75	16	159	2,051	155	4,304
7. Transfers															
8. Total Transformation Sector	-279		-64					-2	-62			-154	-861	263	-1,095
8.1 Main Activity Producer	-279		-64					-2	-62			-154	-7	263	-242
8.8 Charcoal Processing			0										-853		-853
9. Loss & Own Use			-16	-1				-14		0	0	-5		-62	-83
10. Discrepancy	0		14	9		0	0	-40	47	0	-2	0	0		14
11. Total Final Energy Consumption	9		1,583	454		5		962	74	75	14		1,191	356	3,140
12. Industry Sector	9		154	0				82	66	1	5		289	91	543
13. Transport Sector			1,354	454		5		830	0	57	9				1,354
13.2 Domestic Air Transport			5			5		0							5
13.3 Road			1,350	454				830		57	9				1,350
14. Other Sector			75					50	8	16			902	266	1,242
14.1 Residential & Commercial			24						8	16			902	255	1,181
14.1.1 Commerce and Public Services			20						8	12				141	161
14.1.2 Residential			4							4			902	114	1,020
14.2 Agriculture			50					50							50
14.4 Non-specified Others														11	11
15. Of Which Non-energy Use			14								14				14
16 Electricity Output in GWh	863	327	0									1,852	17		3,058

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Table 2.7. Cambodia Energy Balance Table, 2015 (Preliminary)

Unit: ktoe

	1. Coal	3. Crude Oil & NGL	4. Petroleum Products	4.1 Motor Gasoline	4.2 Naphtha	4.3 Jet Fuel	4.4 Kerosene	4.5 Gas / Diesel Oil	4.6 Fuel Oil	4.7 LPG	4.10 Other Petroleum Products	6. Hydro	9. Others	10. Electricity	12. Total
1. Indigenous Production												172	2,112		2,284
2. Imports	510	10	1,896	502	19	97		1,086	36	108	48			133	2,549
3. Exports															
4. International Marine Bunkers															
13.1 International Aviation Bunkers			-79			-79									-79
5. Stock Changes	0		8	-1		2		5	6	-2	-2				8
6. Total Primary Energy Supply	510	10	1,825	502	19	20		1,091	42	105	46	172	2,112	133	4,761
7. Transfers		-10	10	29	-19										0
8. Total Transformation Sector	-497		-45					-1	-43			-171	-884	399	-1,198
8.1 Main Activity Producer	-497		-45					-1	-43			-171	-18	399	-332
8.8 Charcoal Processing													-866		-866
9. Loss & Own Use			-16	-1				-15		0	-1	-1		-85	-102
10. Discrepancy	0		-48	5		-14		-79	34	5	1	0	0		-48
11. Total Final Energy Consumption	13		1,725	534		6		996	32	110	46		1,228	447	3,413
12. Industry Sector	13		112					77	27	2	6		312	98	535
13. Transport Sector			1,549	534		6		882		87	40				1,549
13.2 Domestic Air Transport			6			6		0							6
13.3 Road			1,544	534				882		87	40				1,544
14. Other Sector			64					38	5	21			916	350	1,329
14.1 Residential & Commercial			26						5	21			916	349	1,290
14.1.1 Commerce and Public Services			21						5	16				218	238
14.1.2 Residential			5							5			916	131	1,052
14.2 Agriculture			38					38							38
14.4 Non-specified Others														1	1
15. Of Which Non-energy Use			47								47				47
16 Electricity Output in GWh	2,376	228										2,000	40		4,645

GWh = gigawatt-hour, ktoe = kiloton of oil equivalent, LPG = liquid petroleum gas, NGL = natural gas liquid.

Chapter 3

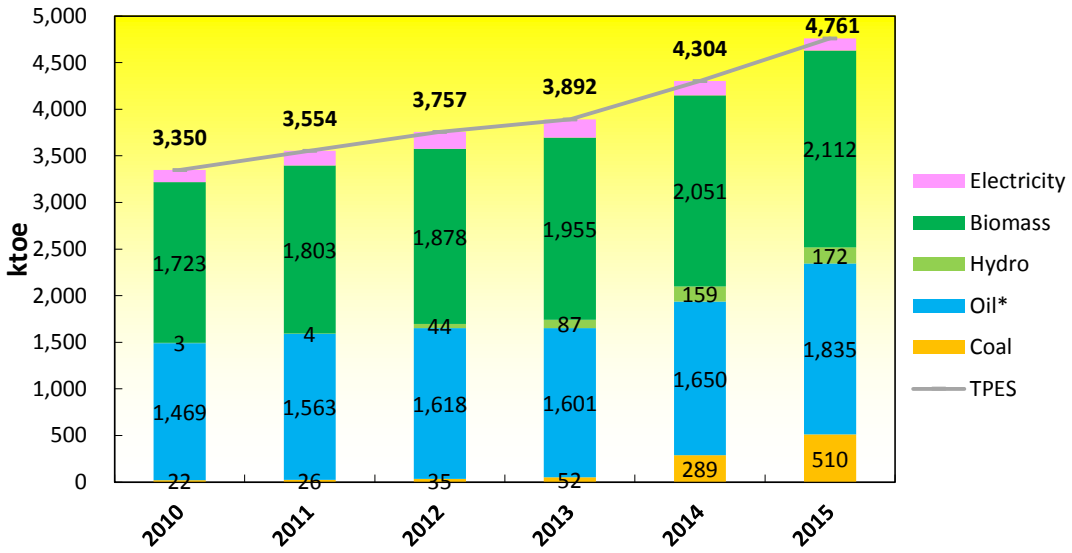
Analysis of Energy Demand Supply Situation

3.1 Primary Energy Supply

The total primary energy supply (TPES) of Cambodia increased from 3,350 kilotons of oil equivalent (ktoe) in 2010 to 4,761 ktoe in 2015 at an average annual growth of 7.3 percent (Figure 3.1). Coal and hydro have the highest increase over the 2010–2015 period because electricity demand has been increasing rapidly during that time. To meet this demand, the Government of Cambodia has commissioned new hydropower and coal power plants.

Electricity supply in Cambodia's TPES is through electricity imports. Electricity imports increased from 133 to 192 ktoe in 2010–2013. After 2013, its electricity imports declined to about 133 ktoe in 2015 due to the increase of domestic power generation.

Figure 3.1. Total Primary Energy Supply



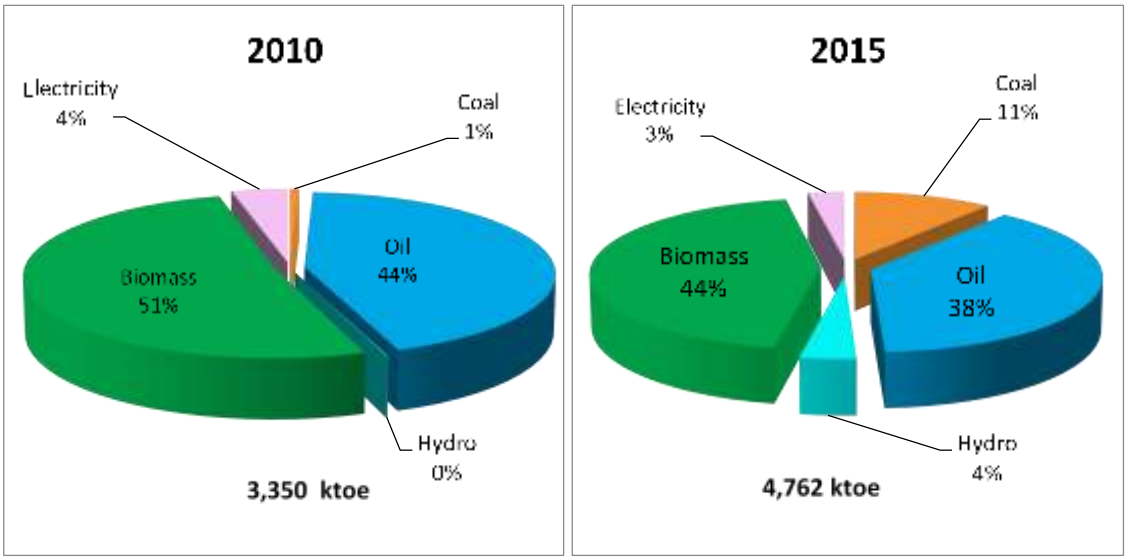
Note: *Oil includes additives for motor gasoline (MTBE) and petroleum products.
ktoe = kiloton of oil equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

The share of biomass in TPES was the largest in 2010 (51.4 percent), followed by petroleum (43.8 percent). By 2015, these two energy types remain the highest in the TPES mix but with decreasing shares.

The share of biomass decreased to 44.4 percent, whereas that of petroleum products is 38.5 percent (Figure 3.2). Both shares were relatively declining due to the high increase of coal and hydro demand in the power sector. Nonetheless, petroleum is still an important energy source, especially for the transport sector. Biomass, on the other hand, will be phased out gradually.

The share of coal in TPES increased to 10.7 percent in 2015 from 0.7 percent in 2010. The coal supply has increased significantly since 2014 since the Sihanoukville coal power plant came into full operation and the first unit of the CIIDG Erdos Hongjun Electric Power Co. Ltd coal power plant became operational. Hydro's share in TPES increased from 0.1 percent in 2010 to 3.6 percent in 2015 as more hydropower plants are being commissioned.

Figure 3.2. Energy Mix of the Total Primary Energy Supply



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Cambodia imports all of its coal and oil requirements. The import of oil increased on average by 4.1 percent per year from 2010 to 2015. Coal imports grew very fast during the same period to meet the power sector's requirement (Table 3.1). In total, the energy imports of Cambodia increased from 1,713 ktoe to 2,549 ktoe over 2010–2015 at an average rate of 8.3 percent per year.

Compared to energy imports, indigenous production of energy (hydro and biomass) grew at a slower rate of 5.8 percent per year. The majority of the biomass production is firewood. In the international context, the consumption of biomass equals its production.

Biomass production increased on average 4.1 percent per year from 1,723 ktoe in 2010 to 2,112 ktoe in 2015. Indigenous production of hydro was only 3 ktoe in 2010. By 2015, the production of hydro increased to 172 ktoe as hydropower plants are being commissioned to meet the increasing demand of electricity.

Table 3.1. Indigenous Production and Imports of Energy

Unit: ktoe

Year	Indigenous	Hydro	Biomass	Imports	Coal	Oil*	Electricity	Dependence on Imported Energy
2010	1,726	3	1,723	1,713	22	1,558	133	49.8
2011	1,807	4	1,803	1,791	26	1,608	157	49.8
2012	1,922	44	1,878	1,897	35	1,681	181	49.7
2013	2,043	87	1,955	1,925	52	1,676	196	48.5
2014	2,211	159	2,051	2,193	303	1,735	155	49.8
2015	2,284	172	2,112	2,549	510	1,906	133	52.7
AAGR	**5.8%**	**129.0%**	**4.1%**	**8.3%**	**86.8%**	**4.1%**	**–0.1%**	**-**

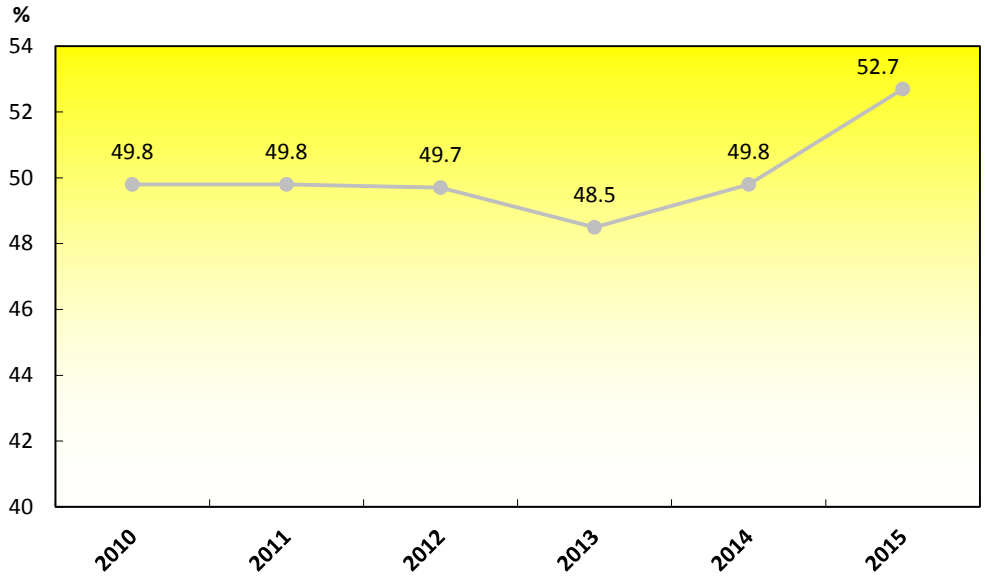
Note: *Oil includes additives for motor gasoline (MTBE) and petroleum products.
AAGR = average annual growth rate, ktoe = kiloton of energy equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Comparing the import of energy and indigenous production with the total, the share of indigenous production (51.2 percent) was slightly higher than that of imports (49.8 percent) in 2010. In 2015, the share of indigenous production decreased to 47.3 percent, whereas the import share increased to 52.8 percent. This is a consequence of the slowdown of biomass consumption due to the shift from traditional biomass to conventional energy.

The increasing share of imported energy compared with indigenous production implies that Cambodia is becoming more dependent on energy imports. Figure 3.3 shows the energy import dependency of Cambodia. As shown in the figure, the import dependency declined from 2010 to 2013 indicating that growth in imported energy is slower than indigenous production. The tenfold increase of hydropower production in 2012 and the twofold increase in 2013 contributed to this faster growth of indigenous production.

From 2013 to 2015, the energy imports increased faster than indigenous production as the coal requirement for power generation increased almost tenfold during this period. Consequently, the import dependency has increased and is expected to continue increasing as the demand for oil in the transport, industry, and residential sectors increases and more coal power plants under construction become operational.

Figure 3.3. Dependence on Imported Energy



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

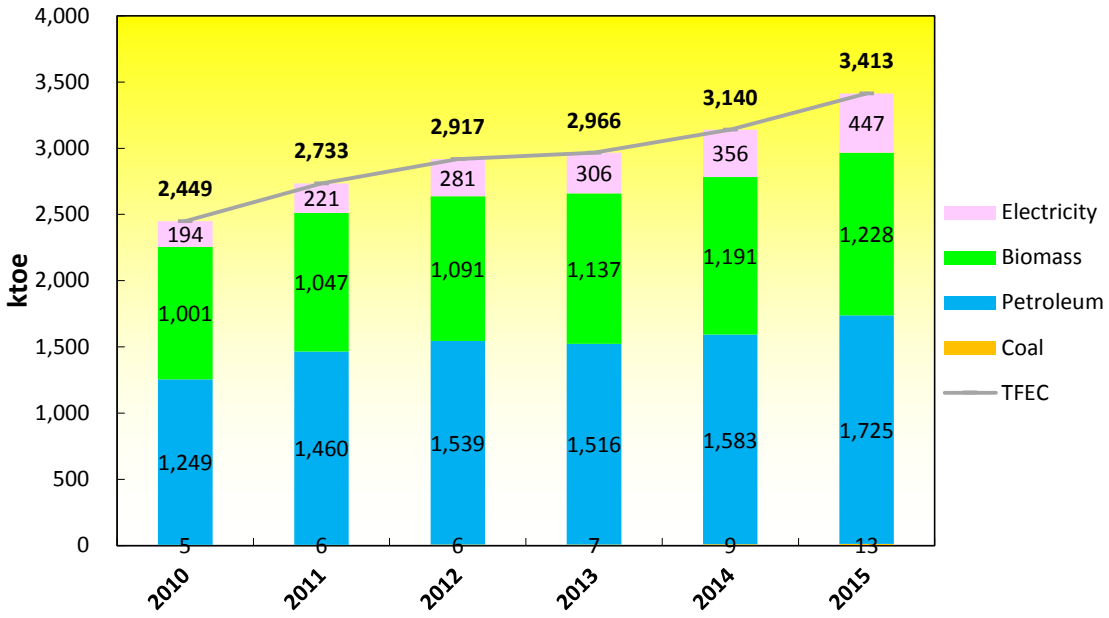
3.2 Total Final Energy Consumption

The total final energy consumption (TFEC) of Cambodia increased at an average annual growth rate of 6.9 percent – from 2,449 ktoe in 2010 to 3,413 ktoe in 2015 (Figure 3.4). By type of fuel, coal grew the fastest at 21.2 percent per year followed by electricity at 18.2 percent per year. Consumption of petroleum products and biomass, the major fuel consumed in Cambodia, grew at an annual average rate of 6.7 percent and 4.2 percent, respectively.

Although it increased the fastest over 2010–2015, especially for cement production, coal constitutes less than 0.5 percent of total consumption. On the other hand, petroleum products and biomass have a total share of more than 90 percent over the 2010–2015 period (Figure 3.5).

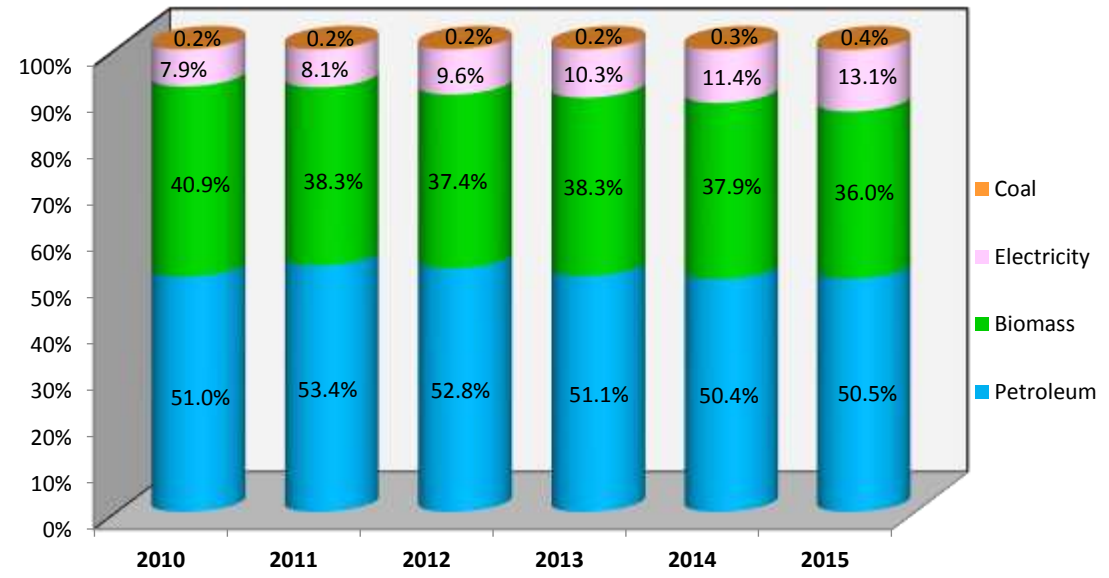
The transport sector consumed majority of the petroleum products. The average growth of the sector's consumption was 10.2 percent per year, from 950 ktoe in 2010 to 1,549 ktoe in 2015 (Table 3.2). The 'other' sector consumption covers the service (commercial and public), the residential, the agriculture, and other sectors. This sector's consumption increased from 1,014 ktoe in 2010 to 1,329 ktoe in 2015, at an average rate of 5.6 percent. The industry sector has the lowest energy consumption and experienced the slowest growth over 2010–2015. In the future, Cambodia shall promote economic zones and industrial zones; consequently, the industry sector has a large potential to increase energy demand, especially for electricity.

Figure 3.4. Total Final Energy Consumption (TFEC) by Fuel



ktoe = kiloton of oil equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Figure 3.5. Fuel Mix in Total Final Energy Consumption



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

The transport sector's consumption accounted for 39 percent of the TFEC in 2010 and reached almost 46 percent in 2015 (Figure 3.6). The industry sector's consumption accounted for around 20 percent of the TFEC in 2010 and declined to 16 percent in 2015.

Table 3.2. Total Final Energy Consumption by Sector

Unit: ktoe

Year	Total								Of Which Non-energy Use
		Industry	Transport	Other	Service	Residential	Agriculture	Others	
2010	2,449	483	952	1,014	133	849	32	0.2	14
2011	2,733	518	1,090	1,131	154	933	38	0.5	19
2012	2,917	546	1,250	1,126	153	923	43	0.9	17
2013	2,966	530	1,259	1,182	166	969	42	0.6	19
2014	3,140	543	1,354	1,245	161	1,020	50	11.1	14
2015	3,413	535	1,549	1,341	238	1,052	38	0.6	47
AAGR	**6.9%**	**2.1%**	**10.2%**	**5.6%**	**12.4%**	**4.4%**	**3.4%**	**26.8%**	**27.7%**

AAGR = average annual growth rate, ktoe = kiloton of energy equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

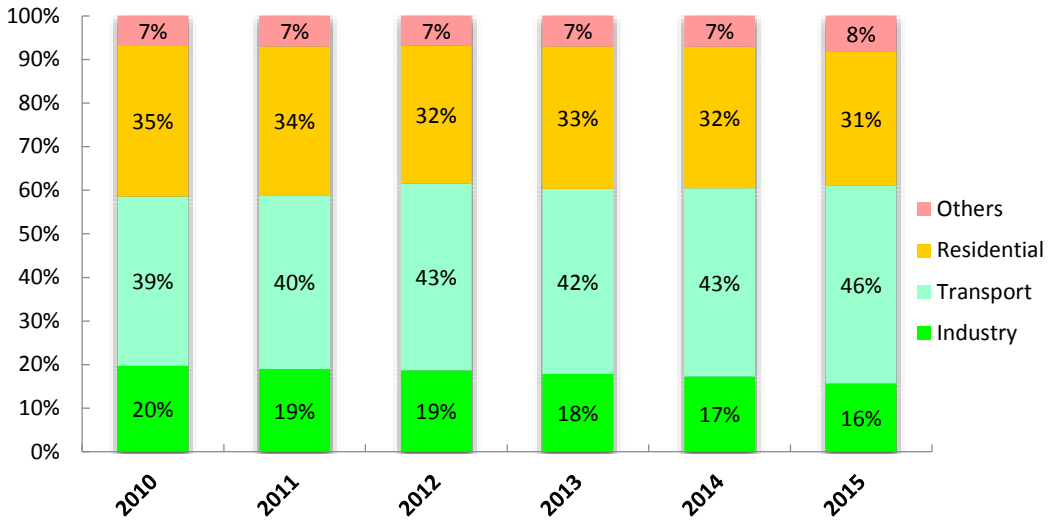
Table 3.3 Coal Supply and Consumption

Unit: ktoe

Year	Supply	Consumption		
			Electricity Generation	Industry
2010	22	22	17	5
2011	26	26	20	6
2012	35	35	29	6
2013	52	52	46	7
2014	303	289	279	9
2015	510	510	497	13
AAGR	**86.8%**	**86.8%**	**95.6%**	**21.2%**

AAGR = average annual growth rate, ktoe = kiloton of energy equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Figure 3.6. Total Final Energy Consumption by Sector



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Biomass has the largest share in the total consumption of the sector, followed by petroleum products. The share of these fuels in the industry sector's total consumption declined as the supply of electricity from EDC became more stable.

The 'other' sector has the second highest share in the TFEC: 35 percent in 2010 and 31 percent in 2015. Around 84 percent of the 'other' sector's consumption in 2010 is that of the residential sector (or 34.7 percent of the TFEC) with fuelwood being the main fuel consumed by this sector. By 2015, the share of the residential sector in the TFEC decreased 31 percent.

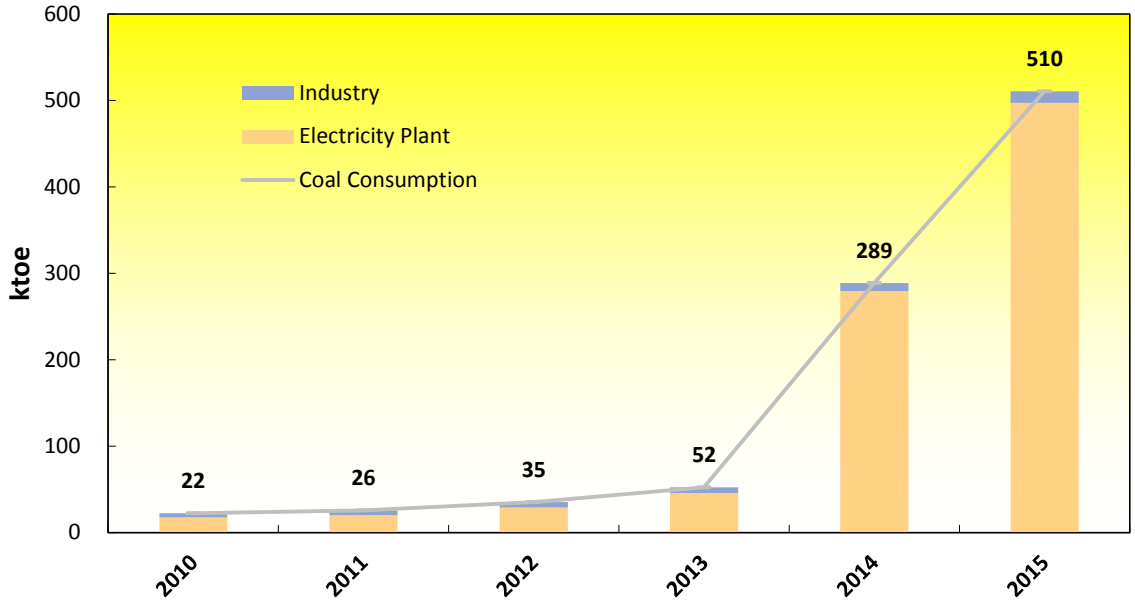
The remaining sectors (service, agriculture, and others) have the smallest share in the TFEC but experienced the fastest growth over the 2010–2015 period. The service sector's consumption grew at an average rate of 12.4 percent per year, increasing its share in the TFEC from 5.4 percent in 2010 to 7.0 percent in 2015 mainly as a result of the rapid increase in electricity consumption.

3.3 Supply and Consumption by Energy Products

The coal supply and consumption of Cambodia is shown in Table 3.3. Cambodia imports coal to meet the demand of the power and industry sectors. Over the 2010–2015 period, coal increased by 86.8 percent per year due to the rapid increase of consumption in the power sector. The sector's consumption increased from 17 ktoe in 2010 to 497 ktoe in 2015. The increase in coal use for power generation is in line with the government plan to reduce oil-based power generation in the country. Consumption of coal in power generation increased significantly since the plant in the Stung Hav district, Preah Sihanouk province started operation in early February 2014.

Coal consumption for power generation accounted for 77 percent in 2010, whereas the share for industry was 23 percent. In 2015, coal consumption of industry grew slower than power generation, resulting in a higher share of coal use for generating electricity. The share of coal for power generation reached 97 percent in 2015, whereas the share of coal consumption in industry declined relatively to around 3 percent (Figure 3.7).

Figure 3.7. Coal Consumption



ktoe = kiloton of energy equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Cambodia imported all of its oil requirements (petroleum products and additives for motor gasoline, MTBE). Total imports amounted to 1,558 ktoe in 2010 increasing to 1,896 ktoe in 2015 (Table 3.4). Some of the imported petroleum products were used to supply the need of international aviation and were thus deducted to derive TPES. Similarly, the increasing stock of petroleum products will also be deducted from imports while the reduction of stock implies an increase for domestic supply. In Table 3.4, supply refers to the imported petroleum products and thus will have a higher figure than consumption.

Table 3.4. Petroleum Products, Supply and Consumption

Unit: ktoe

Year	Supply	Consumption	Electricity Generation	Own Use	Total Final Energy Consumption							Of Which Non-energy Use
					Industry	Transport	Other	Service	Residential	Agriculture	Others	
2010	1,558	1,429	178	2	192	952	105	56	17	32	2	14
2011	1,608	1,653	191	2	204	1,090	166	61	67	38	5	19
2012	1,681	1,727	185	2	197	1,250	92	44	4	44	5	17
2013	1,676	1,645	112	17	177	1,259	81	34	5	42	5	19
2014	1,735	1,664	64	16	154	1,354	75	20	4	50	3	14
2015	1,896	1,786	45	16	112	1,549	64	21	5	38	0	47
AAGR	**4.0%**	**4.6%**	**−24.1%**	**52.4%**	**−10.2%**	**10.2%**	**−9.5%**	**−18.0%**	**−21.4%**	**3.4%**	**37.4%**	**27.7%**

Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Table 3.5. Consumption of Petroleum Products by Product

Unit: ktoe

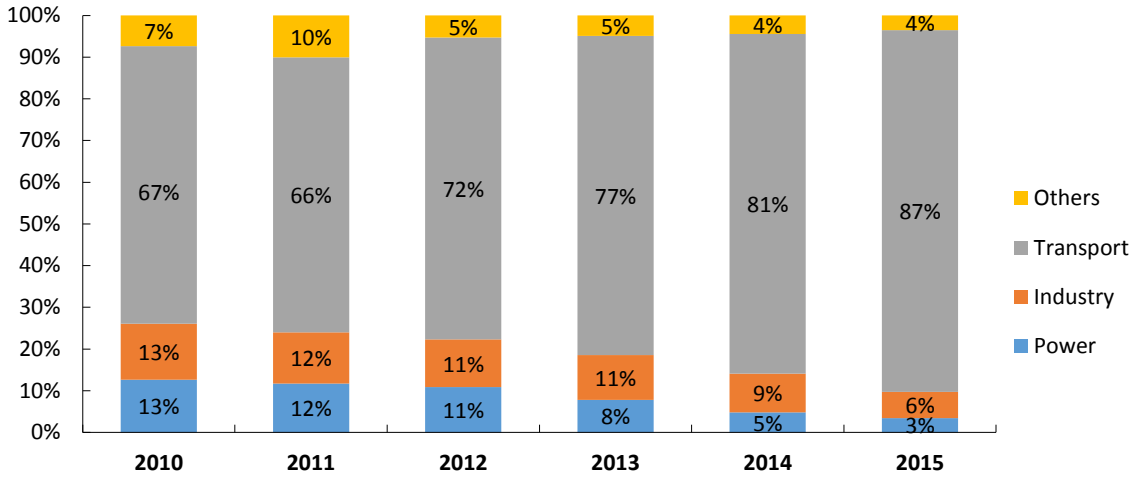
Year	Total	Motor Gasoline	Jet Fuel	Kerosene	Gas/ Diesel Oil	Fuel Oil	LPG	Other Petroleum Products
2010	1,429	392	3	24	649	306	42	14
2011	1,653	391	4	67	785	338	49	19
2012	1,727	421	4	5	910	316	54	17
2013	1,645	419	3	3	916	222	64	19
2014	1,664	455	5	0	979	136	75	14
2015	1,786	516	6	0	1,013	76	110	66
AAGR	**4.6%**	**5.6%**	**15.2%**	**−100.0%**	**9.3%**	**−24.4%**	**21.1%**	**37.0%**

AAGR = average annual growth rate, LPG = liquid petroleum gas.

Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Petroleum products are consumed by the final sectors (industry, transport, service, residential, and others) and for power generation and own use. The transport sector is the major consumer of petroleum products, growing on average 9.7 percent per year, with shares almost 67 percent of the total petroleum products' consumption in 2010 and 87 percent in 2015 (Figure 3.8).

Figure 3.8. Consumption of Petroleum Products by Sector



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

In industry, the consumption of petroleum products decreased at an average rate of 10.2 percent per year, reducing the share in the total consumption from 13 percent in 2010 to 6 percent in 2015. The industry sector is equipped with a self-generating system using diesel in case of a blackout. However, since the current public electricity supply is very stable, petroleum consumption in the industry sector shows a downward trend. Similarly, the power sector's consumption of petroleum products also declined rapidly at an average rate of 24.1 percent per year. This reduction corresponds to the government programme of increasing the share of hydro and coal as substitutes to oil products.

The overall consumption of the 'other' sectors – comprising service, residential, agriculture, and other sectors – also declined at an average rate of 9.5 percent per year. The service sector consumed the most, and reduced consumption in this sector implies that a substitution has occurred in this sector as in the industry sector.

By type of petroleum product, diesel is the main fuel consumed by the sectors. Total diesel consumption increased at an average rate of 9.3 percent per year, from 649 ktoe in 2010 to 1,013 ktoe in 2015 (Table 3.5). The share of diesel among all the petroleum products reached around 57 percent in 2015, increasing from 45 percent in 2010. Motor gasoline accounted for about 29 percent of the total consumption in 2015, higher than it was in 2010 (27 percent). This implies that

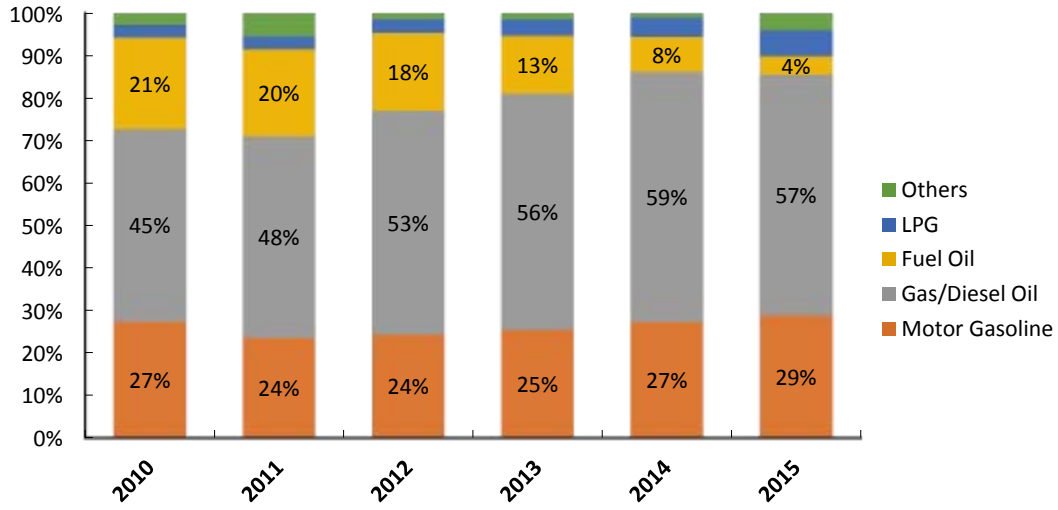
motor gasoline consumption also increased over the 2010–2015 period, but at a slower rate than diesel which is widely used across the sectors. The average growth rate for motor gasoline was 5.6 percent per year.Fuel oil had the third largest share of petroleum products consumed in 2010 (21 percent). Its consumption decreased significantly from 306 ktoe to 76 ktoe over the 2010–2015 period. The share of fuel oil in the total consumption of petroleum products was 4 percent in 2015 (Figure 3.9). Since the majority of fuel oil is consumed by the power sector, the significant decline in consumption is a sign of the shift to non-oil power generation system.

The share of liquid petroleum gas (LPG) in the total consumption of petroleum products was around 3 percent in 2010 and increased to 6 percent in 2015. Although the share of LPG is small, its consumption has increased significantly over the 2010–2015 period, at an average rate of 21.1 percent per year. The increasing consumption of LPG substituted the consumption of kerosene in the residential sector. Kerosene is no longer consumed since 2014.

Domestic jet fuel consumption was only 3 ktoe in 2010 and has increased to 6 ktoe in 2015. The significant increase of jet fuel consumption over this period, which on average was 15.2 percent per year, indicates the increase of air travel between cities in Cambodia.

The consumption of other petroleum products covers mainly lubricants. The consumption of lubricants increased almost threefold from 12 ktoe in 2010 to 47 ktoe in 2015 at an average rate of 28 percent per year due to the increase in the number of vehicles.

Figure 3.9. Petroleum Products Consumption by Products



LPG = liquid petroleum gas.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

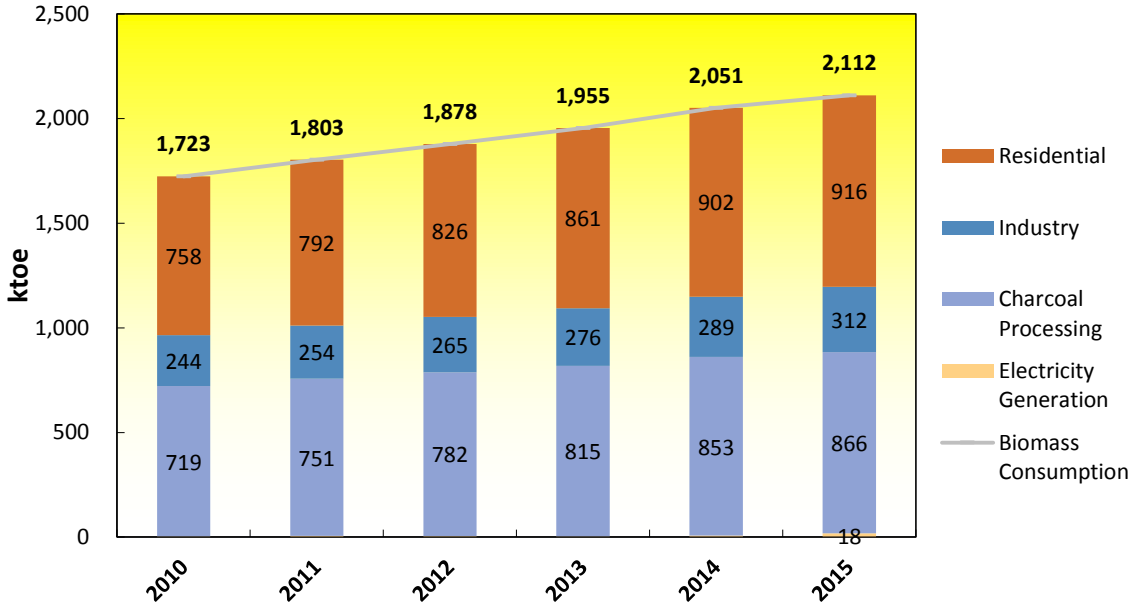
Biomass is the other major energy product consumed in the electricity generation, charcoal processing, industry, and residential sectors. Total biomass

consumption increased from 1,723 ktoe in 2010 to 2,112 ktoe in 2015 at an average rate of 4.2 percent per year. The residential sector is the largest consumer of biomass followed by charcoal processing, industry, and electricity generation (Figure 3.10).

Biomass consumption in the residential sector accounted for 43.4 percent of the total biomass consumption in 2015 whereas the share in industry was almost 15 percent. Compared with 2010, the share of biomass in the residential sector was smaller where it was higher in the industry sector. This indicates that the consumption of biomass in industry grew faster than that of the residential sector. On average, the annual growth rate of biomass consumption in the industry sector was 5.1 percent while in the residential sector it was 3.9 percent. Biomass will fade due to substitution to convenient energy forms such as LPG.

Biomass, particularly fuelwood, is used to produce charcoal. The amount of wood needed to produce charcoal was 719 ktoe in 2010 and had increased to 866 ktoe in 2015. Charcoal is consumed by the residential sector. An increase in the production of charcoal indicates an increase in the residential sector's consumption.

Figure 3.10. Biomass Consumption



ktoe = kiloton of oil equivalent.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Biomass consumption for generating electricity was 3 ktoe in 2010, only around 0.2 percent of the total biomass consumption. The consumption increased to 18 ktoe in 2015 resulting in an average increase of 47.4 percent per year. Biomass use is expected to increase in the future in compliance with government plans to increase the use of renewables in electricity production to support rural

electrification.

3.4 Power Generation

Cambodia's electricity supply increased on average by 19.7 percent per year from 2,515 GWh in 2010 to 6,186 GWh in 2015 (Table 3.6). Electricity imports from neighbouring countries (Viet Nam, Thailand, and the Lao PDR) accounted for 61 percent of total supply in 2010 and 25 percent in 2015. The amount decreased slightly, from 1,546 GWh in 2010 to 1,541 GWh in 2015. Considering that import amount is more or less the same, the significant reduction in the import shares indicates a significant increase in the domestic production. Electricity production increased almost fourfold during 2010–2015, from 968 GWh to 4,645 GWh.

Table 3.6. Electricity Generation

Unit: GWh

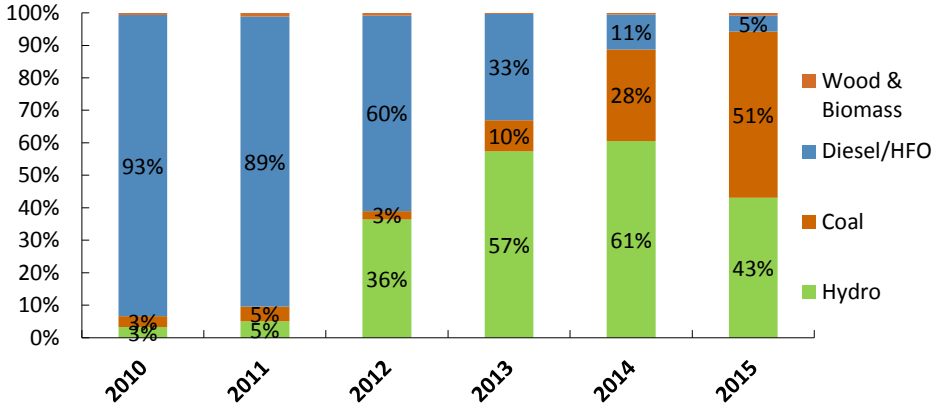
Year	Total	Hydro	Coal	Diesel/HFO	Biomass	Import
2010	2,515	32	32	899	6	1,546
2011	2,848	52	47	909	12	1,830
2012	3,527	517	37	857	12	2,104
2013	4,052	1,016	169	579	7	2,282
2014	4,861	1,852	863	327	17	1,803
2015	6,186	2,000	2,376	228	40	1,541
AAGR	**19.7%**	**129.0%**	**136.6%**	**– 24.0%**	**47.4%**	**– 0.1%**

AAGR = average annual growth rate, GWh = gigawatt-hour, HFO = heavy fuel oil.
Source: Electricity Authority of Cambodia.

Hydropower plants contributed 43 percent of the domestic generation in 2015, while the share was only 3 percent in 2010. Coal also had the same share as hydro in 2010, but the share increased to 51 percent in 2015, indicating a faster growth than that of hydro.

Increased generation from both hydropower and coal power plants is in accordance with the plan to reduce generation from oil-based power plants. Generation from oil-based power plants was dominant in 2010, accounting for 93 percent of total generation. In 2015, the share of oil-based power generation was reduced to 5 percent. The generation of oil-based power plants declined at an average rate of 24 percent per year.

Figure 3.11. Domestic Electricity Generation



HFO = heavy fuel oil.
Source: Electricity Authority of Cambodia.

Total electricity consumption was 2,283 ktoe in 2010, increasing to 5,398 ktoe in 2015 at an average rate of 19 percent per year (Table 3.7). Of the total consumption in 2010, around 29 ktoe (1.3 percent) is own use, while the remainder is for the final sectors (industry, residential, service, and others). Own use increased almost sevenfold in 2015, reaching 197 ktoe and indicating more new plants in operation.

Table 3.7. Electricity Consumption

Unit: GWh

Year	Total	Own Use	Final Sectors					Distribution Loss
				Industry	Service	Residential	Other	
2010	2,283	29	2,254	490	893	869	2	231
2011	2,605	32	2,572	630	1,082	854	6	244
2012	3,314	48	3,265	900	1,276	1,079	10	214
2013	3,620	68	3,552	820	1,539	1,187	6	431
2014	4,244	100	4,144	1,054	1,639	1,323	127	618
2015	5,398	197	5,201	1,137	2,530	1,527	7	788
AAGR	**18.8%**	**46.3%**	**18.2%**	**18.3%**	**23.2%**	**11.9%**	**26.8%**	**27.8%**

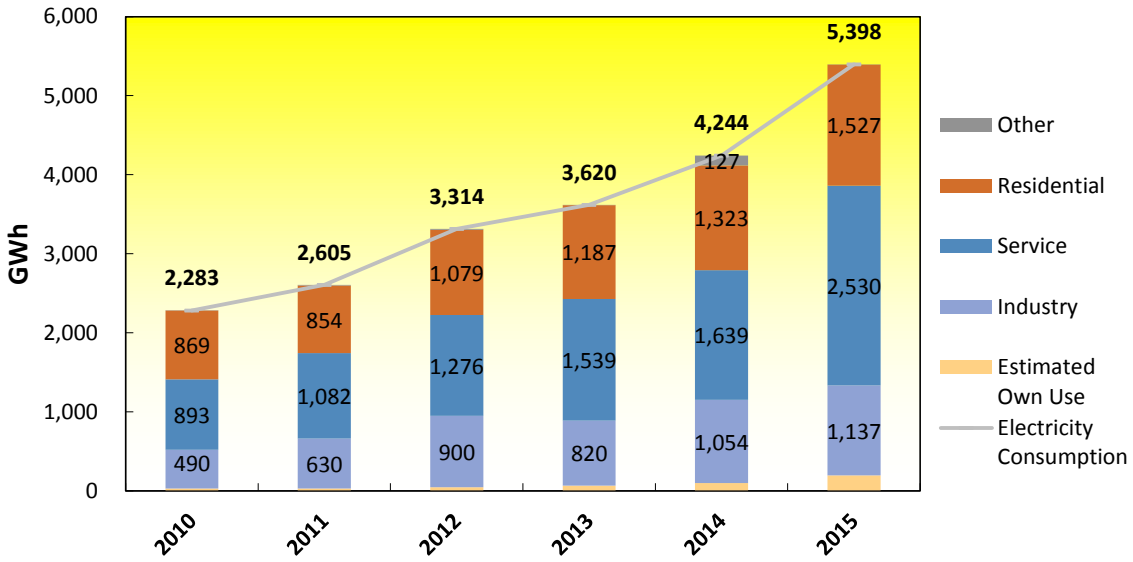
AAGR = average annual growth rate, GWh = gigawatt-hour.
Source: Electricity Authority of Cambodia.

Electricity consumption of the final sectors was 2,254 GWh in 2010. Of this total, the service sector's consumption accounted for 40 percent whereas the residential sector's share was 39 percent. The remaining 22 percent was the share of the industry and other sectors.

By 2015, the electricity consumption of the final sectors increased to 5,201 GWh at an average rate of 18.2 percent per year. The service sector's consumption increased at a faster rate of 23.2 percent per year as more hotels, hospitals, schools, and other commercial buildings were being constructed. The industry sector's electricity consumption increased at an annual average rate 18.3 percent per year while that of the residential and other sectors increased at 11.9 percent per year.

The consumption share of the final sectors to total consumption of electricity decreased to 96 percent in 2015 because the own use share increased to 4 percent (Figure 3.12). Since consumption in the service sector increased faster than in the industry and residential sectors, the share of the service sector to total electricity consumption increased to 49 percent, respectively, while the industry sector's share declined to 22 percent and the residential and other sectors' share, to 29 percent.

Figure 3.12. Electricity Consumption



GWh = gigawatt-hour.
Source: Electricity Authority of Cambodia.

The distribution losses compared to total consumption was projected to increase during 2010–2015. The losses in term of percentage would increase from around 10 percent to almost 14 percent.

3.5 Energy Indicators

Energy consumption is the result of human activities. Therefore, analysing the links between such human activities and energy consumption makes sense. These activities are (i) producing primary and secondary products, (ii) transporting persons

or cargo from point A to point B, (iii) service activities, (iv) household activities, and (v) agriculture, forestry, and fishery.

This chapter, however, focuses on overall activities, such as population and GDP, and analyses the relationship between macro indicators and energy consumption as follows: (i) TPES/GDP, (ii) factor analysis of TPES/GDP, and (iii) CO_2/GDP and CO_2/TPES.

These are called energy indicators and describe the link between energy consumption and human activity. They usually refer to a ratio between an energy consumption indicator and 'human activities', such as energy consumption per capita or energy consumption per unit of GDP (Trudeau, 2012).

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

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

3.5.1 Energy and economics

The real GDP of Cambodia increased at an average rate of 7.2 percent per year from 2010 to 2015. GDP, measured in purchasing power parity (PPP) at constant 2011 international dollars, increased from around $36 billion (at constant 2011 PPP) in 2010 to $51 billion (at constant 2011 PPP) in 2015. Garments, construction, agriculture, and tourism have driven Cambodia's growth. The garment industry accounts for about 70 percent of Cambodia's total exports and has been one of the key pillars of the economy.

The population has grown on average by 1.6 percent per year, from 14.4 million to 15.5 million over the same period. The TPES/capita indicator increased at an average annual growth of 5.6 percent from 0.23 tons of oil equivalent (toe) per person to 0.36 toe/person, while the TPES/GDP indicator remained around 0.09 toe per $1,000 (at constant 2011 PPP) over the 2010–2015 period (Table 3.8).

Figure 3.13 shows the relative changes of GDP, population, TPES, and energy indicators (TPES/GDP and TPES/capita) with 2010 as the baseline (2010 = 100). As

shown, the energy consumption per capita indicator changes in the same way as 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 per capita, electrification, and similar development programmes.

Table 3.8. Energy and Economic Indicators

Year	TPES	GDP	Population	TPES/GDP	TPES/Capita
	ktoe	$ million (constant 2011 PPP)	thousand persons	toe/$ '000 (constant 2011 PPP)	toe per capita
2010	3,350	36,100	14,365	0.093	0.233
2011	3,554	38,652	14,605	0.092	0.243
2012	3,757	41,459	14,864	0.091	0.253
2013	3,892	44,560	15,087	0.087	0.258
2014	4,304	47,711	15,313	0.090	0.281
2015	4,761	51,068	15,543	0.093	0.306
AAGR	**7.3%**	**8.9%**	**1.6%**	**0.1%**	**5.6%**

AAGR = average annual growth rate, GDP = gross domestic product, ktoe = kiloton of oil equivalent, PPP = purchasing power parity, toe = ton of oil equivalent, TPES = total primary energy supply.
Sources: National Statistics Office; IMF (2016), World Economic Outlook Database.

There is relatively small improvement in energy intensity (TPES/GDP) from 2010 to 2015. Energy intensity slightly declined from 2010 to 2013 and then increased to the 2010 level from 2013 to 2015, indicating a faster growth of TPES compared to GDP as a result of the rapid increase of coal consumption.

The energy intensity and GDP growth have separate effects on the change in energy consumption. As shown in Table 3.9 and Figure 3.14, an improvement in the energy intensity (intensity effect) decreased TPES in 2010–2015. GDP growth (production effect), on the other hand, increased TPES.

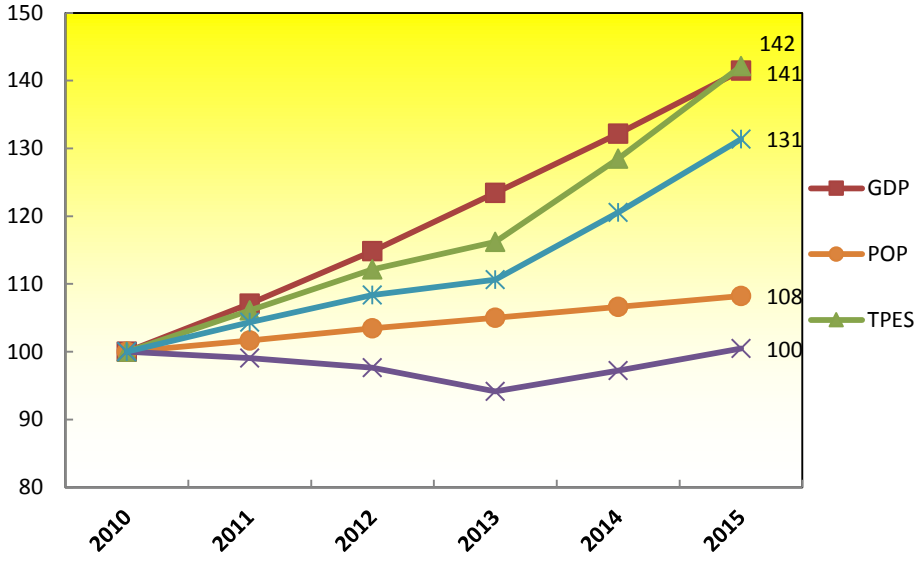
Table 3.9. Factor Analysis of Energy Consumption

Unit: ktoe

Year	Change in TPES	Intensity Effect	Production Effect	Cross Term
2011	203.874	−106.957	301.750	9.082
2012	203.143	−127.016	319.362	10.797
2013	135.115	−209.682	327.171	17.627
2014	412.453	68.742	349.289	−5.578
2015	456.655	112.598	352.391	−8.334
2010–2015	**1,411.2**	**−372.6**	**1,654.4**	**129.5**

ktoe = kiloton of oil equivalent, TPES = total primary energy supply.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Figure 3.13. Total Primary Energy Supply and Energy Intensity



GDP = gross domestic product, POP = population.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

TPES is measured as the energy intensity multiplied by GDP:

$$\text{TPES} = \text{TPES/GDP} \times \text{GDP}$$

The intensity effect is estimated as:

$$\triangle(\text{TPES/GDP}) \times \text{GDP}$$

The production effect is estimated as:

$$(\text{TPES/GDP}) \times \triangle\text{GDP}$$

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

$$\triangle\text{TPES} = \triangle(\text{TPES/GDP}) \times \text{GDP} + \text{Intensity Effect}$$
$$(\text{TPES/GDP}) \times \triangle\text{GDP} + \text{Production Effect}$$
$$\text{Crossover Term}$$

Crossover term is just a term for the difference between the impacts of both effects with the changes in TPES.

3.5.2 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 Intergovernmental Panel on Climate Change (IPCC) 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 provides estimates of CO_2 emissions from the main

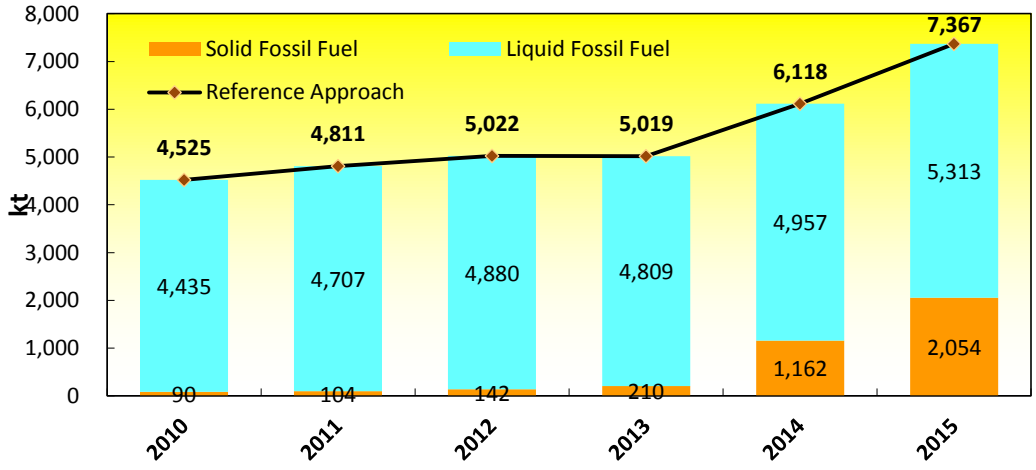
groups of fuel-using activities; as such, information is essential for monitoring and abatement of emissions.

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

The reference approach was used to estimate the CO_2 emissions of Cambodia based on the Cambodia Energy Balance Table 2010–2015. The calculation showed that CO_2 emissions increased from 2010 to 2015 at an average rate of 10.2 percent per year. The major sources of CO_2 emissions from fuel combustion are solid fossil fuel (coal) and liquid fossil fuel (oil). CO_2 emissions from coal combustion contributed only 2 percent in 2010 because the use of coal constituted only 1 percent of the total primary energy consumption. Oil consumption, on the other hand, already accounted for 43 percent of the country's total fuel use. Therefore, the majority of CO_2 emissions came from burning oil in 2010 (Figure 3.14).

Since the transport sector consumed most of the oil, the burning of gasoline and diesel fuel contributed most to the emission, particularly from the use of motor vehicles in Phnom Penh. Total CO_2 emissions from oil combustion were 4,435 kilotons (kt) in 2010. By 2015, CO_2 emissions from oil has increased to 5,313 kt as the number of vehicles continues to increase and as the shift from biomass continues to occur in the industry and residential sectors. Emissions of CO_2 from coal combustion are also increasing, but at a faster rate than from oil combustion. The commissioning of new coal power plants contributed to this increase as coal consumption increased 23 times compared with 2010.

Figure 3.14. CO_2 Emissions from Fuel Combustion by Sector



kt = kiloton.
Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Table 3.10 shows the energy and CO_2 emissions indicators. CO_2 intensity measures the impact of an increase in GDP or TPES on the absolute emissions of CO_2. The intensities (CO_2/GDP and CO_2/TPES) increased from 2010 to 2015 but at different average annual growth rates. For the CO_2/GDP intensity, the increase was 1.4 percent per year, from 0.12 to 0.13 tons of CO_2 per thousand dollars in PPP. The CO_2/TPES intensity increased at a faster rate of 2.9 percent per year, from 1.29 tons of CO_2 per ton of oil equivalent in 2010 to 1.49 tons of CO_2 per ton of oil equivalent in 2015.

Table 3.10. Energy and CO_2 Emissions Indicators

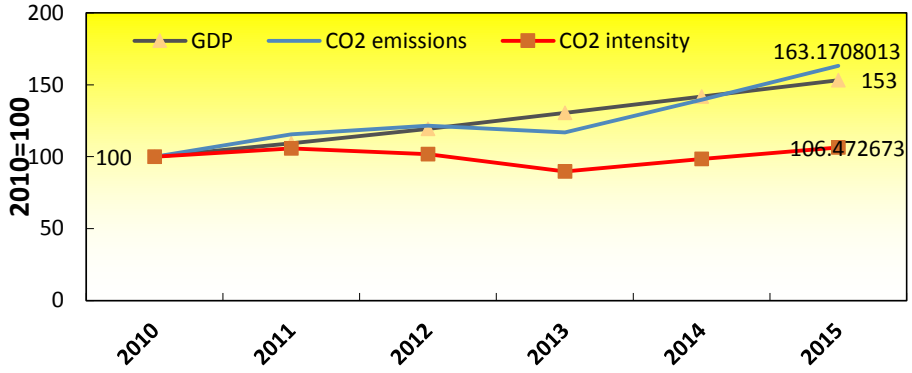
Year	Total Primary Energy Supply	GDP	CO_2 Emissions	CO_2/GDP	CO_2/TPES
	ktoe	10^6 USD in PPP	kt CO_2	ton CO_2/ $'000 PPP	ton CO_2/toe
2010	3,349.8	35,370	4,324	0.122	1.291
2011	3,553.7	38,652	4,992	0.129	1.405
2012	3,756.8	42,243	5,244	0.124	1.396
2013	3,892.0	46,120	5,042	0.109	1.295
2014	4,304.4	50,193	6,016	0.120	1.398
2015	4,761.1	54,205	7,100	0.131	1.491
AAGR	**7.3%**	**8.9%**	**10.4%**	**1.4%**	**2.9%**

AAGR = average annual growth rate, CO_2 = carbon dioxide, GDP = gross domestic product, kt = kiloton, ktoe = kiloton of oil equivalent, PPP = purchasing power parity, toe = ton of oil equivalent, TPES = total primary energy supply.
Sources: National Statistics Office; International Monetary Fund, 2016. World Economic Outlook Database.

Emissions intensities from fuel combustion are influenced primarily by shifts in energy intensity, economic structure, and fuel mix. They are not directly correlated with changes in activity levels (GDP and population). Absolute emissions levels, on the other hand, are most strongly influenced by GDP shifts. When GDP rises, emissions also tend to rise correspondingly (Figure 3.15) (Baumert, Herzog, and Pershing, 2005).

As explained previously, garments, construction, agriculture, and tourism have driven Cambodia's growth, resulting in GDP growth of almost 9 percent per year between 2010 and 2015. Oil and coal play an increasing role in achieving the growth in GDP, consequently resulting in high CO_2 emissions. Figure 3.16 shows the relative changes of GDP, CO_2 emissions, and CO_2 intensity with 2010 as a baseline (2010 = 100).

Figure 3.15. Relationship between CO_2 Emissions and Gross Domestic Product

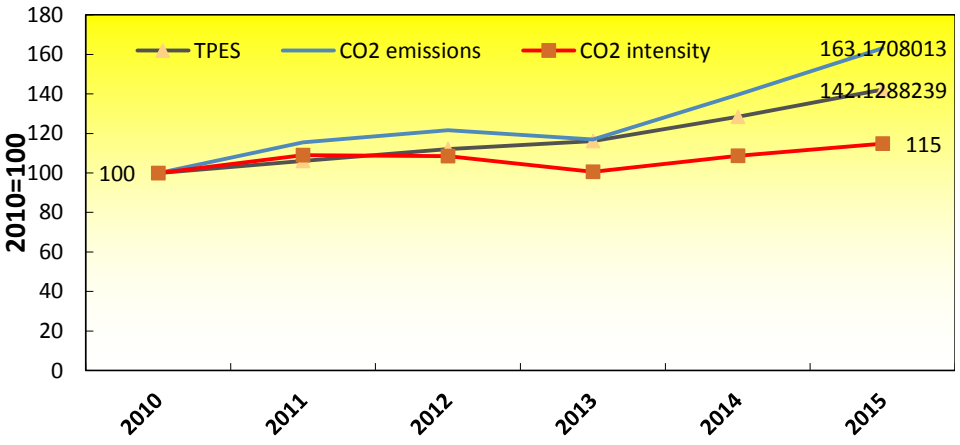


Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

As shown, GDP and CO_2 emissions moved in tandem, while the CO_2/GDP intensity was less affected. By 2015, GDP and absolute CO_2 emissions increased 53 and 63 percent, respectively. The intensity, on the other hand, increased only 6 percent in 2015.

Similarly, TPES also moved in the same way as GDP, but slower. By 2015, TPES and absolute CO_2 emissions increased 42 and 63 percent, respectively. The changes in absolute emissions come from the increment of petroleum products. After 2013, coal use increased and resulted in higher CO_2 emissions. The CO_2/TPES intensity is affected more than the CO_2/GDP intensity. By 2015, the CO_2/TPES intensity increased 15 percent.

Figure 3.16. Total Primary Energy Supply, CO_2 Emissions, and CO_2 Intensity



Source: ERIA, calculated from the Cambodia Energy Balance Table 2010–2015.

Chapter 4

Conclusion and Way Forward

4.1 Conclusion

During the past 6 years, energy consumption increased rapidly at an average annual growth rate of 6.9 percent for total final energy consumption (TFEC) and 7.3 percent for total primary energy supply (TPES). Electricity significantly increased in the same period, followed by petroleum product. Biomass, on the other hand, increased at a slower rate. Nonetheless, biomass is still an important energy source for Cambodia with a share of about 36 percent in 2015.

Electricity was generated from oil, hydropower, and coal power plants. Generation from hydropower and coal power plants increased largely after 2013. For petroleum products, Cambodia has been depending dominantly on diesel oil followed by gasoline and liquid petroleum gas (LPG). Diesel oil is used widely for vehicles as well as for manufacturing and agricultural activities. In addition, large buildings and factories use diesel oil for backup power generation. The share of diesel oil in 2015 was almost 60 percent.

Cambodia achieved high economic growth at 7.2 percent per year from 2010 to 2015. Consequently, the gross domestic product (GDP) elasticity of TPES will be nearly equal to 1.0. This result is still acceptable for Cambodia. However, if biomass is excluded from TPES, its growth rate could be more than 10 percent and energy elasticity per GDP, defined as ΔTPES/ΔGDP, will become worse (more than 1.0). The elasticity was actually more than 1.0 in 2014 and 2015, indicating a more rapid growth in TPES compared with GDP. In this regard, Cambodia should consider the promotion of energy efficiency and conservation, especially for saving electricity demand in the industry, commercial, and residential sectors.

4.2 Way Forward

Through this project, Cambodia has achieved its first publication of official energy statistics. The General Department of Petroleum and General Department of Energy are expected to update the publication annually and, since it can be conveniently accessed through the Internet, upload the pdf file to the Ministry of Mines and Energy website. Parts of the energy statistics come from energy market players and the feedback of national data is useful for them.

Therefore, the General Department of Petroleum and General Department of Energy have been recommended to set up an energy statistics team that will be in charge of the update work. In addition, the General Department of Petroleum

should continuously receive petroleum demand supply data from petroleum companies. On the other hand, the department should be in charge of conducting an energy consumption survey across the final consumption sectors applying sampling.

Based on the experiences from this project, the General Department of Petroleum should conduct energy consumption surveys and use results of the surveys to make accurate energy statistics or energy balance tables. Furthermore, the results should be analysed to set up appropriate energy policies, such as energy efficiency programmes.

The energy statistics team should improve the quality of the energy statistics. This publication includes some estimated numbers, but they should be collected from the data source or estimated from survey results. A more important matter is to analyse the energy statistics. If coal consumption increased rapidly, the reason for this increase needs to be clarified, all the while paying attention to human errors such as typos, differences in units, and so on.

The key role of the General Department of Petroleum and General Department of Energy is to release timely, complete, and accurate energy statistics of Cambodia supported by regulations, good relations with market players, and capacity building training conducted by international and regional organisations.

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Annex 1

Definition of Petroleum Products Sales Questionnaire

Definition of Fuels

1. Liquefied petroleum gas (LPG)

LPG refers to liquefied propane (C3H8) and butane (C4Hl0) or mixtures of both. Commercial grades are usually mixtures of 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. The main uses for naphtha are as feedstock for high octane gasolines and the manufacture of olefins in the petrochemical industry.

3. Motor gasoline

Motor gasoline is a mixture of some aromatics (e.g. benzene and toluene) and aliphatic hydrocarbons in the C5–C12 range. The distillations range is 25°C–220°C. Motor gasoline may also contain biogasoline products.

4. Kerosene type jet fuel

This is a blend of kerosene suited to flight conditions with particular specifications, such as freezing point. The specifications are set down by a small number of national standards committees, most notably the American Society for Testing Material (ASTM), United States; the Ministry of Defence (MOD), United Kingdom; and the GOST (GOsudarstvennyy STandart) Russia.

5. Other kerosene

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

6. Diesel oil

Diesel oils are middle distillates, predominantly of carbon number range C11–C25 and with a distillation range of 160°C–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 has a distillation range of 350°C–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, for which the principal use is to reduce friction between sliding surfaces and during metal cutting operations.

9. Bitumen

Bitumen is a solid, semi-solid, or viscous hydrocarbon with a colloidal structure, being 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 having crossed the national territorial boundaries, whether customs clearance has taken place or not. Quantities of crude oil and products imported or exported under processing agreements (i.e. refining on account) should be included.

2. Blending

Petroleum companies blends several petroleum products and create a petroleum product, so there are + (create) and – (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 on national territory, including stocks held by governments, by major consumers or by stockholding organisations, stocks held on board incoming ocean vessels, stocks held in bonded areas, and stocks held for others, whether under bilateral government agreement or not.

5. Total sales
= 1 ± 2 – 3

6. Sell to power producers
= 6 + 7

7. Electricité du Cambodge (EDC)
Sales of diesel or fuel oil to EDC

8. Independent power producer (IPP), off-grid factory (OGF), 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
International Standard Industrial Classification of All Economic Activities (ISIC) Group 241 and Class 2431 (Statistical Classification of Economic Activities in the European Community (NACE) Groups 24.1, 24.2, and 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 (incl. 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, beverages, 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 your economy's industrial classification of oil consumption does not correspond to the above ISIC (or NACE) codes, please estimate the breakdown by industry and only include in not elsewhere specified the consumption in sectors which are not covered above. This industry is classified as ISIC Division 22, 31, and 32 (NACE Divisions 22, 31, and 32).

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 gas oil 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 on the basis of departure and

landing locations and not by the nationality of the airline. Exclude fuels used by airlines for their road vehicles (see not elsewhere specified – transport sector) and military use of aviation fuels (see not elsewhere specified – other sectors).

25. Domestic air transport

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

26. Inland waterways

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

27. International marine bunkers

Bunkers cover the quantities of fuels delivered to sea-going ships of all flags. Consumption of warships should be included in final consumption under other sector, not elsewhere specified. Consumption by ships engaged in fishing and in transport in inland and coastal waters 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. Note that oil use at railway, 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

Table A1.1 Revised Questionnaire for Sales Data from Petroleum Companies

Petroleum Product Sales Questionnaire

Corporation/Company: Contact Person: Tel:

Year: Email:

Quantity Descriptions	LPG	Naphtha	Motor Gasoline	Kerosene Type Jet Fuel	Other Kerosene	Diesel Oil	Fuel Oil	Lubricants	Bitumen	Other Products (specify)
	Ton	KL	KL	KL	KL	KL	KL	KL	Specify	Specify
Import										
Blending										
Own Use										
Stock (in the end of the year)										
Total Sales										
Sell to Power producers										
EDC										
IPP, Rural, etc										
Sell to Large Scale Industrial Users										
Iron and Steel										
Chemical (incl. Petro-Chemical)										
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 Services such as Mall, Hotel, School, Hospital, Office Building										
Public Services such as Central and Local Governments										
Residential										
Agriculture										
Fishing										
Petroleum Wholesaler										
Sell to Gas Station										
Company Owned Stations										
Company Franchises										

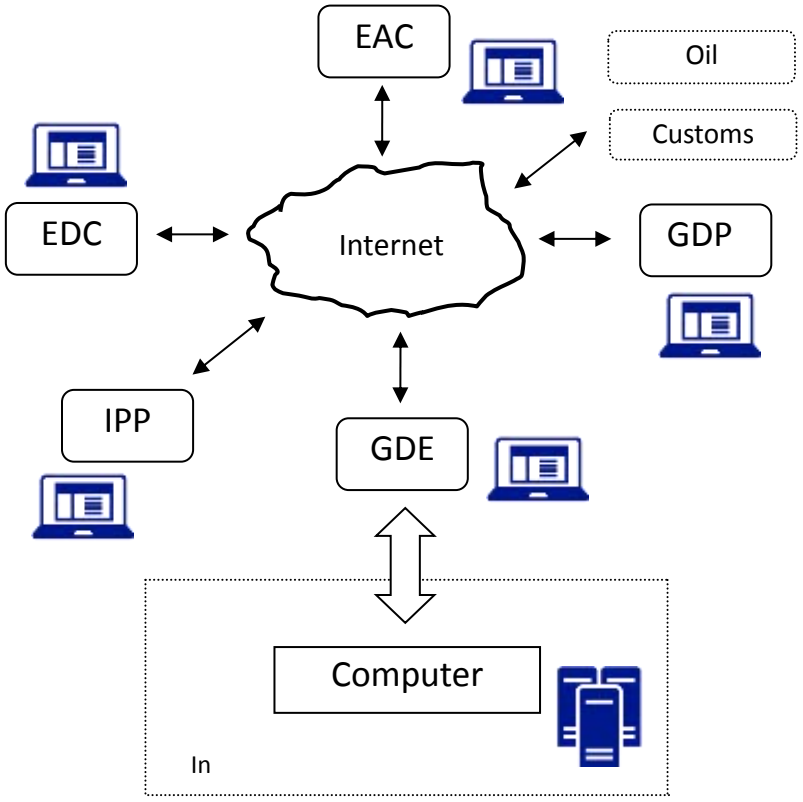
Annex 2

Data Collection Flow of Existing Data

1. Stakeholders of Energy Data

Since energy data are maintained by public facilities and private companies, it is necessary to set up an energy data collection system. The scatter situation of existing energy data is as follows:

Figure A2.1 Scatter Situation of Energy Data Holders



EAC = Electricity Authority of Cambodia, EDC = Electricité du Cambodge, GDE = General Department of Energy, GDE = General Department of Petroleum, IPP = independent power producer.

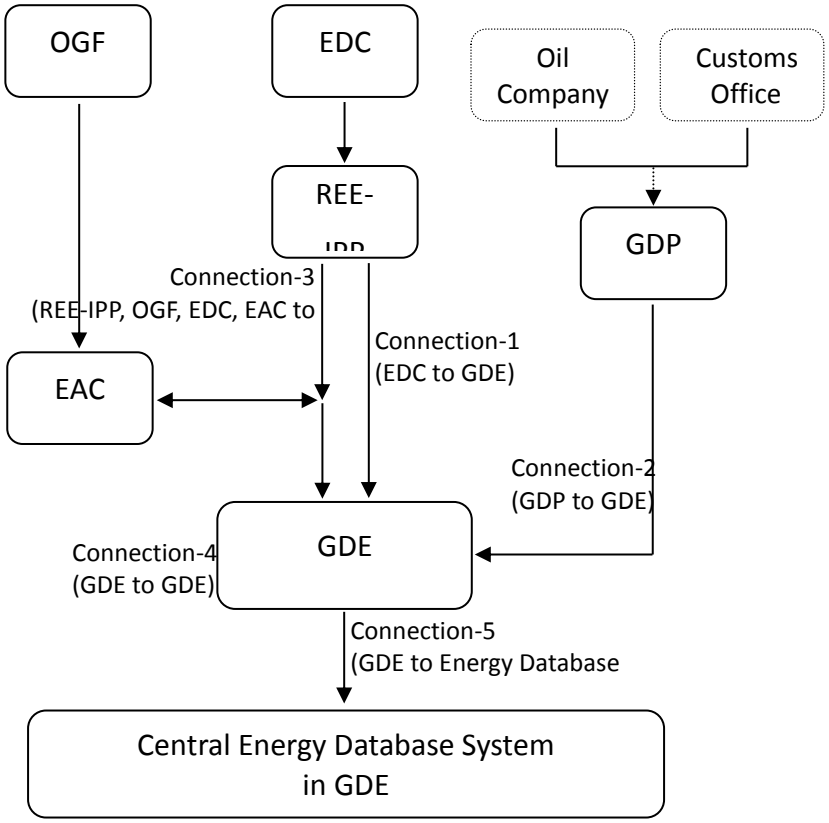
2. Energy Data Collection Flow

Each facility shall be equipped with a Windows PC and an Internet connection. It is recommended that the computer centre be installed in the General Department of Energy (GDE) office.

Energy data via the Internet from each facility will be sent to the management system after changing to the required format.

The data stream can be classified into five significant flows. The main information flow of energy data is shown below:

Figure A2.2 Energy Data Collection Flow



EAC = Electricity Authority of Cambodia, EDC = Electricité du Cambodge, GDE = General Department of Energy, GDP = General Department of Petroleum, IPP = independent power producer, OGF = off-grid factory, REE = rural electricity enterprise.

3. Specification of Each Connection

The five categories are connection-1, connection-2, connection-3, connection-4, and connection-5.

<Connection-1>

Flow between the relevant organisations

_EDC -> EAC -> GDE

Associated data

Coal by transformation input to power plant

Petroleum products by transformation input to own plant

Flow between the relevant organisations

_EDC -> GDE

Associated data

Electricity by own use

Electricity by loss

Electricity by industry consumption

Electricity by service consumption

<Connection-2>

Flow between the relevant organisations

_GDP (Customs office) -> GDE

Associated data

Petroleum products by import

Flow between the relevant organisations

_GDP (Oil company) -> GDE

Associated data

Petroleum products by consumption

<Connection-3>

Flow between the relevant organisations

_OGF -> EDC -> EAC -> GDE

Associated data

Electricity by import

Electricity by transformation output

Electricity by residence consumption

Flow between the relevant organisations

_EDC (REE-IPP) -> EAC -> GDE

Associated data

Hydropower by production

Hydropower by transformation input to power plants

<Connection-4>

Flow between the relevant organisations

_GDE (Data collection department) -> GDE

Associated data

Biomass firewood by production

Biomass firewood by transformation input to power plant

Biomass firewood by transformation input with charcoal

Biomass firewood by industry consumption

Biomass firewood by residence consumption

Biomass biogas by production

Biomass biogas by residence consumption

Biomass charcoal by transformation output

Biomass charcoal by residence consumption

Other necessary data

<Connection-5>

Flow from the data centre to the database registration

_GDE-> Energy database system

Associated data

All of energy data by sect

Annex 3

Energy Efficiency in the Industry Sector

1. Energy Efficiency

Energy efficiency is defined as 'using less energy to provide the same level of service on a per unit basis'.[1] It is generally achieved by adopting a more efficient technology or production process or by applying commonly accepted methods to reduce energy losses.

Using less energy to perform the same function will reduce energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy-efficient technology. Reducing energy use will be important in shaping patterns of energy use and in opening opportunities to increase exports or to decrease imports, which will eventually result in higher domestic (and global) energy security. It will enable the strengthening of research, development, and demonstration (RD&D) activities and creating jobs.[2]

Energy efficiency will also be important for reducing CO_2 emissions because the amount of energy use will be lower. Strategies to implement energy efficiency, if coupled with strategies to develop renewable energy, can raise clean energy supplies, making deep cuts of fossil fuel use. Thus, a sustainable energy economy requires strong commitment to both efficiency and renewables.

Significant improvements in final energy intensity worldwide played a key role in limiting global increases of energy use and CO_2 emissions. The reductions in energy intensity were largest in non–Organisation for Economic Co-operation and Development (OECD) countries, due to a combination of structural changes and efficiency improvements.[3] Developing countries have set energy saving targets and formulated policies and programmes to achieve these targets.

Large potential for further improvements in energy efficiency still remains, particularly in the industry sector and the power generation sector. Strong policy actions from government policies, including stringent norms and standards, will be necessary to accelerate energy efficiency improvements.

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[1] http://dictionary.sensagent.com/Efficient%20energy%20use/en-en/ (accessed 14 June 2016).
[2] Mieke Reece (2010), 'Energy Efficiency Indicators', paper presented at the APEC/ASEAN Joint Workshop on Energy Statistics, Bangkok, 8–12 November 2010.
[3] International Energy Agency (IEA) (2008), *Worldwide Trends in Energy Use and Efficiency: Key Insights from IEA Indicator Analysis*. Paris.

2. Measuring Energy Efficiency

Energy use and efficiency trends are usually analysed using indicators based on detailed statistics. These indicators examine the impacts of economic activity and structure, income, prices, policies, etc. relating to energy use in the different sectors and subsectors of the economy.

The energy intensity of a country is often used as an energy efficiency indicator (EEI) for that country. It is the ratio of the total primary energy supply (TPES) or total final energy consumption (TFEC) divided by the gross domestic product (GDP) of the country. Energy intensity is easy to calculate because the TPES or TFEC and GDP figures are readily available. TPES and TFEC data are available in the energy balance table of the country. GDP is a country's total value of production reflecting the country's economy and, therefore, the number is easily obtained from the national statistics.

Energy intensity is only an aggregate indicator for a country and can be used as a comparative measure between countries. However, a given country with a low energy intensity does not necessarily have high efficiency. For instance, a small service-based country with a mild climate would certainly have a much lower intensity than a large industry-based country in a very cold climate, even if energy is more efficiently consumed in this country than in the former. Other elements beside efficiency need to be considered such as the structure of the economy (presence of large energy-consuming industries, for instance), the size of the country (higher demand from the transport sector), the climate (higher demand for heating or cooling), and the exchange rate.[4]

Overall energy indicators provide an explanation on the basic energy consumption patterns and are usually not suitable for designing or monitoring the effects of policies that operate at lower aggregation levels. The energy intensity of a subsector or specific production process will need energy consumption data at the end-use level and corresponding activity data. Having reliable end-use energy statistics will be crucial in monitoring and evaluating the energy saving targets and action plans and in conducting a robust analysis of the energy saving potential.

A country's energy balance table is usually too aggregated and provides no breakdown of data at the end-use level.[5] In the case of developing countries, the breakdown is sometimes only at the sector level. At this level of disaggregation, the energy data do not provide significant information to monitor energy efficiency trends.

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[4] IEA (2014), *Energy Efficiency Indicators: Fundamentals on Statistics*. Paris.

[5] Roberta Quadrelli (2014), 'The IEA Work on Data and Methodologies for Energy Efficiency Indicators', paper presented at the 9th Meeting of the Oslo Group on Energy Statistics, Hilton Grand Capital, Abu Dhabi, United Arab Emirates, 5–8 May 2014.

Nevertheless, this type of energy balance can still be useful to assess the largest consuming sectors within a country where the energy saving potential will have more impact.

Collecting more detailed data, such as residential or services end-use data, transport vehicle types, or segment data, can provide a better understanding of which subsectors or end users drive energy consumption within each sector. In this regard, the International Energy Agency (IEA) has already designed a template to collect data for the EEIs. The template provides a starting point for data collection and helps in identifying the data gaps and issues.[6] The IEA published a corresponding manual[7] to provide guidance on how to collect the data needed for the EEIs. The IEA also published a guideline for policymakers to develop and interpret EEIs.[8]

3. Energy Efficiency in the Industry Sector

The industry sector covers the manufacturing sector (the manufacture of finished goods and products), construction, and mining and quarrying of raw materials. It does not include transport-related energy consumption and refineries. Industries consume energy to power a diverse range of manufacturing and resource extraction processes. In addition, some industries generate fuel from waste products that can be used to provide additional energy.

As a boiler fuel, energy is used to generate steam or hot water. In process heating, energy is used to raise the temperature of products in the manufacturing process. Besides fuel, energy is also used by some industries as feedstock to make products or for other non-energy purposes.

Considering the diversity of industrial processes, there is a multitude of possible opportunities for energy efficiency in industries. Many depend on the specific technologies and processes in use at each industrial facility.

Installing combined heat and power (co-generation) plants in industries that use both steam and electricity within their facilities will be more efficient compared to just installing conventional power plants. In a co-generation plant, the heat produced as a byproduct of electricity generation can be captured and used as process steam. Consequently, a co-generation plant can convert up to 90 percent of the fuel into usable energy, whereas a conventional power plant is only about 30 percent efficient.

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[6] Taejin Park (2014), 'Energy Efficiency Indicators Data Collection', paper presented at the Energy Statistics Training, Paris, 24 March 2014.
[7] IEA (2014), *Energy Efficiency Indicators: Fundamentals on Statistics*. Paris.
[8] IEA (2014), *Energy Efficiency Indicators: Essentials for Policy Making*. Paris.

Another area for energy efficiency is replacing conventional boilers and furnaces with advanced types that can operate at higher temperatures while burning less fuel. Another option would be reducing the fuel used to produce steam by insulating steam and condensate return lines, stopping steam leakage, and maintaining steam traps.[9]

Electric motors usually run at a constant speed, but a variable speed drive allows the motor's energy output to match the required load. This achieves energy savings ranging from 3 to 60 percent, depending on how the motor is used. Motor coils made of superconducting materials can also reduce energy losses. Motors may also benefit from voltage optimisation.[8]

Although many industries already implement energy efficiency practices, achieving energy efficiency in this sector remains challenging due to the variety of activities within the sector, the variety of relevant actors, and the importance of industry for national economies. The Rocky Mountain Institute points out that in industrial settings, 'there are abundant opportunities to save 70–90 percent of the energy and cost for lighting, fan, and pump systems; 50 percent for electric motors; and 60 percent in areas such as heating, cooling, office equipment, and appliances.' In general, up to 75 percent of the electricity used in the United States today could be saved with efficiency measures that cost less than the electricity itself.[10]

3.1 Energy Efficiency Indicator (EEI) for Industry

In principle, the EEI is the ratio of energy consumption per activity; in other words, it is the amount of energy required to conduct an activity. In the industry sector, activity is the process of producing an output. Thus, it can be measured in quantity produced or its value.

According to the IEA manual on Energy Efficiency Indicators,[11] the indicator for commodities production is the energy intensity calculated as the ratio of production divided by energy use. This relates to the physical production of major manufacturing sectors (energy-intensive industries) covering:

- ISIC 21. Paper and paper products
- ISIC 24. Chemicals and chemical products
- ISIC 26. Other non-metallic mineral products
- ISIC 27. Basic metals

The manual differentiates the aggregate indicators and the disaggregate indicators. The aggregate indicators are sufficient to provide a high-level picture of

[9] Wikipedia. Efficient Energy Use. https://en.wikipedia.org/wiki/Efficient_energy_use (accessed 12 June 2016).
[10] http://dictionary.sensagent.com/Efficient%20energy%20use/en-en/ (accessed 14 June 2016).
[11] IEA (2014), *Energy Efficiency Indicators: Fundamentals on Statistics*. Paris.

the sectoral consumption and allow a first comparison across countries, as well as a preliminary assessment of the importance of the various subsectors and energy sources. These indicators are:

- Total industry energy consumption (absolute or as a share of TFEC)
- Share of each energy source in the total industry energy consumption mix

Another indicator at the aggregate level referring to intensity is the total industry energy consumption divided by total industry value added. This indicator provides a first assessment of the overall intensity of the sector and its trends. The total output of the sector at the overall industry level is represented by the sector's value added because the physical output across the subsectors is not homogenous. The value added should be in constant currency to avoid bias induced by fluctuations in the monetary market.

At the subsector level, the indicators describing the energy use and energy efficiency trend are:

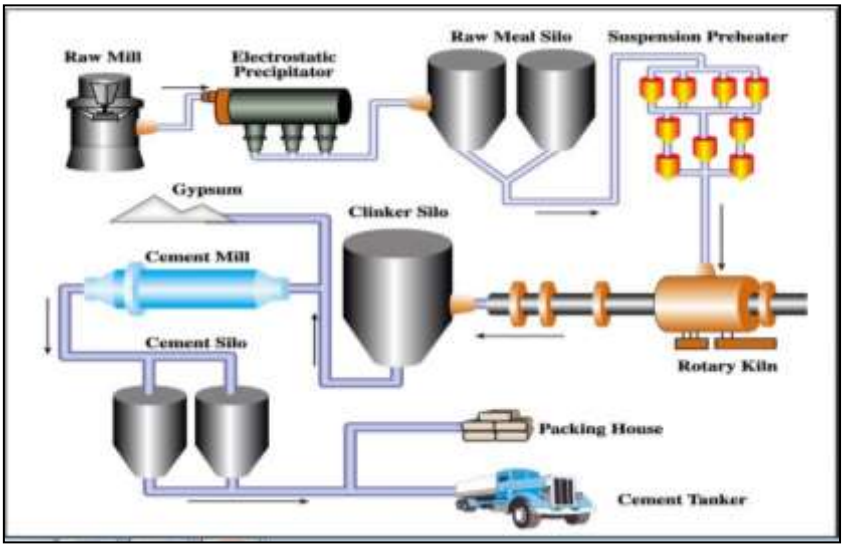
- Total subsectoral energy consumption (absolute or as a share of industry consumption)
- Share of each energy source in total subsectoral energy consumption mix
- Subsectoral energy consumption per unit of subsectoral physical output
- Subsectoral energy consumption per subsectoral value added
- Energy consumption per unit of physical output for each process/product type
- Energy consumption per value added for each process/product type

3.2 An Example of the Use of EEI: Cement Industry

The cement industry is classified under the non-metallic minerals subsector which refers to ISIC Division 23. The production of cement accounts for 83 percent of total energy use in the production of non-metallic minerals and 94 percent of CO_2 emissions. Energy represents 20–40 percent of the total cost of cement production. The production of cement clinker from limestone and chalk by heating limestone to temperatures above 950°C is the main energy consuming process. Mixing additives to clinker to form cement is less energy intensive. Portland cement, the most widely used cement type, contains 95 percent cement clinker. Large amounts of electricity are necessary to grind the raw materials and finished cement. Figure A3.1 shows the cement production process.

Depending on the water content of the raw feedstock, the process of clinker production can be either 'wet' or 'dry' – the first being much more energy intensive than the latter because it avoids the need for water evaporation. The dry process has a lower energy intensity (around 3.0 gigajoules [GJ] per ton of clinker) compared with 4.2 GJ per ton of clinker for efficient plants. The other major difference is between vertical shaft kilns and rotary kilns, their more efficient counterparts.

Figure A3.1 Cement Production Process



Source: Lootahgroup, cited in ClimateTechWiki. Energy Efficiency and Saving in the Cement Industry. http://www.climatetechwiki.org/technology/energy-saving-cement (accessed 30 June 2016).

Considering that cement production is a relatively simple process with well-defined system boundaries and a uniform product, the IEA developed disaggregate indicators to track the progress of energy efficiency over time and also to calculate the technical potential for energy reductions that could be achieved by moving to best available technology (BAT) or best practical technology (BPT).

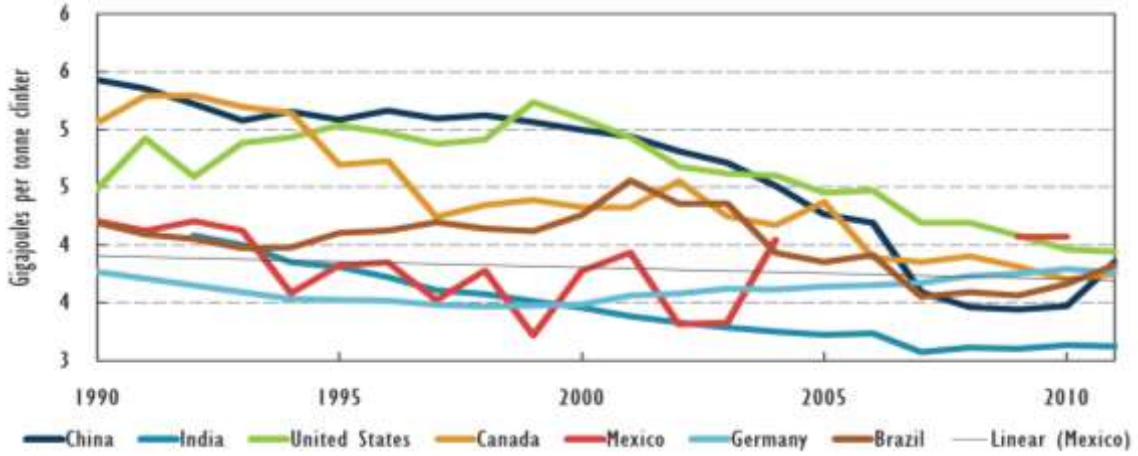
A number of indicators can easily be calculated for clinker (the partially fused product of a kiln, which is then ground for use in cement) and cement production to track developments over time. These include:

- Energy consumption, including alternative fuels, per ton of clinker
- Electricity consumption per ton of cement
- Total primary energy equivalent per ton of cement
- Total CO_2 emissions (process and energy-related) per ton of cement
- Alternative fuel use in clinker production
- Clinker-to-cement ratio
- Waste heat recovered per ton of clinker

- CO_2 emissions from energy consumption (including electricity) per ton of cement

From an energy efficiency view, the most important indicator is the average energy consumption per ton of clinker produced. For most countries, the indicator shows a downward trend in the energy intensity of clinker production between 1990 and 2011 (Figure A3.2). The reason for this downward trend has largely been due to the shift from wet-process to dry-process cement kilns, coupled with the replacement of older dry kilns by the latest technology using pre-heaters and pre-calciners. Using consistent definitions and boundaries across all countries, it can be seen that the average energy consumption per ton of clinker in China is currently about 3.45 GJ per ton whereas the European Union, Canada, and the United States all use around 3.8–4.0 GJ per ton of clinker.

Figure A3.2 Energy Consumption per Ton of Clinker by Country



Source: IEA (2014), Energy Efficiency Indicators: Essentials for Policy Making. Paris.

Cement companies are investing in low-consumption technologies to be more competitive as they can reduce energy consumption and thus lower the production cost. Moreover, legislation in terms of greenhouse gas (GHG) emissions as well as local pollution often pushes industry to be cleaner and more energy-concerned. Today's state-of-the-art dry rotary kilns are fairly fuel efficient, using around 2.9–3.0 GJ per ton of clinker.

Annex 4

Energy Efficiency in Buildings

1. Introduction

In 2015, about 40 percent of total energy consumption in the United States was in residential and commercial buildings.[1] In the ASEAN region, energy consumption in buildings accounts for about 32 percent of energy demand.[2] For countries with a hot and humid climate such as Cambodia, the energy demand for air-conditioning systems in buildings accounts for the largest proportion of energy use in the operation of buildings. Therefore, it makes sense to channel efforts to devising both appropriate policy strategies and technical measures to achieve energy efficiency in the design, operation, and maintenance of new and existing buildings.

Substantial energy will be saved through the adoption of energy efficiency measures and practices. If one takes into account a building's life span, the operational energy savings can be huge, and such savings can be translated into reduction in the country's CO_2 emissions, in addition to energy cost savings.

2. Benchmarking of Energy Efficiency for Buildings

Before embarking on strategies to achieve energy efficiency, it is important to set a parameter that can determine or indicate the extent of energy efficiency in the operation of buildings. It is recognised that daily energy consumption in a building fluctuates by hour, day, and month because the main energy use for air-conditioning cooling loads changes and peaks at different hours during the day as a result of solar heat gained mainly through daily solar radiation. Building occupancy and seasonal changes will also influence the energy consumption in buildings.

Taking the above into account, it is recommended to use building energy intensity (BEI) as an energy efficiency indicator or index to gauge and compare building energy performance, which is based on a building's annual energy consumption and gross floor area. The following formula is used to calculate BEI:

$$\text{BEI} = \frac{Annual\ Energy\ Consumption\ (kWh/yr)}{Gross\ Floor\ Area\ (m^2)}$$

It should be noted that the annual energy consumption shall include all energy usage by the owner and tenants, including installations that consume energy

[1] US Energy Information Administration (2016), Frequently Asked Questions, http://www.eia.gov/tools/faqs (accessed April 2016).
[2] International Energy Agency (IEA) and Economic Research Institute for ASEAN and East Asia (ERIA) (2013), *Southeast Asia Energy Outlook*. Paris: OECD/IEA.

and serve the whole building except car parks and data centre equipment because their inclusion would distort the BEI. The gross floor area shall be the gross area of occupied space excluding car park areas and the data centre room, which corresponds with the exclusion of energy consumption for these areas. It should also be noted that this BEI method is not applicable to buildings without much air-conditioning in building floor spaces, such as for residential buildings. For the purpose of this study, it is suggested to set the minimum air-conditioned space to be at least 50 percent of the gross floor area for a meaningful comparison of BEI in buildings.

Another aspect that will influence the BEI values is building categories and operational hours. For example, BEI for office buildings will differ from that of shopping malls, which again will differ from that of hotels and hospitals. In the absence of proper surveyed data in Cambodia and for the purpose of having some values for discussion purposes, the table below provides typical values, which are based on the green building benchmark values in Malaysia. It is not suggested that Cambodia should adopt the benchmarking values listed below. The intention of listing these values is to illustrate that BEI values can be determined if there are sufficient quality data on buildings. From the energy consumption survey data obtained for the building sector in Cambodia in the recent exercise, it was not possible to establish similar BEI benchmarking values.

Table A4.1 Typical Minimum Building Energy Intensity Benchmarking Values for Green Buildings

Building Category	Typical Operational Hours	BEI (minimum values to be considered energy efficient) ($kWh/m^2/yr$)	
Office	52 hours/week	150	
Retail and Mall	84 hours/week	200	350 (incl. high energy intensity outlets)
Hotel	24 hours / 7 days week	200 (3-star & below)	290 (4-star & above)
Hospital	24 hours / 7 days week	200	290 (incl. major clinical services)

Source: Green Building Index (GBI), GBI Tools, Malaysia.

3. Strategies to Achieve Energy Efficiency

The common approach to achieve energy efficiency in buildings is to improve efficiency in lighting and air-conditioning systems. However, for a hot and humid climate like in Cambodia, it is important to firstly adopt a ***passive design strategy*** before considering an ***active design strategy*** in order to attain a holistic approach to energy efficiency in buildings.

3.1 Passive Design Strategy

For a hot and humid climate, all buildings have the primary function of providing an internal environment with thermal comfort, which is desirable for the purpose of occupancy in buildings. Therefore, understanding weather conditions will offer opportunities to minimise solar heat gains, which will lead to saving capital costs due to the reduction in the capacity of air-conditioning equipment and ultimately saving energy costs in the operation of buildings.

The primary objective in a passive design strategy is to minimise solar thermal heat gains and some examples of the key elements to be considered in this strategy are as follows:

a) ***Building orientation*** with the longer building axis facing North–South so that the narrow ends of the building face East–West.
b) ***Building facades*** that provide shading for windows.
c) ***Fenestrations (windows)*** that provide low thermal transmittance and an effective shading coefficient of glazing used in the fenestration system.
d) ***Building and insulating materials*** that provide low thermal transmittance of the opaque walls and roofs.
e) ***Strategic landscaping*** that provides shading from the sun, shielding from heat reflection in the surrounding spaces, and the creation of a cooler microclimate around the building.
f) ***Daylighting*** design that captures the natural daylight to reduce the need for artificial lighting.
g) ***Natural ventilation*** that makes use of the natural forces of wind and buoyancy to deliver sufficient fresh air and air change to ventilate enclosed spaces without the need to rely on air conditioning.
h) ***Measures to prevent air leakage*** as uncontrolled mixing of outside air with air-conditioned space requires more energy to remove moisture and heat gain contributed by air leakage.

3.2 Active Design Strategy

Having minimised solar heat gain and having maximised the capture of daylight and natural ventilation, an active design strategy will play a key role to complete the achievement of energy efficiency in buildings.

The extent of energy efficiency in active systems often depends on budget allocations. If budget permits, sophisticated energy management and lighting control systems may be considered. The minimum approach in an active design strategy is to cover systems that consume higher shares of energy, i.e. air-conditioning systems and lighting.

a) Air-conditioning system

The design of energy-efficient air-conditioning system requires a clear understanding of the building's functional requirements and consideration of many aspects. This may begin with accurate estimates of cooling load requirements, correct sizing, configuration and selection of chillers or air-conditioning equipment, pumps, fans, motors, variable speed drives, etc. Other considerations are appropriate zoning, effective air distribution and type of control, energy loss minimisation in ducting and piping systems, air leakage minimisation, and energy recovery system. Setting the temperature for the air-conditioned space during building occupancy will have a significant influence on the energy consumption of a building. The lower the temperature setting, the higher the energy consumption will be.

b) Lighting

Lighting must provide a suitable level of illuminance for the performance of a range of tasks and provision of a desired appearance. In general, lighting for infrequently used areas should be designed with lower illuminance (e.g. 100 lux[3] for corridors, car parks, etc.); lighting for working interiors should be designed with higher illuminance (e.g. 300–400 lux for general offices, reading and writing areas, 500 lux for proof reading, etc.). In addition, there should be guidelines for the design of lighting load, which should not exceed the maximum allowable power (e.g. 15 watts per square meter (W/m^2) for restaurants, offices, and hotel rooms; 20 W/m^2 for lobbies and concourses; 25 W/m^2 for supermarkets, departmental stores, etc.).[4] It should be noted that these are typical maximum values. For higher energy efficiency, these values should be set lower. It is possible to achieve such design objectives by using high efficiency lamps with high efficacy (e.g. > 80 lumens/watt light fittings).

[3] Department of Standards Malaysia (2014), *MS1525:2014: Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-residential Buildings*. Cyberjaya.
[4] Ibid.

Further savings in lighting can be achieved by employing methods to capture daylight to reduce artificial lighting, provision of lighting zones control for energy saving, use of task lights, and also use of lighting controls with timers as well as motion and photoelectric sensors.

4. Conclusion

It can be concluded from the above that building energy performance can be assessed by means of determining the BEI. Based on the BEI method, national average benchmarking values can be established to evaluate building energy performance and estimate building energy consumption when building floor areas are known.

Effective energy efficiency in buildings can be achieved through a holistic approach by adopting passive and active design strategies. As illustrated in the above, there are various design measures and values to be considered and incorporated in order to achieve energy efficiency in buildings. As a way forward towards energy efficiency in buildings, national energy-efficient building guidelines are recommended to be developed and established for the effective implementation and achievement of energy efficiency in buildings in a consistent way, which can be translated into energy cost savings, CO_2 emissions reductions, and improved building energy performance. Such guidelines for energy efficiency in buildings will require the support of a national building code for enforcement purposes.

Annex 5

Enabling Policy and Institutional Support for Functioning Cambodia Energy Statistics

1. Introduction

The Ministry of Mines and Energy (MME) has been working to improve energy policies towards realising the power sector strategy, energy efficiency and conservation (EE&C) goals, and other policies to ensure that a stable and affordable supply of primary energy – such as coal, oil, gas, and electricity – can be achieved for the sustainable economic development of Cambodia. As Cambodia has been moving up in terms of gross domestic product per capita thanks to stable economic growth, energy consumption is also expected to continue to grow which will increase the pressure to find appropriate and effective energy policies for the present and the future.

The MME also recognised that the current situation of Cambodia's energy data and statistics remains delicate and requires strengthening in terms of procedure, analytical tools, and systematic data collection from concerned agencies and ministries. The ministry also believed that improving the country's energy data and statistics would not only serve Cambodia's policy purposes but also enhance regional energy cooperation with other member states of the Association of Southeast Asian Nations (ASEAN), and other regional and international bodies such as the ASEAN Centre for Energy and International Energy Agency (IEA) that require data for policy and analyses from time to time.

Given the above-mentioned needs, the MME's General Department of Energy (GDE), together with the General Department of Petroleum, approached the Economic Research Institute for ASEAN and East Asia (ERIA) for support and preparation of the Cambodia Energy Statistics, including the construction of energy balance tables. The ministry had also received support from ERIA in past projects such as the preparation of Cambodia Petroleum Products Demand and Outlook Modelling and the Study on Preparation of Accurate Petroleum Statistics in Cambodia. The past projects and this current project on Cambodia Energy Statistics provide a good baseline and preparation towards appropriate energy policy planning.

The MME hopes to see the Cambodia Energy Data and Statistics (CEDS) function and continue even after ERIA's support for the above-mentioned projects comes to an end. Towards that, it will be necessary to clearly elaborate the goal, objective, structure, and policy support of a functioning energy statistics unit.

In this respect, the CEDS unit may play a forward-looking role:

- Having a lead role in developing and maintaining comprehensive national and sectoral statistics for energy production, transformation, and end use
- Producing data for advising policymakers and informing investment decisions
- Sharing data as a vital input to meeting regional and international reporting obligations
- The core function of CEDS may include the collecting, processing, and publishing energy statistics to support policy analysis; conducting statistical and economic analyses of energy services sectors and sustainable energy options; and contributing to the development and promulgation of appropriate sustainability indicators. Timely and reliable statistics are essential to monitor the energy situation.

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

Cambodia's Statistics Law consists of 29 articles and provides a legal framework for all matters relating to collection, processing, compilation, analysis, publication, and dissemination of statistical data pertaining to the whole country.

According to the Statistics Law, Article 17 states the National Institute of Statistics (NIS) of the Ministry of Planning as the official national statistical institution of the Royal Government, with the responsibility for establishing, leading, and coordinating an integrated national statistical system which covers all designated official statistics and statistical units within ministries and government institutions. In addition to the NIS, Article 18 states that each ministry and other government institution shall have a statistics unit responsible for producing statistics. Article 12 states that ministries and government institutions shall collect sectoral data either independently or in cooperation with the NIS by conducting surveys and/or collecting statistical data on administrative records.

Article 2 states that the technical terms used in this law shall have the following meaning:

- **Statistics** are data obtained by collecting, processing, compiling, analysing, publishing, and disseminating results gathered from respondents through statistical collection or from administrative data sources.
- The **National Statistics System** is made up of integrated statistics data at the national and local levels, including all official statistical data and national statistical programmes, statistical organisations and statistical

units within the ministries and government institutions, as well as their statistical staff and other infrastructure.

- **Basic statistics** are official economic, environmental, and socio-demographic national and subnational statistics that are cross-sectoral in nature and that are required by the government for policy and programme formulation and evaluation, as well as for use by the wider Cambodian and international communities.
- **Sectoral statistics** are statistics collected by the ministries or government institutions for their internal needs and reporting purposes.

Article 13 states that the NIS under the Ministry of Planning shall be responsible for making official statistical policies in establishing an integrated National Statistical System, encompassing all designated official statistics and statistical organisational units within the ministries and institutions. The Royal Government shall issue a sub-decree on the operation of the National Statistical System and designated official statistics.

Under the Statistics Law, there are two sub-decrees that define the work for the National Statistical System: Sub-Decree on Organization and Functioning of the National Statistical System and Sub-Decree on Designated Official Statistics.

The Sub-Decree on Designated Official Statistics defines which surveys the statistical units shall be responsible for and what data obligations the NIS and the statistical units have to collect, compile, analyse, publish, and disseminate to the public. The system consists of NIS and 27 line ministries, government institutions, and the National Bank of Cambodia, who are all producers of designated official statistics. In the sub-decree, the defined role of the Ministry of Industry, Mines and Energy for the above task is to have '[e]nergy statistics, annually, mineral resources statistics, annually, clean water statistics annually, and Industrial property registration statistics, annually'.

3. Proposed Actions and Collaboration for Data Collection and Acquisition

Asia-Pacific Economic Cooperation (APEC) economies have experience performing energy data collection, analyses, and dissemination that is worth exploring. Some APEC economies such as Japan, Indonesia, Thailand, and the United States collect their energy data through their energy ministry, whereas others such as Canada, China, and Russia use their national statistical office to collect the energy data.

The Statistics Law of Cambodia and the Sub-Decree on Designated Official Statistics provide a legal framework for the MME to have a fully functioning sectoral statistical unit to collect, compile, analyse, publish, and disseminate data and information such as energy statistics and mineral resources statistics to the public.

However, the current statistical unit within the MME needs support to make it fully functional in the near future. The envisaged coordination, policy, and institutional support include the following:

- **Institutional and Data Collection Coordination**
  - Work with NIS to issue a sub-decree with regard to regular energy data consumption surveys, household/residential surveys, transportation surveys, industrial surveys, and commercial/building surveys.
  - Collaborate with NIS as it has a well-established structure of administrative data collection from line agencies. The first step is to set up an official meeting with NIS to see how energy data statistics can be collected from line agencies. It is very important to define clear and simple energy data as well as the types of energy data to be collected. The next step is to have a well-designed energy data collection format for the discussion with NIS and relevant agencies.
  - The GDP has designated staff for the petroleum statistics. Thus, it may explore the Statistics Law to get the petroleum imports companies to comply with the data acquisition.

- **Technical Capacity Building and Budgets**
  - There are capacity constraints to process, analyse, and publish the data after these have been collected. Therefore, capacity building is necessary to have trained staff to handle the energy data and statistics.
  - The GDP and GDE may continue to request ERIA's support to further strengthen the design of the petroleum product specifications and the legal framework, regulation, policy, and procedures further down the line.
  - The GDE may continue to seek ERIA's technical advice and lead a regular technical and high-level working group on the energy statistics.
  - Have clear financial support and budget for the Energy Statistical Unit for its daily core functions (including surveys, data collection and coordination, and capacity building).
  - Maintain staff and update knowledge and analytical skills. The Energy Statistical Unit may aim for a series of publications (monthly, quarterly, yearly statistics). Furthermore, it may aim to produce a Cambodia Energy Outlook and other energy-specific papers to support the policy formulation.

- **Energy Data Centre**
  - The GDE may act as the energy data centre by linking to all concerned stakeholders for data sharing as well as data collection and updating.
  - Both hardware and software (computer, software, staff) have to be equipped with GDE as the energy data centre.

Annex 6

Definition of Cambodia's Energy Products and Flows

1. Energy Products

Energy Products	Definition
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.
3. Crude Oil and Natural Gas Liquids	Comprise crude oil, natural gas liquids (NGLs), refinery feedstock, additives, and 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).
4. Petroleum Products	Comprise motor gasoline, aviation gasoline, naphtha, jet fuel, kerosene, gas/diesel oil, fuel oil, liquefied petroleum gas (LPG), refinery gas, ethane, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke, and other petroleum products.
4.1 Motor Gasoline	A mixture of some aromatics (e.g. benzene and toluene) and aliphatic hydrocarbons in the C5–C12 range. The distillation range is 25°C–220°C. Motor gasoline may also contain biogasoline products.
4.2 Naphtha	Refers to light or medium oils distilling between 30°C and 210°C which do not meet the specification for motor gasoline. The main uses for naphtha are as feedstock for high octane gasoline and the manufacture of olefins in the petrochemical industry.
4.3 Jet Fuel	A blend of kerosene suited to flight conditions with particular specifications, such as freezing point. The specifications are set down by a small number of national standards committees, most notably ASTM (United States), MOD (United Kingdom), and GOST (Russia).
4.4 Kerosene	Used for heating, cooking, lighting, solvents, and internal combustion engines. Other names of this product are burning oil, vaporising oil, power kerosene, and illuminating oil.
4.5 Gas/Diesel Oil	Diesel oils are middle distillates, predominantly of carbon number range C11–C25 and with a distillation range of 160°C–420°C. This product comprises road diesel and heating or other gas oil.
4.6 Fuel Oil	Comprises residual fuel oil and heavy fuel oil which are usually a blended product based on the residues from various refinery, distillation, and cracking processes. Residual fuel oil A-5 has a distillation range of 350°C–650°C and a kinematic viscosity in the range 6–55 centistokes (cSt) at 100°C with a flash point always above 60°C and a specific gravity above 0.95.
4.7 Liquefied Petroleum Gas (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.
4.10 Other Petroleum Products	Comprise lubricant, bitumen, white spirits and special boiling points industry spirits, paraffin wax, petroleum coke, and other products.

Energy Products	Definition
6. Hydro	The energy content of the electricity produced in hydropower plants. Hydro output excludes output from pumped storage plants.
9. Other (Combustible Renewables and Waste)	Comprise 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.
10. Electricity	Showing final consumption and trade in electricity, which is accounted at the same heat value as electricity in final consumption (i.e. 1 MWh = 0. 086 toe).
12. Total	Defined as 1 + 3 + 4 + 6 + 9 + 10

2. Energy Flow

Energy Flows	Definition
1. Indigenous Production	The production of primary energy, i.e. hard coal, lignite/brown coal, peat, crude oil, NGL, natural gas, combustible renewables and waste, nuclear, hydro, geothermal, solar, and 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).
2. Imports **and** **3. Exports**	Comprise amounts having crossed the national territorial boundaries of the country, whether or not customs clearance has taken place. • For coal: Imports and exports comprise the amount of fuels obtained from or supplied to other countries, whether or not there is an economic or customs union between the relevant countries. Coal in transit should not be included. • For oil and gas: 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, NGL, and natural gas are reported as coming from the country of origin; refinery feedstock and oil products are reported as coming from the country of last consignment. Re-exports of oil imported for processing within bonded areas are shown as exports of product from the processing country to the final destination. • For electricity: Amounts are considered 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 import and export.
4. International Marine Bunkers	The quantities delivered to ships of all flags that are engaged in international navigation, which 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.
5. International Aviation Bunkers	Including 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.
6. Stock Changes	Reflecting 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.
7. Total Primary Energy Supply (TPES)	Equals Indigenous Production + Imports − Exports − International Marine Bunkers − International Aviation Bunkers ± Stock Changes
8. Transfers	Include interproduct transfers, products transferred, and recycled products (e.g. used lubricants which are reprocessed).
9. Total Transformation Sector	Transformation is the process where part or all of the energy content of a product entering a process moves 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). The total is the sum of transformation input (negative number) and

Energy Flows	Definition
	transformation output (positive number) of various energy industries.
9.1 Main Activity Producers	Generating electricity and/or heat for sale to third parties is their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid. Columns 1–9 show the use of primary and secondary fuels for the production of electricity and/or heat as negative entries. Gross electricity and/or heat produced (including power stations' own consumption) appears as a positive quantity in the electricity and heat column. Transformation losses appear in the total column as a negative number.
9.8 Charcoal Processing	Recording the transformation of fuelwood or other vegetal matter to produce charcoal. The quantity of fuelwood or other vegetal matter input is recorded as a negative number, whereas the output of charcoal is recorded as a positive number.
10. Loss and Own Use	Losses include distribution and transmission losses in gas distribution, electricity transmission, and coal transport. Own use contains the primary and secondary energy consumed by transformation industries for heating, pumping, traction, and lighting purposes (ISIC4 Divisions 10-12, 23, and 40). These quantities are shown as negative figures. Included here 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.
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.
12. Total Final Energy Consumption (TFC)	The sum of consumption by the different end-use sectors. Backflows from the petrochemical industry are not included in final consumption.
13. Industry Sector	Specified in the following subsectors (energy used for transport by industry is not included here but is reported under transport): • Iron and steel industry (ISIC Group 271 and Class 2731); • Chemical (incl. petrochemical) industry (ISIC Division 24) excluding petrochemical feedstock; • Non-ferrous metals basic industries (ISIC Group 272 and Class 2732); • Non-metallic minerals such as glass, ceramic, cement, etc. (ISIC Division 26); • Transport equipment (ISIC Divisions 34 and 35); • Machinery comprising fabricated metal products, machinery and equipment other than transport equipment (ISIC Divisions 28 to 32); • Mining (excluding fuels) and quarrying (ISIC Divisions 13 and 14); • Food, beverages, and tobacco (ISIC Divisions 15 and 16); • Paper, pulp, and printing (ISIC Divisions 21 and 22); • Wood and wood products (other than pulp and paper) (ISIC Division 20); • Construction (ISIC Division 45); • Textile and leather (ISIC Divisions 17–19); • Other industry (any manufacturing industry not included above) (ISIC Divisions 25, 33, 36, and 37). Note: The other industry row is also used when there is difficulty breaking down industrial subsectors. This number should be treated with caution.
14. Transport Sector	Includes all fuels used for transport (ISIC Divisions 60–62) 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

Energy Flows	Definition
	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 on the basis of 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 not specified) are excluded from the transport sector.
14.1 Domestic Air Transport	Quantities of aviation fuels delivered to aircraft for domestic aviation (commercial, private, agricultural, etc.). Includes fuel used for purposes other than flying, e.g. bench testing of engines. The domestic/international split should be determined on the basis of departure and landing locations and not by the nationality of the airline. Note that this may include journeys of considerable length between two airports in an economy (e.g. San Francisco to Honolulu). Excludes fuels used by airlines for their road vehicles (see not elsewhere specified – transport sector) and military use of aviation fuels (see not elsewhere specified – other sectors).
14.2 Road	Oil for use in road vehicles. Includes fuel used by agricultural vehicles on highways and lubricants for use in road vehicles. Excludes 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 gas oil used in engines at construction sites (see construction – industry sector).
15. Other sector	Covers residential, commercial, and public services (ISIC Divisions 41, 50–52, 55, 63–67, 70–75, 80, 85, 90–93, 95, and 99); agriculture (ISIC Divisions 01 and 02); fishing (ISIC Division 05); and others. Others include military fuel 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 the military of another country.
15.1 Residential and Commercial	Defined as 15.1.1 + 15.1.2
15.1.1 Commercial and Public Services	ISIC Divisions and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84 (excl. Class 8422), 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96, and 99. Oil consumed by businesses and offices in the public and private sectors. Note that oil use at railway stations, bus stations, shipping piers, and airports should be reported in this category and not shown in the transport sector.
15.1.2 Residential	Fuels consumed by all households including households with employed persons (ISIC and NACE Divisions 97 and 98).
15.2 Agriculture	Oil consumption by users classified as agriculture, hunting, and forestry. ISIC Divisions 01 and 02 (NACE Divisions 01 and 02).
15.3 Others	Activities not included elsewhere, please specify. This category includes military use.
16. Non-energy Use	Covers those fuels that are used as raw materials in the different sectors and 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.

Annex 7

Cambodia's Energy Demand Outlook

Cambodia's energy needs have been forecasted until 2035. The forecast was made as part of the Study on Petroleum Demand Projection Modelling in Cambodia. The study was conducted in 2015 by the Economic Research Institute for ASEAN and East Asia (ERIA) in collaboration with the Institute of Energy Economics, Japan (IEEJ) and the General Department of Petroleum, Ministry of Mines and Energy (MME), Cambodia. The following are the major results of the projection:

Table A7.1 Final Energy Consumption by Sector

	Historical			Projection				Average Annual Growth Rates, %			
	1995	2005	2012	2015	2025	2030	2035	1995-2012	2012-2025	2025-2035	2012-2035
Industry	438	693	884	895	1,138	1,474	2,140	4.2	2.0	6.5	3.9
Transport	382	441	1,223	1,489	2,457	3,135	3,976	7.1	5.5	4.9	5.3
Other Sector	1,716	1,653	2,904	3,073	3,819	4,312	4,889	3.1	2.1	2.5	2.3
Commercial	3	20	72	91	192	262	343	21.2	7.8	6.0	7.0
Residential	1,712	1,629	2,822	2,971	3,601	4,014	4,498	3.0	1.9	2.2	2.0
Others	1	4	9	12	25	36	48	14.5	7.9	6.5	7.3
Non-energy	8	10	14	17	25	30	36	3.7	4.2	3.8	4.0
Total	**2,543**	**2,798**	**5,025**	**5,473**	**7,438**	**8,951**	**11,041**	**4.1**	**3.1**	**4.0**	**3.5**

Figure A7.1 Evolution of Final Energy Consumption by Sector

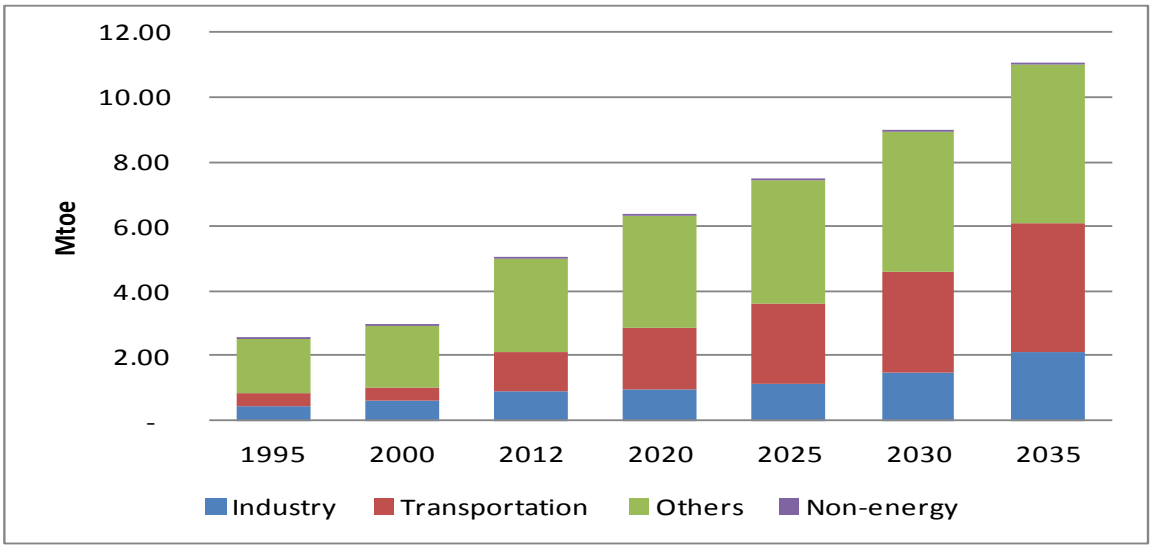


Table A7.2 Final Energy Consumption by Fuel

	Historical			Projection				Average Annual Growth Rates, %			
	1995	2005	2012	2015	2025	2030	2035	1995-2012	2012-2025	2025-2035	2012-2035
Biomass	1,854	1,834	2,725	2,763	2,868	2,913	2,956	2.3	0.4	0.3	0.4
Charcoal	239	335	598	616	667	690	711	5.6	0.8	0.6	0.8
Gasoline	138	132	393	499	724	854	1,002	6.4	4.8	3.3	4.1
Diesel	247	317	843	1,014	1,747	2,284	2,960	7.5	5.8	5.4	5.6
Fuel Oil	4	26	70	45	63	75	90	18.3	(0.8)	3.5	1.1
LPG	2	35	100	166	388	520	655	24.6	11.0	5.4	8.5
Jet Kerosene	12	21	33	44	73	80	87	6.0	6.2	1.9	4.3
Kerosene	39	31	6	6	3	1	-	-10.1	-6.1	-	-
Lubricants	8	10	14	17	25	30	36	3.7	4.2	3.8	4.0
Electricity	10	74	260	345	946	1,576	2,622	20.9	10.4	10.7	10.6
Total	**2,554**	**2,815**	**5,044**	**5,512**	**7,503**	**9,023**	**11,118**	**4.1**	**3.1**	**4.0**	**3.5**
Oil	*451*	*572*	*1,460*	*1,789*	*3,022*	*3,845*	*4,829*	*7.2*	*5.8*	*4.8*	*5.3*

Figure A7.2 Evolution of Final Energy Consumption by Fuel

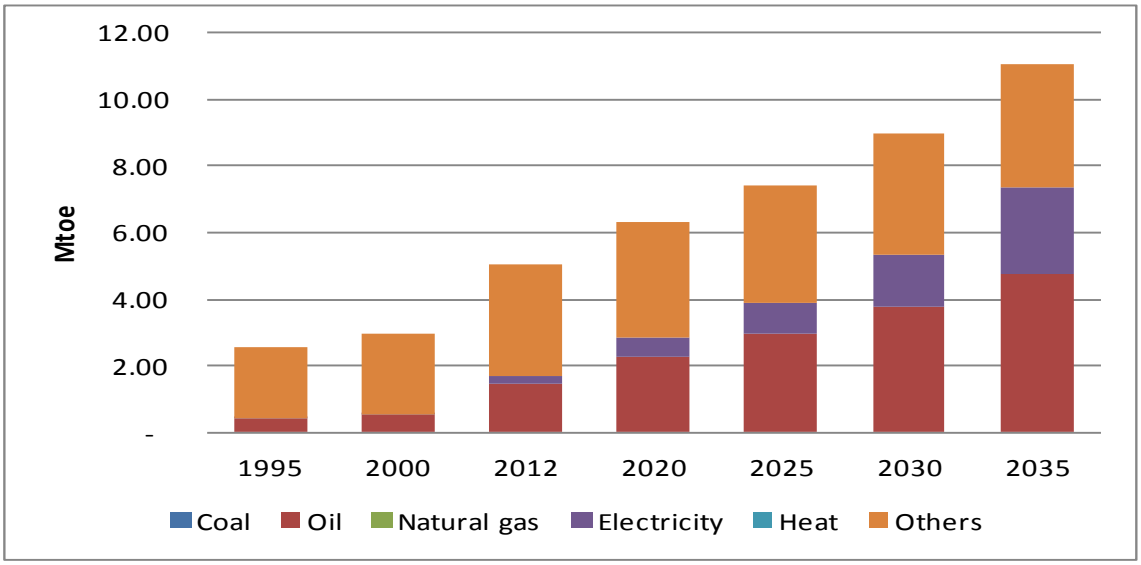


Table A7.3 Primary Energy Supply

	Historical			Projection				Compounded Annual Growth Rates, %			
	1995	2005	2012	2015	2025	2030	2035	1995-2012	2012-2025	2025-2035	2012-2035
Coal	0.0	0.0	8.1	564.2	1,624.9	1,568.8	1,555.7	-	50.4	-0.2	25.7
Oil	511.3	761.7	1,550.0	1,759.5	3,274.5	4,073.4	5,051.8	6.7	5.9	2.3	5.3
Crude Oil	0.0	0.0	0.0	0.0	5,305.1	5,305.1	5,305.1	-	-	-	-
Oil Products	511.3	761.7	1,550.0	1,759.5	-2,030.6	-1,231.8	-253.4	6.7	-202.1	-10.4	-192.4
Hydropower	0.0	3.8	2.2	219.6	542.4	1,261.5	2,421.4	-	52.5	8.2	35.5
Others	2,325.4	2,494.5	3,735.6	3,941.5	4,146.3	4,234.1	4,319.1	2.8	0.8	0.2	0.6
Renewables	0.0	0.1	0.3	0.3	0.3	0.3	0.3	-	-0.1	0.0	0.0
Biomass	2,325.4	2,491.9	3,618.6	3,963.8	4,168.6	4,256.5	4,341.4	2.6	1.1	0.2	0.8
Electricity	0.0	2.5	116.7	-22.6	-22.6	-22.6	-22.6	-	-188.1	0.0	-193.1
Total	2,836.7	3,259.9	5,295.9	6,484.8	9,588.1	11,137.8	13,347.9	3.7	4.7	1.8	4.1

Figure A7.3 Evolution of Primary Energy Supply

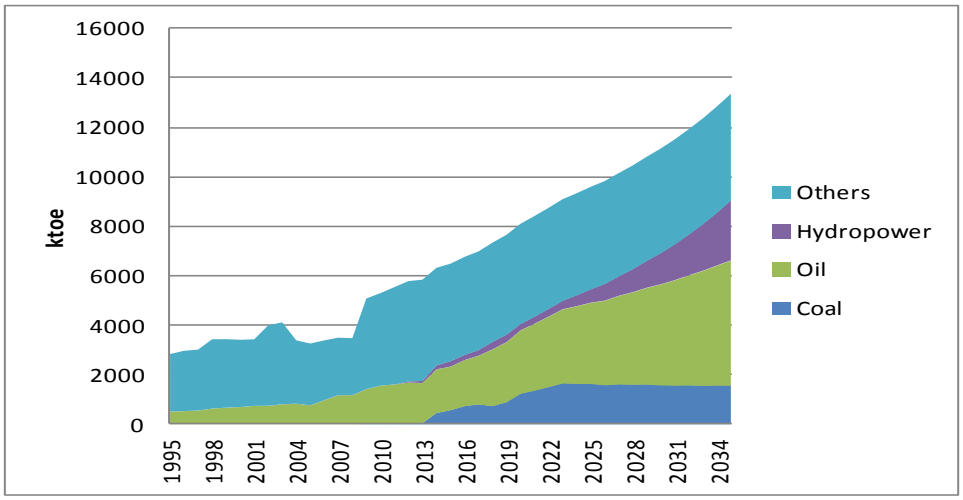


Table A7.4 Energy Balance Table of Cambodia in 2035

Energy Balance for Cambodia Scenario: BAU, Year: 2035, Units: Thousand Tonnes of Oil Equivalent	Solid Fuels	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	2,421.4	0.3	4,341.4	-	-	6,763.1
Imports	1,555.7	5,305.1	-	-	-	-	1,227.6	8,088.5
Exports	-	-	-	-	-	(22.6)	(1,481.0)	(1,503.6)
Total Primary Supply	1,555.7	5,305.1	2,421.4	0.3	4,341.4	(22.6)	(253.4)	13,347.9
Charcoal Production	-	-	-	-	(667.2)	-	-	(667.2)
Oil Refining	-	(5,305.1)	-	-	-	-	5,004.8	(300.4)
Electricity Generation	(1,555.7)	-	(2,421.4)	(0.3)	(7.4)	2,918.5	-	(1,066.3)
Transmission and Distribution	-	-	-	-	-	(273.4)	-	(273.4)
Total Transformation	(1,555.7)	(5,305.1)	(2,421.4)	(0.3)	(674.6)	2,645.1	5,004.8	(2,307.2)
Industry	-	-	-	-	570.6	1,373.5	196.1	2,140.2
Transport	-	-	-	-	-	-	3,976.1	3,976.1
Other Sectors	-	-	-	-	3,096.2	1,249.0	543.4	4,888.6
Non Energy	-	-	-	-	-	-	35.8	35.8
Total Demand	-	-	-	-	3,666.8	2,622.5	4,751.4	11,040.7