ERIA Research Project Report 2020, No. 17

Mongolia's Energy Efficiency Indicators 2019

Study conducted by

Mongolian Energy Economics Institute

Supported by

Economic Research Institute for ASEAN and East Asia

Mongolia's Energy Efficiency Indicators 2019

Economic Research Institute for ASEAN and East Asia (ERIA)

Sentral Senayan II 6th Floor

Jalan Asia Afrika no.8, Gelora Bung Karno

Senayan, Jakarta Pusat 10270

Indonesia

ERIA Research Project FY2020 No. 17

Published in January 2021

Preface

Mongolia has achieved remarkably high economic growth. Its average gross domestic product (GDP) growth rate was 7.2% during the period 2008–2018, the second-fastest amongst East Asian countries over that period. In 2018, Mongolia's real GDP per capita amounted to US$4,017. This strong economic growth from 2008–2018 was accompanied by an increase in energy consumption in all sectors. With its promising long-term development prospects, the rise of the country's energy consumption should continue into the future.

Mongolia has set its Nationally Determined Contribution (NDC) to reduce its total national greenhouse gas emissions – excluding land use, land use change, and forestry – by 14% by 2030, compared with the projected emissions under the business-as-usual scenario. Reaching this NDC target would not be possible without improvements in energy efficiency in all sectors, especially in residential, commercial, industrial, transport, and power generation.

The Economic Research Institute for ASEAN and East Asia (ERIA) was honoured by the request to conduct this study on Mongolia's energy efficiency indicators 2019, which establishes a solid starting point for further policy measures to improve energy efficiency in Mongolia. The study has compiled and collected data on energy consumption and sectoral activities, and defined and estimated energy indicators for the first time. The report shows that energy efficiency should be a high priority issue on the political agenda.

Mongolia has abundant natural and mineral resources. To efficiently meet most of its daily energy needs these resources need to be properly developed and managed. Its energy policy aims to ensure access of its citizens to modern energy services developed on the basis of its important and high potential renewable energy sources. At the same time, it is developing infrastructures to optimise the use of its mineral deposits as energy feedstock. Mongolia also recognises electricity as the main source driving economic development and addresses the need to generate and distribute more power in terms of greater volume, density, and reliability.

The increase of energy demand puts pressure on the government to take energy conservation seriously. Energy efficiency figures prominently in Mongolia's National Green Development Plan approved by Parliament in June 2014. For example, the government aims to reduce greenhouse gas emissions in the energy sector through an increase in energy efficiency of 20% by 2030, whilst seeking to reduce building heat losses by 20% and 40% by 2020 and 2030, respectively.

In the 'State Policy on Energy 2015–2030', energy efficiency was one of the three major policy principles approved by the Government of Mongolia. On 26 November 2015, the Parliament ratified the Energy Conservation Law, which requires a subset of Mongolia's electricity and heat consumers (referred to as 'designated entities') to implement activities aimed at improving energy efficiency.

Energy efficiency indicators are widely considered an important tool for supporting energy efficiency and conservation policymaking, to design effective policies, and to monitor progress towards policy objectives.

On behalf of the Ministry of Energy of Mongolia, I would like to thank ERIA for the technical and financial support for this study on Mongolia's Energy Efficiency Indicators 2019 Project.

We will continue to work together to build the energy data to support energy policies and planning in Mongolia.

H.E. N. Tavinbekh

Minister of Energy Mongolia

Prof. Hidetoshi Nishimura

President

Economic Research Institute for ASEAN and East Asia

Acknowledgements

We would like to acknowledge with much appreciation the valuable contributions of **Shigeru Kimura,** special advisor on energy affairs; **Leong Siew Meng,** energy efficiency expert for buildings; **Cecilya Malik,** energy efficiency expert for industry; **Alloysius Joko Purwanto,** energy efficiency expert for transport; and **Dewi Anggraini**, **Wuri Wulandari** and **Risa Annisa,** assistants from the Economic Research Institute for ASEAN and East Asia (ERIA)**.**

We would also like to thank the head of the energy conservation department, Ts. Atarjargal from the Energy Regulatory Commission of Mongolia; researcher Sanj Sainzorig of the Mongolian Energy Economics Institute; the Ministry of Energy of Mongolia; the Energy Regulatory Commission of Mongolia; the National Statistical Office; Western Electric Power System; Dornod Electric Power System; Altai-Uliastai Electric Power System; and the Mongolian Association of Certified Consulting Engineers for their contributions.

Makhbal Tumenjargal

Director, Mongolian Energy Economics Institute (MEEI)

Project Members

Mongolian Energy Economics Institute

- Tumenjargal M., Director of Mongolian Energy Economics Institute
- Enkhtuvshin R., Scientific secretary, Mongolian Energy Economics Institute
- Erdenebat D., Senior of sector, Scientific research, policy and planning department
- Tumurbaatar Sh., Research officer, Mongolian Energy Economics Institute
- Chinsetgel B., Research officer, Mongolian Energy Economics Institute
- Myagmarbaatar D., Research officer, Mongolian Energy Economics Institute
- Sainzorig S., Research officer, Mongolian Energy Economics Institute

Ministry of Energy

- Myagmarsuren M., Adviser to the Minister of Ministry of Energy
- Enkhtaivan G., Head of policy and planning department, Ministry of Energy
- Enkhtuvshin G., Senior specialist at policy and planning department, Ministry of Energy

Energy Regulatory Commission

- Atarjargal Ts., Head of energy conservation department, Energy regulatory commission
- Khiimorisaikhan P., Energy conservation specialist, Energy regulatory commission

Mongolian Association of Specialized Consulting Engineers

- Ganchimeg J., Director of training research institute, Mongolian Association of specialized Consulting Engineers

ERIA Working Team

- Shigeru Kimura, Special Adviser to the President on Energy Affairs, Economic Research Institute for ASEAN and East Asia (ERIA)
- Dr Alloysius Joko Purwanto, Energy Economist, ERIA
- Ir. Leong Siew Meng, Energy Efficiency and Conservation Expert, Malaysia
- Cecilya Malik, ASEAN Energy Expert, Indonesia

Contents

List of Tables

Disclaimer: Unless otherwise specified, data from tables are from the results of the survey

List of Figures

Disclaimer: Unless otherwise specified, data from figures are from the results of the survey

List of Abbreviations and Acronyms

AUEPS	Altai-Uliastai Electric Power System
BEI	building energy intensity
CHP	combined heat and power
EEC	energy efficiency and conservation
EEI	energy efficiency indicator
EPS	electric power system
ERC	Energy Regulatory Commission
ERIA	Economic Research Institute for ASEAN and East Asia
ETE	electricity and thermal energy
ETEWS	electricity, thermal energy, and water supply
GCal	gigacalorie
GDP	gross domestic product
MEEI	Mongolian Energy Economics Institute
PPS	photovoltaic power station
₮	'Tugrik': Mongolian currency
toe	tonne of oil equivalent
TPP	thermal power plant

Executive Summary

Mongolia achieved high and stable economic growth from 2008–2018. Energy consumption, especially of conventional energy – such as coal, oil, and electricity – increased significantly as a result. The Government of Mongolia recognises the importance of an energy efficiency and conservation (EEC) policy for the future. As it does not have benchmarks for the current energy efficiency level in the country, the Mongolian Energy Economics Institute (MEEI), a member of the Energy Research Institute Network (ERIN) of the East Asia Summit, requested the support of the Economic Research Institute for ASEAN and East Asia (ERIA) to produce energy efficiency indicators (EEIs). These are to serve as benchmarks in Mongolia's final energy consumption sectors comprising industry (production of industrial products), transport (transport of passengers or freight from point A to point B), commercial buildings and the residential sector.

Phase 1 involved ERIA inviting several MEEI staff members to the ERIA office for capacity building training on basic EEI concepts in June 2018. Lecturers were experts from ERIA, Indonesia, Malaysia, and Thailand. ERIA emphasised that when the MEEI produces EEIs – not energy intensity – a detailed energy consumption survey of each final energy sector is needed. ERIA committed financial and technical assistance to the MEEI in the understanding that the latter will produce the country's EEIs during phase 2.

Phase 2 started in July 2019. The ERIA team, comprising four energy efficiency experts on the residential and commercial, transport, and industry sectors and on EEIs, visited the MEEI office in Ulaanbaatar, Mongolia for detailed discussions with MEEI staff on sampling methodology, questionnaires, expected EEI for each final sector, etc. Following this meeting, MEEI staff conducted a survey on actual energy consumption with remote technical support from the ERIA team. This report mainly described the survey results. Despite the lack of experience of MEEI staff to conduct energy consumption surveys (this being the first time for the institute) and limited sample numbers, the MEEI obtained several significant results from the survey.

The residential sector has two types of energy use: (i) space heating and cooking, and (ii) electricity such as for lighting, TV, and refrigeration. For space heating and cooking, coal and biomass are the main fuel in rural and herder areas. Households in urban areas use less coal and biomass compared with rural and herder areas. Stand-alone houses consume most electricity followed by apartments and *gers* (Mongolia's traditional dwellings). End-use of electricity in urban areas depends on the type of house. Many stand-alone houses in urban areas consume electricity for space heating, followed by cooking, refrigerator, and water heating. Apartments in urban areas consume electricity for cooking, refrigeration, and water heating. *Gers* in urban areas show an end-use pattern of electricity consumption similar to that of apartments. Urban households are shifting from coal and biomass to electricity, including for space heating. On the other hand, rural and herder areas still depend on traditional fuels, such as coal and biomass. Looking at the EEI in the residential sector, defined as energy consumption per floor area (kWh/m^2/year), stand-alone houses are most efficient (201.4 kWh/m^2/year), followed by apartments (278.7), and *gers* (313) in urban areas. Other areas show the same trend. This indicator consists of electricity and heat from coal and biomass, and heat demand is much higher than that for electricity. Heat demand is around two to four times higher than that for electricity, and it depends on the type of house. If we compare the indicators for urban and rural areas, those for rural areas tend to be higher.

This survey covers only the road transport sector, i.e. cars, buses, taxis, and trucks. In terms of fuel consumption, taxis are most efficient at 8.0 litre/100 km, followed by cars (10.3) and buses (35.4). Regarding travel distance, buses are highest at 241 km/day, followed by taxis (234), and cars (49.4). Comparing efficiency of rail and road using tonne of oil equivalent (toe)/passenger and tonne km, that of rail is much higher than road and is consistent globally.

The industry sector uses both coal and electricity for its energy needs, but coal is dominant. The sector is made up mostly of the manufacturing and the mining sectors. The energy indicators of the manufacturing sector are larger than those of the mining sector, 275.31 toe/million US$ and 11.02 toe/million US$, respectively. The manufacturing sector mainly consists of food, construction materials such as cement, basic metals, and others. Metal and cement consume a lot of coal for heating – their energy indicators are 172.9 toe/million U$ and 98.03 toe/million U$, respectively, which is much higher than for food and others.

The commercial sector consists of five building types – hotels, offices, restaurant, shopping malls, and hospitals. From the survey results the MEEI obtained the following energy indicators: 865 kWh/m2/year for hotels, 495 for offices, 808 for restaurants, 591 for shopping malls, and 682 for hospitals. The order of the energy indicators by building type is appropriate but the absolute values of energy indicators are much higher than for ASEAN countries. Despite the difference in climate and environment between Mongolia and the ASEAN region – heating energy demand is dominant in Mongolia but cooling demand is in the ASEAN region – the values of energy indicators by building type are too high. Appropriate and implementable energy efficiency policies and action plans will be needed, therefore, to mitigate energy consumption in the commercial sector, especially electricity consumption.

The detailed energy consumption survey for Mongolia, implemented by the MEEI with the support of ERIA, has been successful as several meaningful EEIs were extracted from it. But the MEEI needs to improve its capacities to be able to better analyse the sample data generated through the survey. Such analysis would include an assessment of possible bias that may be present in the sampled data (overestimation or underestimation), finding outliers to produce more appropriate EEIs, gaining a correct understanding of actual energy usage in the final sectors, and gaining an exact understanding of the meaning of EEIs. The MEEI's capacities will be upgraded through repeatedly undertaking energy consumption surveys and through training to be provided by the countries of the Organisation for Economic Co-operation and Development, such as Japan, and international organisations such as the Asian Development Bank and ERIA.

Finally, ERIA suggests that the MEEI repeats this survey every 3 or 5 years and analyses the historical trend of the EEIs for each final sector. Regularly repeating the survey is essential for promoting appropriate energy efficiency and conservation polices to mitigate energy consumption in Mongolia – especially of coal, oil, and electricity.

Chapter 1
Introduction

1. Mongolia's Current Socioeconomic Situation

By administrative division, Mongolia is divided into 21 aimags (or provinces), 330 *soums*, 1,618 baghs (aimags consist of *soums*, *soums* consist of baghs), and a capital city which has 9 districts and 152 *khoroos* (districts consist of *khoroos*).

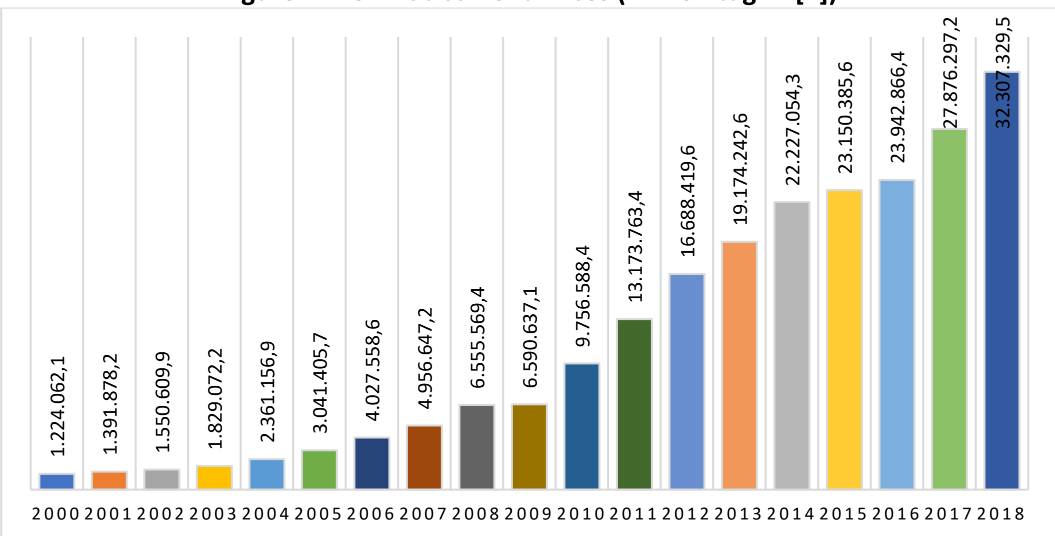
Mongolia has an area of 15,641,000 square kilometres. In 2018, the population density was 2.1 persons per square kilometre (km^2) nationwide, whilst it was 317.3 persons/km^2 in Ulaanbaatar city.

The total population of Mongolia in 2018 was 3.2 million**,** increased by 0.8 million or 34.8**%** from 2000. Average annual population growth was 1.9% for the period 2000–2018.

In 2018, there were 8.945 million households in Mongolia, which was an increase by 89,000 households or 1% compared to the previous year; 43.3% of these households lived in Ulaanbaatar city. Each household has an average of 3.6 persons.

Mongolia's gross domestic product (GDP) reached 32.3 trillion tugrik (₮) in 2018, which constituted an increase of 15.9% from the previous year (Figure 1-1). The industry sector's share in GDP was 41.9%; agriculture, 10.7%; and service sector's share, 47.4%.

Figure 1-1 GDP at Current Prices (million tugrik [₮])



Source: National statistical office of Mongolia (2018b).

Mongolia's mining and quarrying sub-sector's share in total exports is about 80%. In 2018, 51.4 million tonnes of coal were extracted, of which 36.3 million tonnes were exported; 20.7 tonnes of gold were extracted, of which 3.4 tonnes were exported; and 1.3 million tonnes of copper ore were extracted, and 1.4 million tonnes were exported. Compared to 2000, the quantity of extracted coal had risen twice; copper ore, by 2.5 times; gold, by 3.4; and oil, by 2.9 times in 2018.

The share of sub-sectors in the service sector by contribution to GDP was: trade, 34.5%; real estate activities, 11.8%; finance and insurance, 11%; transport, 9.8%; public administration, 7.9%; education, 7.7%; information and communications, 4.6%; health, 3.4%; other services, 9.4%.

In 2018, 69.9 million tonnes of goods were transported by all types of transport, which was an increase of 15.9 tonnes or 29.5% from 2017. Goods transported by road increased by 12.9 tonnes or 41.4% compared to the previous year. This increase was largely due to the increase in mining products. Road transport accounted for 63.1% of all goods transported, whilst rail transport accounted for 36.9%. In 2018, 200.4 million people were transported – 98.2% by road, 1.3% by rail, and 0.5% by air.

In 2018, the revenues of Mongolia's transport sector were ₮1,686.4 billion, of which 37.2% were from road transport; 36.5%, from rail transport; and 26.2%, from air transport.

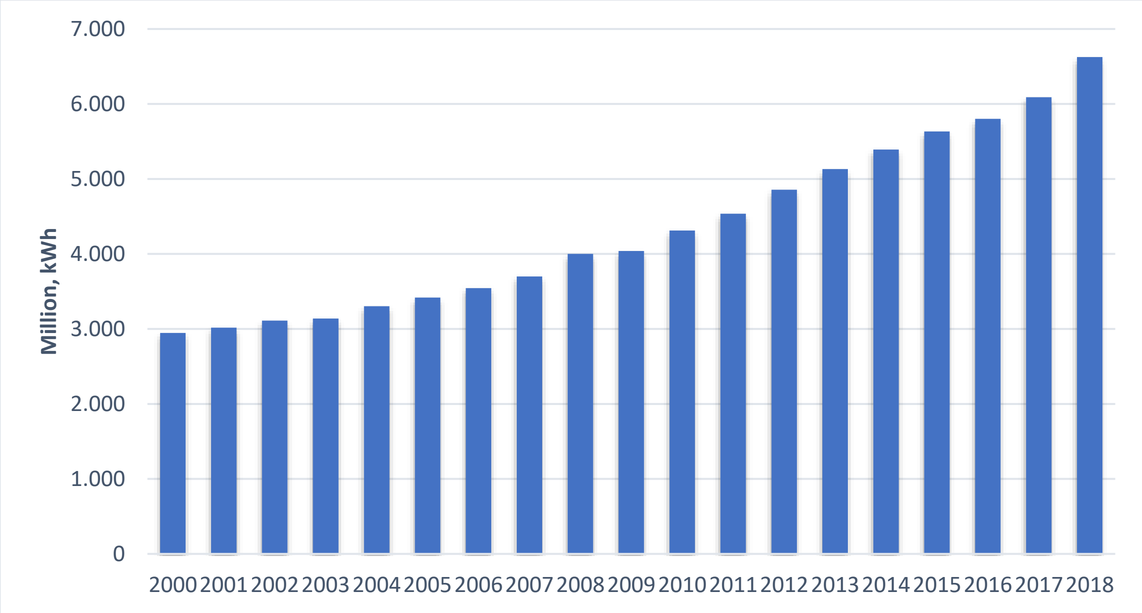
2. Energy Consumption Trend

Out of 330 *soums* in Mongolia, 329 soums are connected to the electrical grid, and 1 *soum* is being supplied by electric power from a combined renewable energy and diesel source. Also, 81.2% of herder families use electric power from their portable solar PV systems. Currently, 97% of all consumers have uninterrupted power source.

In recent years, the share of renewable energy in Mongolia's energy mix has increased (in 2019 total installed capacity of renewable energy sources was 238 MW), which is in line with the world's energy development trend.

Mongolia's total installed capacity (not including diesel generators) is 1,328.8 MW. In 2018, electric power generation was 6,624.8 million kWh, which was an increase of 8.8% from 2017. Thermal energy production was 94.251 million gigacalorie (GCal), which was an increase of 4.485 million GCal or 5% from the previous year. Domestic power generation accounted for 80% of total consumption, whilst 20% or 1,683.6 million kWh were imported from the neighbouring countries.

Figure 1-2. Historical Trend of Power Generation in Mongolia, by Year



Source: Energy regulatory commission (2018).

Table 1-1 shows electric power generated and imported in Mongolia in the 2014 – 2018 period. It illustrates that the total generation of electric power had increased every year as the country developed and the economy and population grew.

Table 1-1. Quantity of Mongolia's Power Generation and Imports

Indicators	Unit	2014	2015	2016	2017	2018
Total consumption	million kWh	6,788.9	6,935.5	7,221.4	7,611.6	8,308.3
From domestic generation	million kWh	5,392	5,541.7	5,802.4	6,089.1	6,624.8
From imported EP	million kWh	1,396.9	1,393.8	1,419.1	1,522.5	1,683.6
Share of imports	percent	25.91	20.10	19.65	20	20.26

Source: Energy Regulatory Commission (2018).

3. About Mongolia's Energy Conservation and Efficiency Policy

Energy consumption of Mongolia significantly grew in 2000–2018. To mitigate the consumption, Mongolia must start and implement an energy efficiency and conservation (EEC) policy. In this regard, the Mongolian Energy Economics Institute (MEEI), with the support of ERIA, started producing the EEIs by sector as benchmarks.

Mongolia's energy law was first approved in 2001 and amended in 2015.

Mongolia's State Great Khural (Parliament) approved a renewable energy law in 2007, which was amended in 2015 and 2019. This law provided Mongolia with a legal framework to create a competitive market of renewable energy.

The State Great Khural, in 2015, adopted Resolution Number 63, 'The State Policy on Energy Sector for 2015–-2030. In 2018, it also approved the 'Medium-term Programme for Implementing the State Policy on the Energy Sector' to ensure the realisation of the policy.

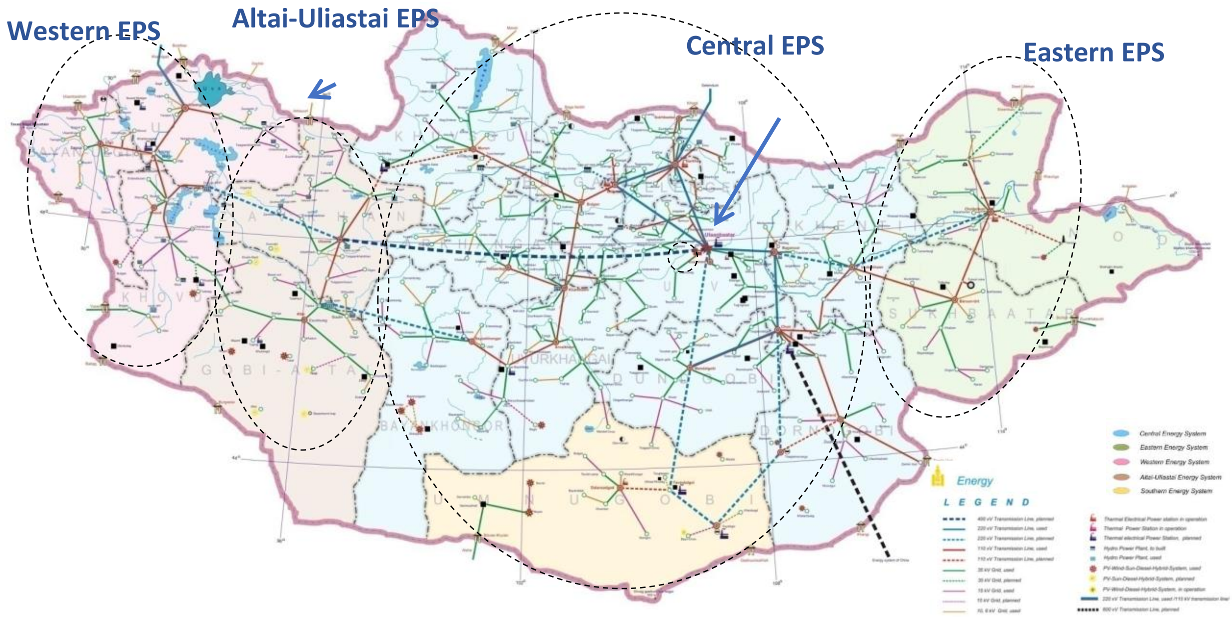
The energy conservation law of 2015, intended to regulate activities related to energy conservation and efficient use, has provided a legal framework to implement a policy aimed at improving the efficiency of energy use; creating a culture of energy conservation; and introducing technologies that are highly productive, environment friendly, and efficient.

The government's action plan for 2016–2020, sub-clause number 2.108, states: 'Certain measures, projects and programmes aimed at improving energy conservation and efficiency, reducing transmission losses, and introducing innovation level new technologies and equipment will be implemented'. Based on this plan and with a goal to accelerate the implementation of the energy conservation law, the parliament approved in 2017 the 'National Energy Conservation Programme for 2018–2022' by its Resolution number 247. Works are being done according to this programme.

4. Mongolia's Electricity Consumption, by Province

Mongolia has four independent electric power systems (EPSs): Western EPS, Altai-Uliastai EPS (AUEPS), Western EPS, and Central EPS. Also, it has diesel generator plants and renewable energy sources that are not connected to any of these systems.

Figure 1-3 Mongolia's Electric Power Systems



Source: Gansukh (2015).

Uvs, Khovd, and Bayan-Ulgii provinces are connected to the Western EPS, which annually consumes 162 million KWh with a load of 32 BW. Western EPS operates based on imports from the connection with Krasnoyarskaya EPS of Russia and 12 MW capacity of Durgun Hydropower Plant.

Zavkhan and Gobi-Altai provinces are connected to the AUEPS, which has an annual consumption of 75.7 million KWh with a load of 15 BW. The AUEPS operates on 12 MW capacity of the Taishir Hydropower Plant and the diesel generator plants of Uliastai and Yesunbulag.

Fourteen provinces of Khangai, Central and Southern region are connected to the Central EPS, which has an annual consumption of 6.3 billion kWh with a peak load of 1,117 MW (+150 MW of Oyu Tolgoi). Ulaanbaatar city's second, third, and fourth combined heat and power (CHP) thermal power plants (TPPs), Darkhan city's CHP TPP, Erdenet city's CHP TPP, Dalanzadgad's condensing power plant (CPP), Ukhaakhudag's CPP, Salkhit wind farm, Tsetsii wind farm, Sainshand wind farm, Nar Photovoltaic Power Station (PPS), Monnar PPS, Naranteeg PPS, Khushig PPS, and Sumber PPS operate in the Central EPS with a combined capacity of 1,281.8 MW. The Central EPS is connected to the Buryatia EPS of Russia via a 220 kV line, importing and exporting power as needed.

Oyu Tolgoi mine's electric power consumption is being supplied by electric power imported from China.

Dornod and Sukhbaatar provinces are connected to the Eastern EPS, which annually consumes 199.4 million kWh with a load of 36 MW. The Eastern EPS operates based on 36 MW capacity of the Dornod CHP TPP.

Chapter 2
Outline of Energy Consumption Survey in Mongolia

1. Current Situation of Each Sector

1.1. Residential sector

In terms of the highest level of administrative division unit, Mongolia is divided into 21 provinces and the capital city Ulaanbaatar. In 2018, Mongolia had 894,496 households, of whom 44% or 387,453 households lived in Ulaanbaatar city and 56% or 507,043 households lived in the rest of the country. A total of 605,796 households (or 67.7% of the country's total) lived in permanent dwellings, whilst 288,700 households (or 32.3% of the country's total) were herder families with portable homes. These portable homes are Mongolian traditional dwellings called *ger*. *Gers* use a stove, which burns wood, coal, dry dung fuel, etc., for space heating and cooking. They are also used as permanent dwellings by some residents of the cities who are not herders. Moreover, many residents of the cities live in standalone houses with a stove as a means of space heating. Other types of space heating are district heating, low-pressure boilers, and electric heaters. In terms of type of space heating, 69.9% of Mongolia's total households live in *gers* and houses with stove heating; 27.5% live in houses and apartments with district heating; 2% live in houses and apartments with a low-pressure boiler heating; and 0.6% live in dwellings with electric heating systems. Table 2-1 shows the number of households in each province and in Ulaanbaatar city.

Table 2-1. Number of Households in Mongolia's Provinces and Ulaanbaatar

Provinces/Capital	2000	2005	2010	2015	2018	Percentage
Total	553,990	611,026	742,274	859,106	**894,496**	**100**
Western region						
Bayan-Ulgii	20,805	21,328	20,696	23,082	24,306	
Uvs	20,713	19,800	19,732	21,212	22,047	
Khovd	18,505	19,478	20,299	21,706	22,863	
					69,216	**7.73**
Altai-Uliastai region						
Gobi-Altai	15,351	15,473	15,683	16,072	16,711	
Zavkhan	21,992	19,929	20,079	20,695	21,785	
					38,586	**4.31**
Khangai region						
Bayankhongor	20,909	20,935	23,157	24,821	26,643	
Arkhangai	25,612	24,276	26,452	26,727	27,912	
Uvurkhangai	29,489	28,793	32,646	33,438	34,652	
					89,207	**9.97**
Central region						
Khuvsgul	29,595	29,655	35,105	37,773	39,449	
Selenge	21,757	22,193	28,416	29,316	30,123	
Darkhan-Uul	18,500	22,238	28,340	29,971	30,503	
Orkhon	17,315	20,870	24,334	28,089	28,959	
Bulgan	15,931	15,016	16,786	18,479	19,072	
Tuv	23,678	23,309	26,635	28,622	30,509	
					17,8615	**19.9**
Eastern region						

Khentii	17,498	17,941	21,158	23,484	25,172	
Sukhbaatar	12,920	13,339	15,486	17,251	18,268	
Dornod	17,265	18,087	21,565	22,916	24,552	
					67,992	**7.59**
Gobi region						
Umnugobi	11,616	12,798	16,112	20,098	21,980	
Dundgobi	12,506	12,628	13,092	13,900	14,863	
Dornogobi	11,956	13,968	17,796	20,018	21,286	
Gobisumber	2,896	3,245	4,289	5,017	5,388	
					63,517	**7.1**
						56.6
Ulaanbaatar	167,181	215,727	294,416	376,419	**387,453**	**43.31**

Source: National Statistics Office of Mongolia (2018b).

1.2. Transport sector

Being a landlocked country between Russia and China, Mongolia has prioritised the development of its land transport network. From 1992 to 2012, a total of 21,000 km of vehicle roads was built nationwide, whilst 37,000 km were built from 2012 to 2017. In 2018, 476.6 km of vehicle roads were built, of which 370 km were paved roads.

The total length of Mongolia's vehicle road network was 110.1 thousand km in 2018. From this, 9.0 thousand km were paved roads, whilst 101.1 thousand km were ordinary or improved dirt roads. The length and share of roads by the type of surface were as follows: asphalt concrete roads, 8,706.4 km or 7.8% of the total length of vehicle road network; gravel roads, 1,207.9 km or 1.1%; minimally paved roads, 205.2 km or 0.2%; cement concrete roads, 81.7 km or 0.1%; ordinary or improved dirt roads, 101.1 thousand km or 90.3%.

Mongolia has air connections with Russia and China through 15 air border-crossing points, and 62 total air routes are in operation. In 2018, there were 20 international routes and 13 domestic routes with regular flights. The number of domestic flights reached 6,394, boosted by the demand from the mining industry. The number of mining industry-chartered flights is constantly increasing.

In the railroad transport sector of Mongolia are two entities in operation: Mongolian and Russian jointly owned UBTZ company and Mongolian railroad state-owned joint-stock company.

The length of the UBTZ company's main route is 1,110 km. Other routes include Salkhit–Erdenet route with 164 km length, Darkhan–Sharin Gol route with 63 km length, Bagakhangai–Baganuur route with 96 km length, Tolgoit–Songino with 21 km length, Khonkhor–Nalaikh route with 13 km length, Airag–Bor Undur route with 60 km length, Sainshand–Zuunbayan route with 50 km length, and Ereentsav–Bayantumen route with 238 km length. The total length of the railroad network is 1,815 km. There are five routes from the north border to the south border, with a total of 63 stations and 45 passing loops. There are 38 stations from Ulaanbaatar to the south border, 25 stations from Ulaanbaatar to the north border.

1.3. Commercial sector

Figure 2-1. Statistics on Registered Entities in Mongolia

Number of registered entities
170,166

Percentage of actively operating entities
50.4%

Percentage of entities that have up to 50 employees
97.1%

Percentage of entities that operate in Ulaanbaatar
65.8%

Source: National Statistics Office of Mongolia (2018b).

The number of registered entities in Mongolia had risen by 9.7% from 2017 to 2018, reaching a total of 170,166 entities. However, only 50.4% of these registered entities were actively operating entities.

From 85,749 entities actively operating nationwide, 97.1% of the entities have less than 50 employees, and 65.8% of entities are in Ulaanbaatar city. Table 2-2 shows the classification of registered business entities in the annual report of the National Statistics Office (2018b).

Table 2-2. Registered Entities in the Business Registry Database, by International Standard Industrial Classification

Division	2018
Wholesale and retail trade	71,486
Hotels and restaurants	4,282
Public administration and defence, compulsory social security	1,494
Education	5,671
Health and social work	4,817
Others	82,416
Total	**170,166**

Source: National statistical office of Mongolia (2018b).

In the field of economic activity, the percentage of business entities and organisations operating in the wholesale and retail sectors, including shopping malls across the country, was high and accounted for 42% of the economy in 2018.

The number of state hospitals decreased from 399 in 2000 to 386 in 2018. However, the number of private hospitals was 1,583 in 2018, i.e. an increase of 3.4 times since 2000.

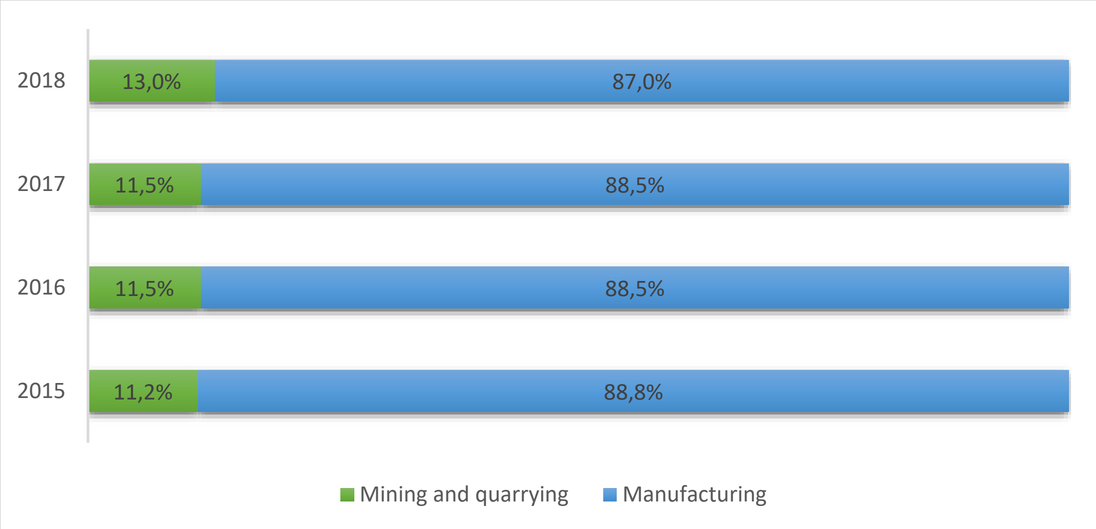
In 2018, 803 secondary schools were active: 80 (10%) elementary schools, 115 (14.3%) secondary schools, 563 (70.1%) high schools, and 45 (5.6%) comprehensive schools. State-owned schools total 81.7% and 18.3% are private schools.

As of 2018, 85,749 entities were actively operating according to the Statistical Business Registry database (National Statistics Office of Mongolia, 2018b); 2,410 or 2.8% were actively operating in the hotel, accommodation, and catering services.

1.4. Industry sector

Mongolia's industry sector is divided into the mining and quarrying, and manufacturing sub-sectors. Figure 2-2 shows the share of the above two sub-sectors of the industry sector by the number of entities operating in these sub-sectors.

Figure 2-2 Share of Sub-sectors in the Industry Sector, by the Number of Entities



Source: National Statistics Office of Mongolia (2018b).

1.4.1 Mining and quarrying sub-sector

The mining and quarrying sub-sector is important in the industry sector in terms of gross industrial output. This sub-sector has the following five divisions according to the International Standard Industrial Classification: (i) mining of coal and lignite, (ii) extraction of crude petroleum, (iii) mining of metal ores, (iv) other mining and quarrying, and (v) mining support service activities.

Mining and quarrying have rapidly developed in recent years to become one of the leading sectors in the economy of Mongolia. This is largely due to the start of mining activities at the largest mineral deposits of a strategic level, such as Oyu tolgoi and Tavan tolgoi.

1.4.2 Manufacturing sub-sector

The country's manufacturing sub-sector is divided into the following:

- Manufacture of food products
- Manufacture of beverages
- Manufacture of tobacco products
- Manufacture of textiles
- Manufacture of wearing apparel
- Manufacture of leather and related products
- Manufacture of wood and cork products, except furniture
- Manufacture of paper and paper products
- Manufacture of printing and reproduction of recorded media
- Manufacture of coke and refined petroleum products
- Manufacture of chemicals and chemical products
- Manufacture of pharmaceuticals, medicinal chemical and botanical products
- Manufacture of rubber and plastics products
- Manufacture of other non-metallic mineral products
- Manufacture of basic metals
- Manufacture of fabricated metal products, except machinery and equipment
- Manufacture of computer, electronic and optical products
- Manufacture of electrical equipment
- Manufacture of machinery and equipment n.e.c.
- Manufacture of motor vehicles, trailers and semi-trailers
- Manufacture of other transport equipment
- Manufacture of furniture
- Other manufacturing
- Repair and installation of machinery and equipment

2.1.5 Electricity, thermal energy, and water supply (ETEWS) sector

This sub-sector has the following divisions:

- Electric power generation
- Thermal energy generation
- Water supply activities

In 2018, 8.2 billion kWh of electric power was consumed, of which 6.5 billion kWh (or 79.7% of total) was generated domestically and 1.7 billion kWh (or 20.3% of total) was imported from China and Russia.

From the total number of electric power consumers, 52,200 (or 7.6%) are entities and 633,100 (or 92.4%) are households. A total of 41,300 entities (79.2% from total entities that consume electric power) get their electric power from the Central Electric Power System (EPS), 4,600 (or 8.8%) from the WEPS, 2,200 (or 4.2%) from the Eastern EPS, 1,900 (or 3.7%) from the Southern EPS, and 2,100 (or 4.1%) from the Altai-Uliastai EPS (AUEPS).

In 2018, a total of 12.5 million gigacalorie (GCal) of thermal energy was generated, which was an increase of 1.2 million GCal or 10.7% from 2017. Entities and households consumed 10.6 million GCal (85.1% from total) produced in 2018 were consumed by entities and households, whilst 1.38 million GCal (or 11.0% from total) were consumed by CHP thermal power plants (TPPs) for internal use and 0.5 million GCal (or 3.9%) were lost in transmission and distribution.

From the total number of consumers of thermal energy from CHP TTPs, 25,200 (or 7.7%) are entities and 300,300 (or 92.3%) are households. From the total number of entities that get their thermal energy from CHP TPPs, 14,800 (or 58.7%) are in Ulaanbaatar city; 1,800 (or 7.1%) are in Darkhan-Uul province; 1,400 (or 5.5%) are situated in Orkhon province; 1,000 (or 4.0%) are in Dornogobi province; 800 (or 3.2%) are in Dornod province; the remaining 5,400 (or 21.5%) are situated elsewhere.

In 2018, gross industrial output of water supply and sewerage and waste management remediation activities amounted to ₮0.4 trillion.

In terms of the share of sub-activities by their gross industrial output, in 2018, water accumulation, purification, and supply activities had a share of 63.8%; waste collection and processing activities had a share of 35.3%; wastewater collection and treatment activities had a share of 0.5%; and other waste management activities and remediation activities had a share of 0.4%.

2. Implementation of the Survey by Each Sector

To determine Mongolia's energy efficiency indicators (EEIs), an energy consumption survey covering the whole country was conducted in 2018–2019 with the technical assistance of the Economic Research Institute for ASEAN and East Asia (ERIA). Through this survey, the actual energy consumption in each final energy consumption sector – consisting of industry, transport especially road, and the residential and commercial sectors – is extracted. Based on the survey results, the country's EEIs are estimated as benchmarking numbers of each sector. The major points of this survey focused on how and how much each sector used energy, i.e. the end-use energy consumption amounts.

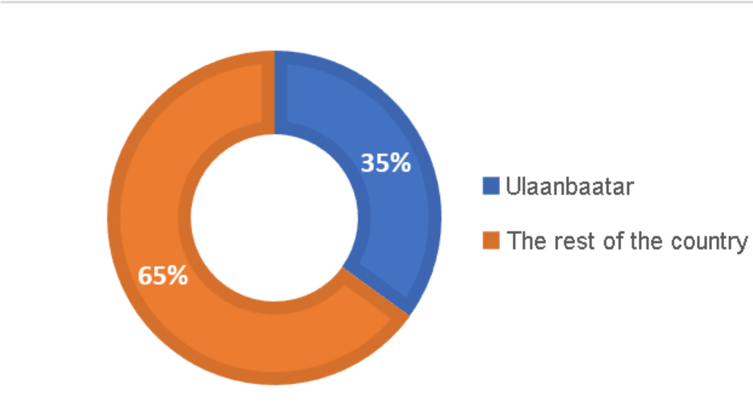
A total of 800 samples were taken from four sectors: residential (400), commercial (200), industry (100), and transport (200).

The survey was conducted by the employees of MEEI, as well as some contractor organisations: Western EPS, AUEPS, Eastern EPS, and Mongolian association of specialised consulting engineers. The MEEI employees travelled to Darkhan, Erdenet cities and locations in 14 different provinces, in addition to conducting a survey in Ulaanbaatar.

2.1. Residential sector sample survey

From a total of 400 samples taken from the residential sector, as shown in Figure 2-3, 140 samples (or 35% from total) were taken from Ulaanbaatar and 260 samples (or 65%) were taken from the rest of the country.

Figure 2-3 Share of Residential Sector Samples Taken from Ulaanbaatar



Source: MEEI's survey.

Based on energy consumption characteristics, Mongolia's total territory was divided into the following six regions:

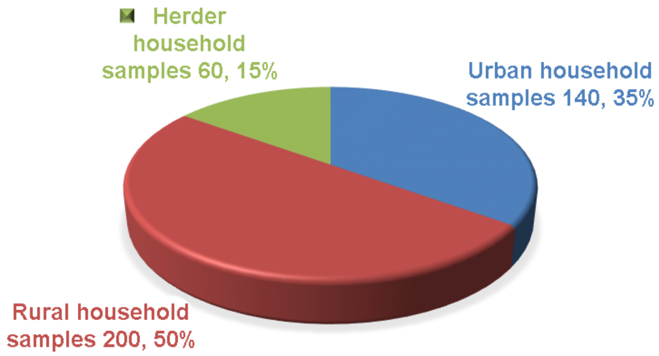
- Western region (which included Bayanulgii, Uvs, Khovd provinces)
- Altai-Uliastai region (which included Gobi-Altai, Zavkhan provinces)
- Khangai region (which included Bayankhongor, Uvurkhangai, Arkhangai provinces)
- Central and northern region (which included Khuvsgul, Bulgan, Orkhon, Selenge, Darkhan-Uul, Tuv provinces)
- Eastern region (which included Khentii, Dornod, Sukhbaatar provinces)
- Gobi region (which included Umnugobi, Dornogobi, Dundgobi, Gobisumber provinces)

By type of location, the households were divided into three categories: urban, rural, and herder. Urban households are located in Ulaanbaatar city. Rural households are in provincial and *soum* centres. Urban and rural households have permanent dwellings. Herder households are located in pasturelands of various provinces. They do not have a permanent place of living. They move their mobile homes (*ger*) with their livestock whenever there is a need to move to another pastureland.

The survey conducted was on electricity, heat, and other fuel consumption such as wood, dry dung, coal, etc. The survey also included information on electric appliances of houses, apartments and *gers*.

As shown in the Figure 2-4, on the number of samples, 140 samples were from urban households; 200, from rural households; and 60, from herder households.

Figure 2-4 Number and Share of Residential Sector Samples, by Type of Location



Source: MEEI.

2.2. Transport sector sample survey

The sample survey was conducted on 170 road vehicles, 20 locomotives, 11 aircraft, and 2 ships. Questionnaires asked information on vehicle model, engine capacity, age, standard fuel consumption, winter and summer fuel consumption, unloaded fuel consumption, daily and monthly travel distance, etc.

Road vehicles were divided into the following three categories:

- Cars (with 55 samples)
- Buses (with 45 samples)
- Trucks (with 70 samples)

The 55 car samples were manufactured in Russia, Republic of Korea (henceforth Korea), and Japan, with vehicles aged 4–30 years.

Table 2-3. Cars Included in the Survey, by Engine Displacement

Engine Displacement, cm^3	Number of Samples
1500 and lower	13
1501–2500	34
2501–3500	5
3501–4500	3
Total	**55**

Source: MEEI's survey.

Table 2-4. Cars Included in the Survey, by Fuel Type

Fuel Type	Number of Samples
diesel	**4**
gasoline	**51**
AI-80	1
AI-92	48
AI-95	2
Total	**55**

Source: MEEI.

From the total of 45 samples, 26 samples were buses manufactured by Hyundai, and 19 samples were manufactured by Daewoo, both of Korea. Engine displacement ranged from 11,051 cm^3 to 11,149 cm^3, with an average displacement of 11,108 cm^3. All buses had diesel engines, and their ages ranged from 7 to 11 years.

According to a sample study, the average standard technical consumption of 70 trucks is 62.1 litres/100 km, with a heavy-duty diesel engine from Nord Benz, Howo, and Beiben factories.

Twenty railway surveys were collected from the locomotive sector: fourteen locomotives were manufactured in Russia, six (*2zagal*[1]) locomotives were manufactured in Mongolia, with age up to 30 years. The survey collected data on fuel consumption, daily and monthly routes, and technical characteristics. There is no data in the railway sector statistics for locomotives classified as freight and passenger. In 2018, the railway sector, comprising public and private companies, provided freight and passenger services – with 138 locomotives, 3,571 freight wagons, and 608 freight cars.

Eleven survey questionnaires were collected to gather information on aircraft model, age, fuel consumption, daily and monthly mileage, etc.

In 2018, the volume of water transport was 25,638 people, with a passenger turnover of 0.4 million man/km, increasing the number of passengers by 5,082 people or 24.7% from the previous year, which is 0.01% of the total passenger traffic in the 2018 traffic. Waterway study is not included since Mongolia is a landlocked country, has not been involved in cargo transport since 2006, and uses only 0.01% of passenger traffic.

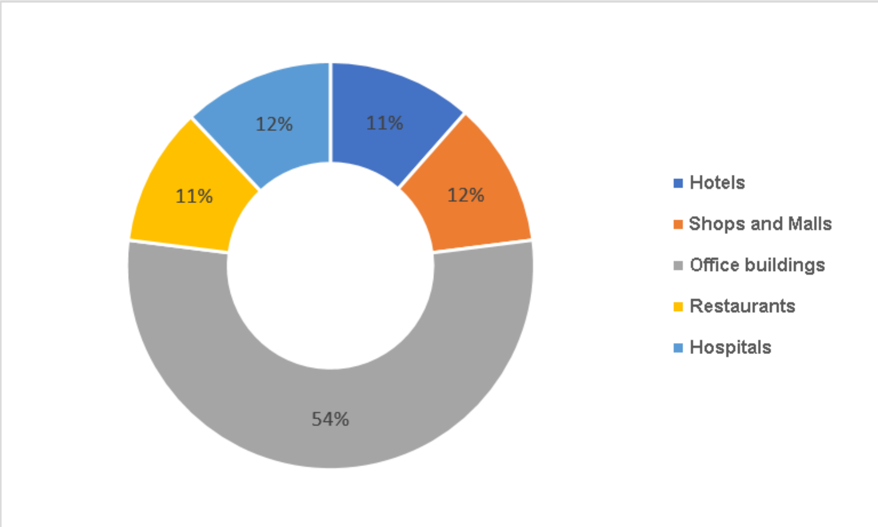
[1] Mongolia-built double diesel engine locomotive.

2.3. Commercial sector sample survey

The commercial sector sample survey was conducted for five types of buildings: hotels (23 samples), shops and malls (23), office buildings (108), restaurants (22), and hospitals (24), as per the percentage breakdowns shown in Figure 2-5. A total of 200 samples were taken, of which majority of the buildings were located in Ulaanbaatar city.

The survey also collected information on energy consumption, including electricity, heat, and other fuels. Heat consumption was calculated due to the lack of information.

Figure 2-5 Share of Commercial Sector Samples, by Type of Building



Source: MEEI.

2.4. Industry sector sample survey

The National Statistics Office of Mongolia (2018b) divides the industry sector into the following sub-sectors: mining and quarrying, manufacturing, and electricity thermal energy and water supply (ETEWS). Originally, 100 samples were taken from these sub-sectors: mining and quarrying (18), manufacturing (62), and ETEWS (20).

However, some entities returned incomplete questionnaires that were unusable for the purposes of this study. ETEWS sub-sector’s entities were also viewed as a separate category because they are not energy consumers, but energy transformers.

Therefore, in terms of energy consumer entities, the industry sector comprises the mining and quarrying sub-sector and the manufacturing sub-sector. Additional samples were taken from these two sub-sectors, making the total number of usable samples as follows:

- Mining and quarrying sub-sector, which has a total of 927 entities – 14 samples
- Manufacturing sub-sector, which has a total of 6,219 entities – 75 samples

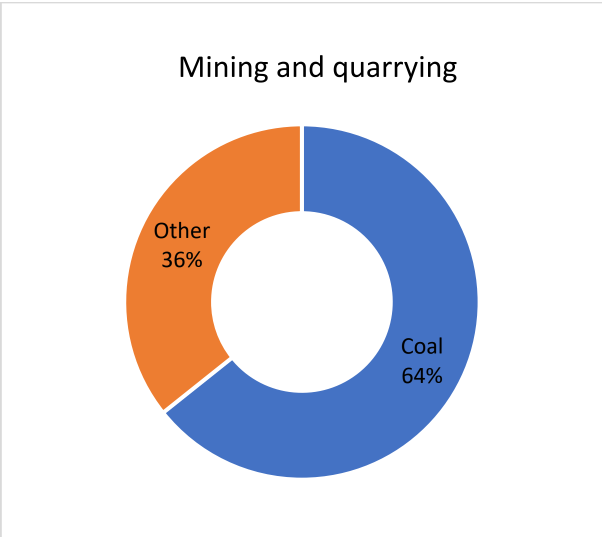
Samples from the manufacturing sub-sector amounted to 78% of the total sample, whilst those from the mining and quarrying sub-sector amounted to 22% of the total sample. Table 2-5 gives the number of samples included in each types of industry whilst Figure 2-6 shows the share of the number of samples in each Sub-sector in the industry sector survey.

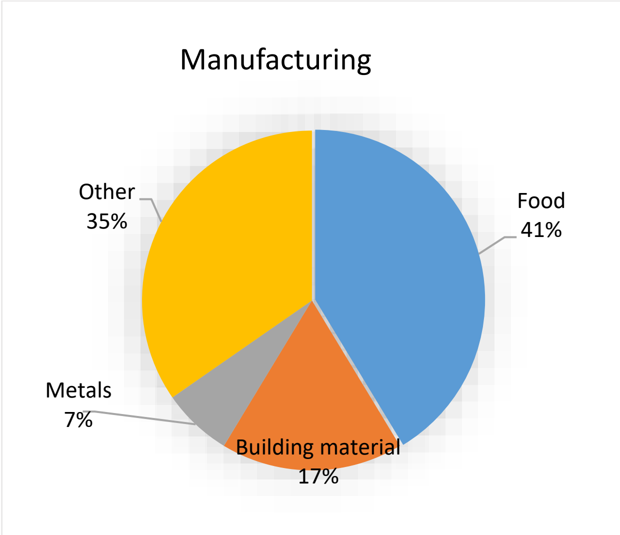
Table 2-5. Types of Industries and Number of Samples Included in the Industry Sector Survey (Energy-Consuming Entities)

Types of Industries	Number of Samples
Mining and quarrying	**14**
Coal	9
Other	5
Manufacturing	**75**
Food	31
Building materials	13
Metals	5
Other	26
TOTAL	**89**

Source: MEEI.

Figure 2-6 Share of the Number of Samples in Each Sub-sector in the Industry Sector Survey (Energy-Consuming Entities)





Source: MEEI.

The sample survey questionnaire for industry included:

• Name, address, year of establishment, number of employees, and direction of activities in the organisation's description

• Construction information that includes information on the year of construction, purpose, size, operation status, total area, and heating area

• Production summary information such as product name, production volume, and price.

Power source and consumption data include data on electricity and heat sources, annual electricity consumption, heat consumption, price and consumption, price of fuel, and fuel and lubricants.

Two questionnaires were developed for the industry sector survey: (i) industrial and mining, geological exploration, and farming companies; and (i) a sample survey randomly conducted from urban and rural industrial enterprises.

Within the framework of the research work, we concluded agreements with the energy companies of the western sector of the energy system (Western EPS), Altai-Uliastai power system (UAEPS), the Eastern region (Eastern EPS) energy system companies, and industry consultants for conducting sample surveys.

2.5 Electricity, heat, and water supply sector sample survey

Two questionnaires were developed for the electricity, heat, and water supply sector survey.

Within the framework of the research work, we concluded agreements with the energy companies of the western sector of the energy system, Altai-Uliastai power system, the Eastern region energy system companies, and industry consultants for conducting sample surveys.

Table 2-6. Types of Industries and Number of Samples included in the Electricity, Thermal Energy, and Water Supply Sub-sector of the industry Sector Survey (Energy-Transforming Entities)

Types of Industry	Number of Samples
Electricity, thermal energy, and water supply	**11**
Electricity, thermal energy	5
Other	6

Source: MEEI.

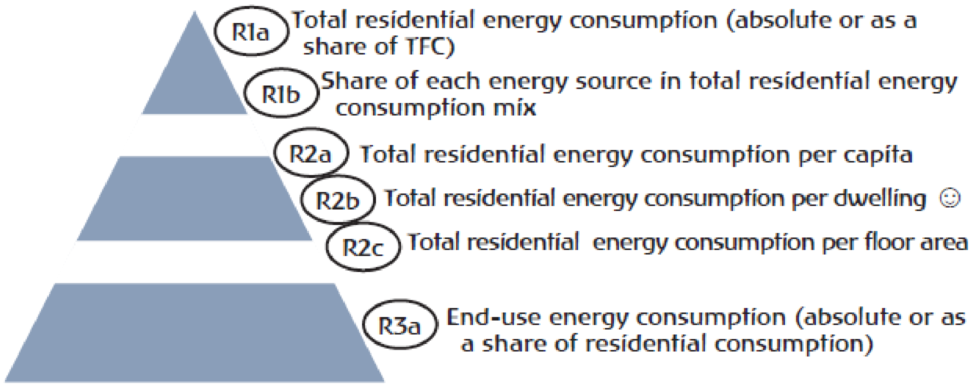
Twenty samples were taken from the ETEWS sector, which has 268 entities. Only 11 sample entities returned a questionnaire form with usable data.

Chapter 3
Residential Sector

1. Energy Efficiency Indicators in the Residential Sector

Based on the International Energy Agency's concept of energy efficiency indicators (EEIs) (Figure 3-1, the simplest indicator is level 1, which is the overall consumption of energy for the residential sector expressed either in absolute value or in percentage of the country's total final consumption. The second indicator of level 1 is the share of each energy source in the total residential consumption mix (R1b) as reported in section 3.4. However, the focus of this survey is the energy consumption in households and end-use of energy. Therefore, this chapter reports mainly on the total energy consumption per dwelling (R2b), total energy consumption per floor area (R2c), and share of end-use consumption by appliance (R3a).

Figure 3-1 Pyramid of Residential Indicators



TFC = total final consumption.

Source: International Energy Agency (2014a).

2. Effective Samples

A total of 430 survey samples were taken from six regions of Mongolia. However, 30 survey samples were excluded due to inadequately filling out of questionnaires. Considered in data analysis were 400 survey samples.

Table 3-1. Number of Households and Type of Dwelling

Type	Urban			Rural			Herder	
Type of dwelling	Apartment	House	Ger	Apartment	House	Ger	House	Ger
Number of households	70	63	7	43	110	47	4	56

Source: MEEI.

3. Characteristics of Households

Energy consumption is caused by extraterritorial, climatic conditions, and ethnic customs. The majority of urban households are relatively energy efficient, and have access to the centralised energy system, whilst the decentralised individual houses and *gers* are relatively energy-inefficient due to the lack of infrastructure facilities connecting to the centralised heating system. Depending on the location of the dwellings and type of houses, large heat losses are common. The heat losses in homes are substantial and can be equivalent to large consumption of fuel, coal, and wood.

The average area of houses is 35–70 m^2, whilst that of *gers* is 27– 34 m^2.

Most of the herder households are not connected to the electricity system, but generate electricity from small-scale power generation systems such as diesel generators and solar PV systems, as well as burning natural wood, dung, *khurzun* (which is dung- and animal-derived fuel) for space heating.

4. Fuel Consumption of the Residential Sector

Table 3-2 shows the average annual consumption of fuel used in heating and cooking in households.

Table 3-2. Household Fuel Consumption

		Coal (ton)	Wood (m^3)	Dung (m^3)	Khurzun (m^3)	Number of Households Surveyed
Herder	Fuel consumption	0.76	1.25	8.3	8.3	60
	Number of households consumed	48 80%	22 36.6%	52 86.6 %	46 76.6%	
Rural	The amount of fuel used	45.9	50.1	8.7	7	200
	Number of households consumed	120 60%	121 60,5%	41.2 20,6 %	38 19%	

Urban	The amount of fuel used	4.56	3.3	6.4	3	140
	Number of households consumed	67 47.8%	43 30.7%	9 45%	8 4%	

Source: MEEI.

Households use coal, wood, dung, and briquettes for heating and cooking. Most herders use 0.76 tonnes of coal and 8–12 m^3 of dung annually, whilst Ulaanbaatar and rural area use 4.5–5.5 tonnes of coal, 3–7m^3 of wood and dung.

Households are divided into three sections: connected to centralised (district) heating system, decentralised heating system, and *ger*. House- heating consumption is expressed in terms of gigacalorie (Gcal) and megawatt based on field and volume methodology. Those living in houses use electric heaters and most of them use natural wood and coal, whilst herder households use wood and dung.

Gases and other types of fuels are used in small quantities and, therefore, are not included in the survey analysis.

3.5. Residential Sector Energy End-Use

Table 3-3, Table 3-4 and Figure 3-2 show the annual average consumption of households and the average annual energy consumption per household.

Table 3-3. Average Annual Electricity Consumption of Households (kWh/year)

Type	**Urban**			**Rural**			**Herder**	
Type of dwelling	**Apartment**	**House**	***Ger***	**Apartment**	**House**	***Ger***	**House**	***Ger***
Surveyed households	70	63	7	43	110	47	4	56
Total electricity consumption kWh/y	225,973	272,212	16,972	121,284	719,996	104,960	1,885	17,932

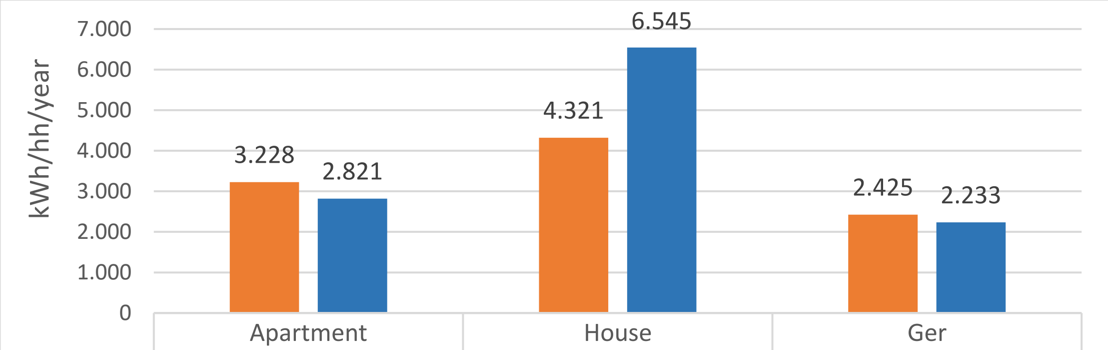
Source: MEEI.

Table 3-4. Average Electricity Consumption per Household

Type	**Urban**			**Rural**			**Herder**	
Type of dwelling	**Apartment**	**House**	***Ger***	**Apartment**	**House**	***Ger***	**House**	***Ger***
One household per year (kWh/y)	**3,228**	**4,321**	**2,425**	**2,821**	**6,545**	**2,233**	**471**	**320**
One household per month (kWh/month)	**269**	**360**	**202**	**235**	**545**	**186**	**39**	**27**
%								
Lighting	13	10	11	10	5	9	12	14
Refrigerator	16	12	20	16	8	20	0	15
Freezer	7	5	2	14	6	11	63	35
Washing machine	2	1	2	2	1	1	1	1
TV	7	5	9	8	4	12	25	34
Rice cooker	3	3	4	4	2	3	0	1
Computer	2	1	2	1	1	1	0	0
Electric stove	32	21	37	27	13	19	0	0
Iron	3	2	3	3	2	4	0	1
Electric kettle	14	9	10	14	5	10	0	0
Water heater	0	1		0	2	0	0	0
Electric heater	0	28		0	16	9	0	0
Fan	1			0	0	0	0	0
Vacuum cleaner	1	1		2	1	0	0	0

Source: MEEI.

Figure 3-2 Average Annual Electricity Consumption of Households (kWh/hh/year)



	Apartment	House	Ger
Urban	3.228	4.321	2.425
Rural	2.821	6.545	2.233

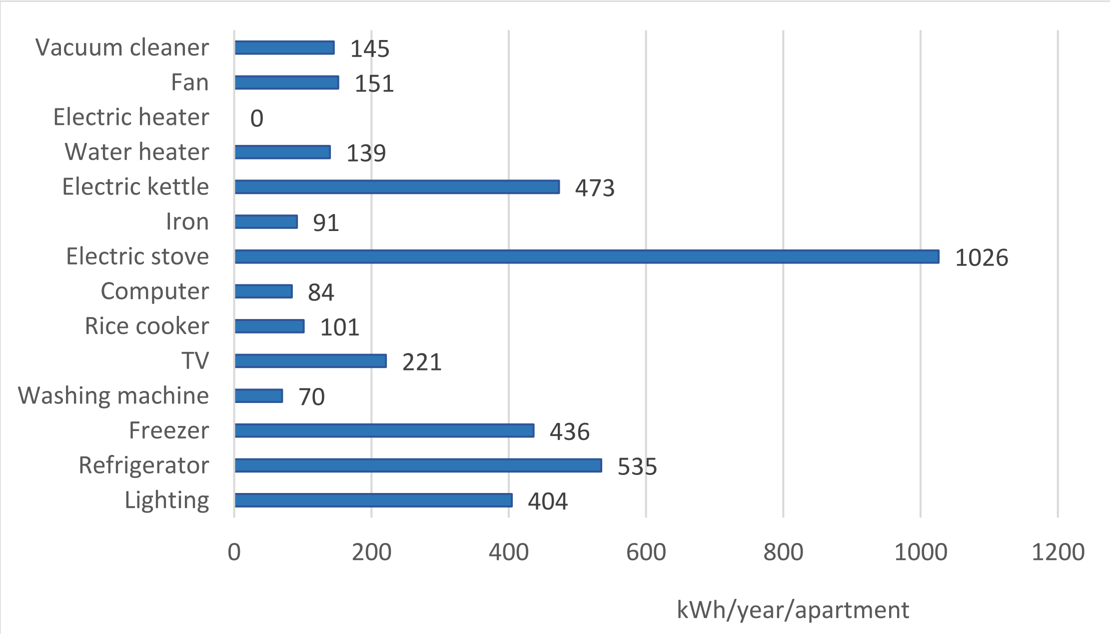
hh = household.

Source: MEEI.

Figure 3-2 compares the average annual electricity consumption per household (hh) between urban and rural areas for the three types of housing: apartment, house, and *ger*.

Figure 3-3 shows the average annual electricity consumption of electrical appliances per apartment in Ulaanbaatar. Figure 3-4 illustrates the average share of electricity consumption of household electrical appliances in a typical Ulaanbaatar apartment.

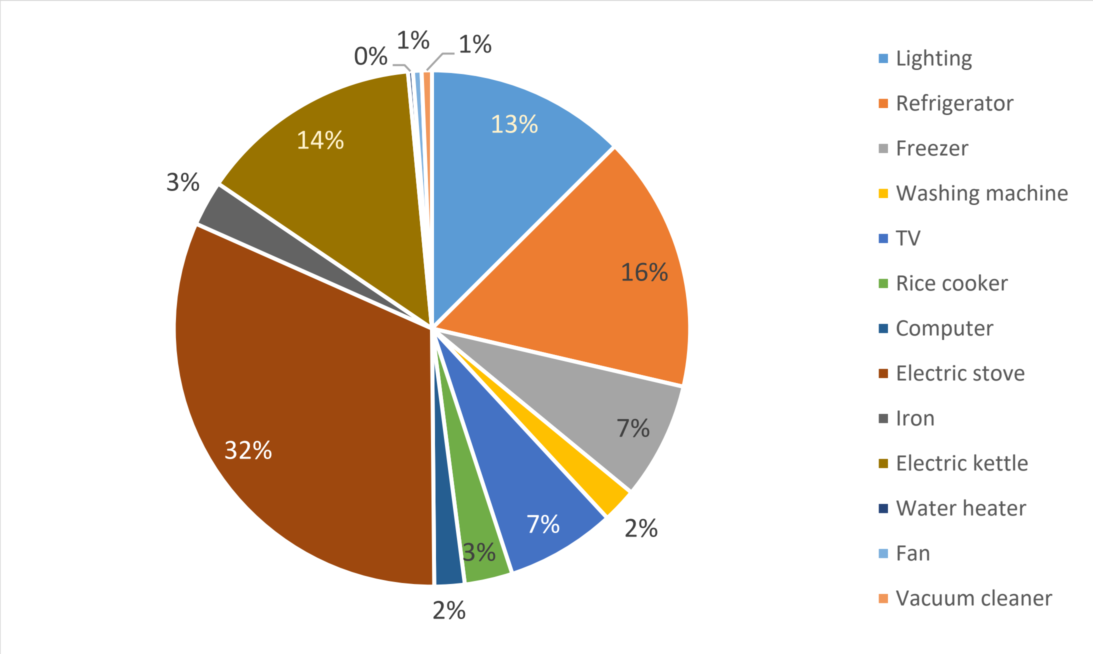
Figure 3-3 Average Annual Electricity Consumption of Appliances in Ulaanbaatar, per Apartment (kWh/year)



Source: MEEI.

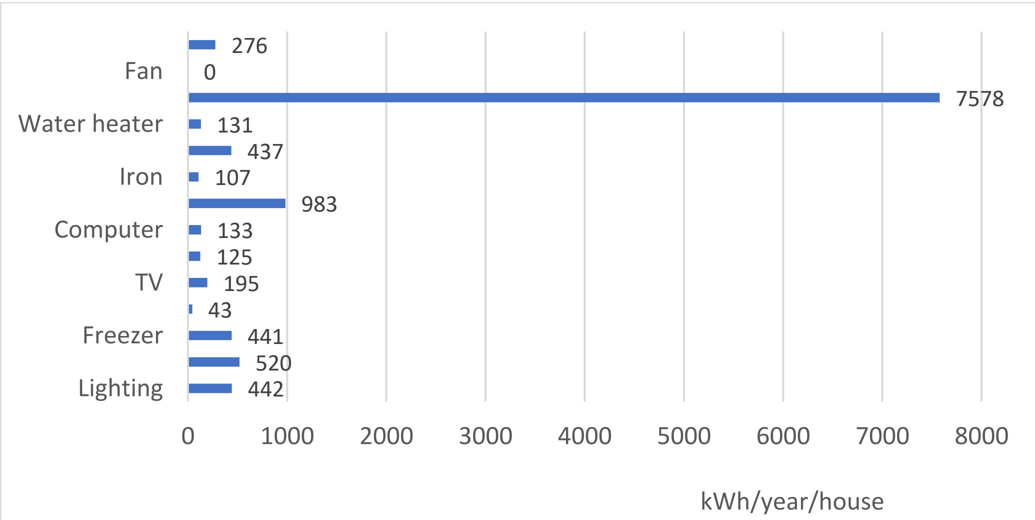
Annual household electricity consumption in Ulaanbaatar apartments shows that 32% of the total electricity comes from electric stoves; 16%, from refrigerators; 7%, from freezers; 13%, from lighting; 14%, from electric kettle;, and the remaining 18%, from other electric appliances.

Figure 3-4. Share of Electricity Usage in a Typical Urban Apartment, by Appliances (%)



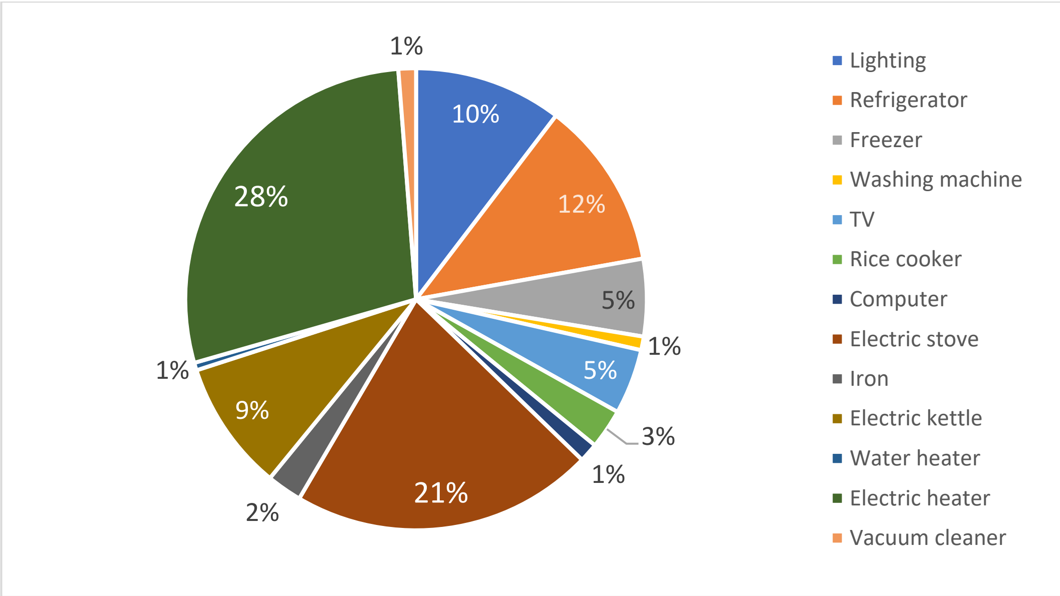
Source: Author based on MEEI's data.

Figure 3-5 Average Annual Electricity Consumption of Appliances in Ulaanbaatar, per House (kWh/year)



Source: MEEI.

Figure 3-6 Share of Electricity Usage in a Typical Urban House, by Appliance (%)



Source: Author based on MEEI's data.

Figure 3-7 Average Annual Electricity Consumption of Appliances in Urban Areas, per *Ger* (kWh/year)

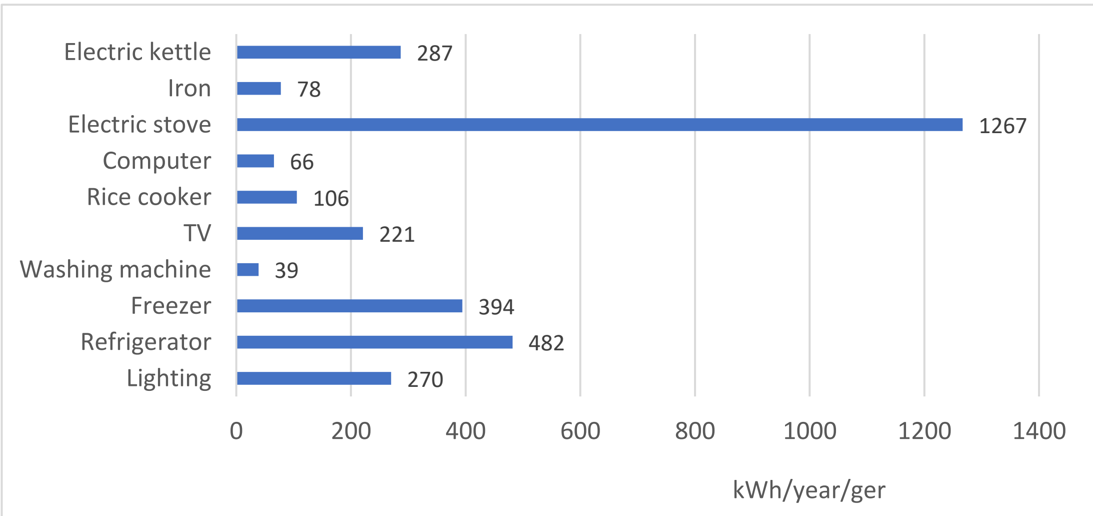
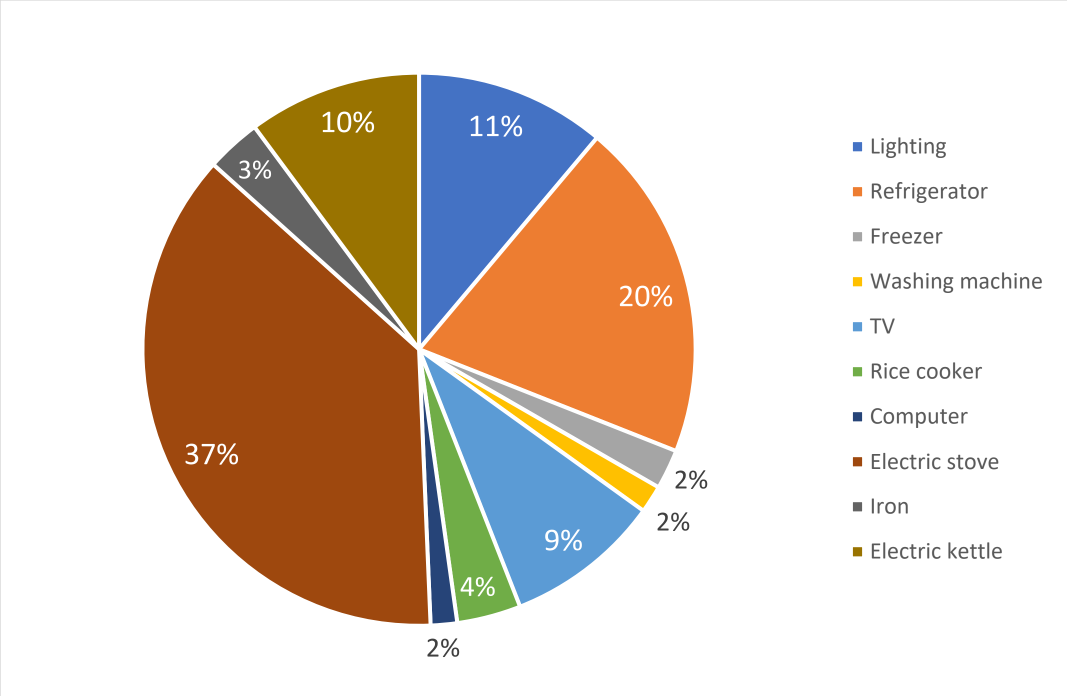


Figure 3-8 Share of Electricity Usage in a Typical Urban *Ger*, by Appliance



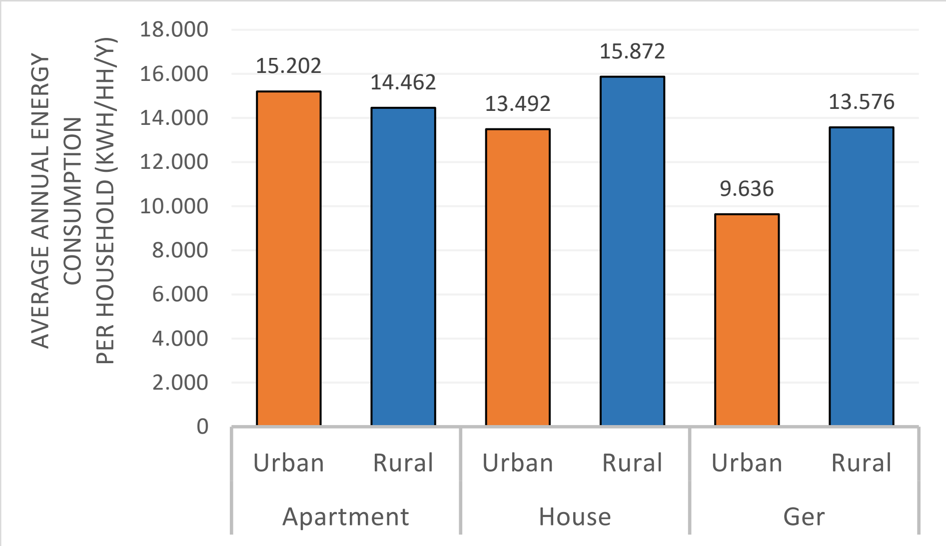
Source: Author based on MEEI's data.

The survey results show that all households use lights, refrigerators, washing machines, televisions, irons, electric tiles, rice cookers, water boilers, freezers, and vacuum cleaners. Few households use electric heaters, boilers, fans, and computers. Figure 3-3, , Figure 3-5, and). In urban households, electric stoves and heaters consume the majority share of the household energy usage. Other significant energy users are refrigerators, freezers, lighting, and electric kettles. Urban houses mainly use electric heaters for heating instead of electric stoves as in urban apartments and *gers*.

Herder households not connected to the central energy system use 150–158 kW of electricity per year from their own power using solar panels, small wind turbines, and electric generators. Electricity consumption is very low compared to settled households; electricity is used only for lighting, TV, and space antenna feed. On average, one household uses solar panels with 100–130 watts, which are typically used in herder areas. Heat energy consumption is almost the same with urban and rural households.

Figure 3-9 compares the total average annual consumption of electricity and heat energy consumed by each surveyed household, expressed in KWh per household per year. Table 3-5 and Table 3-9, respectively, show the average total energy consumption of each household in urban and rural areas.

Figure 3-9. Comparison of Total Average Annual Energy Consumption per Household between Urban and Rural Areasa (KWh/hh/year)



[a] Includes electricity and heat energy.

Source: Author based on MEEI's data.

Table 3-5. Average Total Energy Consumption of Each Urban Household (kWh/hh/year and Percentage Share of Energy Source)

Type of Dwelling	Total	Electricity		Heat	
Apartment	**15,202**	3,228	21%	11,974	79%
House	**13,492**	4,321	32%	9,171	68%
Ger	**9,636**	2,425	25%	7,211	75%

Source: Author based on MEEI's data.

Table 3-6. Average Total Energy Consumption of Each Rural Household (kWh/hh/year and Percentage Share of Energy Source)

Type of Dwelling	Total	Electricity		Heat	
Apartment	**14,462**	2,821	20%	11,641	80%
House	**15,872**	6,545	41%	9,327	59%
Ger	**13,576**	2,233	16%	11,343	84%

Source: Author based on MEEI's data.

5. Energy Intensity

The average annual consumption of combined electricity and heat energy in the surveyed households and dwellings, calculated per household and per square meter floor area, is shown in Table 3-7 to Table 3-9. Unlike the commercial sector, where the EEI is based on energy intensity defined as building energy intensity (BEI) (which is a ratio of energy consumption to gross floor area), energy intensity for the residential sector is more appropriate if based on average annual energy consumption per household because more appliances are used in dwellings. Appliances such as refrigerators, freezers, washing machines, TV sets, rice cookers, etc. are used only in certain parts of a dwelling. Unlike in the commercial sector, the energy usage in commercial buildings is more evenly distributed. Therefore, it is more accurate to compare the values of energy intensity based on the average annual energy consumption per household to determine energy efficiency in the residential sector. However, for practical purposes in terms of feedback to household residents, average monthly energy consumption per household would provide more realistic comparison of energy intensities to household owners, who can relate them to their monthly energy bills.

In addition, household composition data are found in the national statistics. Therefore, it will be useful to establish energy intensity in terms of annual energy consumption per household, which can facilitate the compilation of energy statistics for the residential sector. To promote energy efficiency in the residential sector, it would be useful to establish the monthly energy intensity based on the monthly energy consumption per household for residents to more easily understand and monitor their respective monthly energy usage.

Table 3-7. Average Annual Energy Consumption of Each Typical Urban Household in Ulaanbaatar, per household and per floor area comparisons

Type of Dwelling	Description	Electricity	Heat	Total Energy
Apartment **Average area: 54.5**	Average annual energy consumption per household (kWh/hh/y)	3,228	11,974	15,202
	Average annual energy consumption per floor area ($kWh/m^2/y$)	**58**	**220**	**278**
House **Average area: 65.5**	Average annual energy consumption per household (kWh/hh/y)	4,297	9,171	13,195
	Average annual energy consumption per floor area ($kWh/m^2/y$)	**65**	**140**	**201**
Ger Average area: 34.4	Average annual energy consumption per household (kWh/hh/year)	2,352	7,211	9,564
	Average annual energy consumption per floor area ($kWh/m^2/y$)	**77**	**236**	**313**

Source: MEEI.

Table 3-8. Average Annual Energy Consumption of Each Typical Rural Household, per household and floor area comparisons

Type of Dwelling	Description	Electricity	Heat	Total Energy
Apartment Average area:48.1 m^2	Average annual energy consumption per household (kWh/y)	2,828	11,641	14,607
	Average annual energy consumption per floor area (kWh/m^2/y)	**58**	**242**	**303**
House Average area:59.2 m^2	Average annual energy consumption per household (kWh/hh/y)	4,294	9,327	13,185
	Average annual energy consumption per floor area (kWh/m^2/y)	**72**	**157**	**222**
Ger Average area: 30.5 m^2	Average annual energy consumption per household (kWh/hh/y)	2,210	11,343	13,553
	Average annual energy consumption per floor area(kWh/m^2/y)	**72**	**371**	**444**

Source: MEEI.

Table 3-9. Average Annual Energy Consumption of Herder Households, Intensity per Year

Type of Dwelling	Description	Electricity	Heat	Total Energy Consumption
House Average area: 70.2 m^2	Average annual energy consumption per household (kWh/hh/y)	150	10,670	10,820
	Intensity (kWh/m^2/y)	**2**	**152**	**154**
Ger Average area: 30.5 m^2	Average annual energy consumption per household (kWh/hh/y)	158	13,631	13,789
	Average annual energy consumption per floor (kWh/m^2/y)	**5**	**451**	**456**

Chapter 4

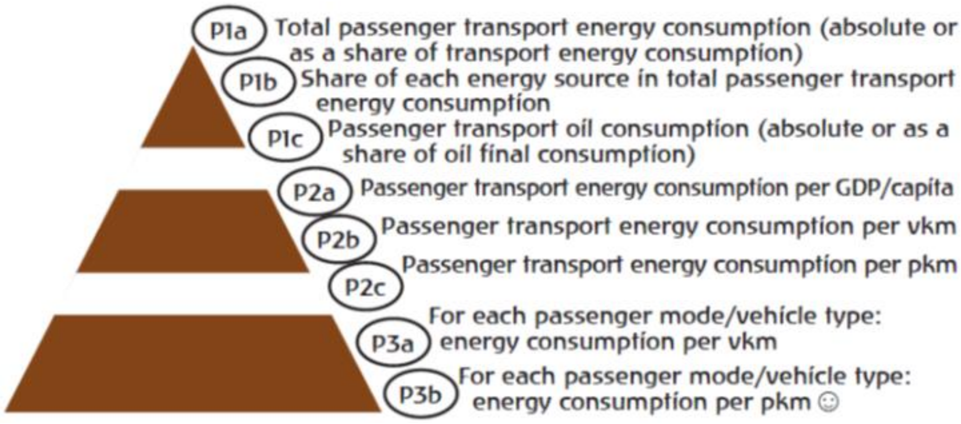
Transport Sector

1. Energy Efficiency Indicators in the Transport Sector

Like other sectors, energy efficiency indicators (EEIs) in transport are in principle results of dividing energy consumption by the sector's activity. Based on type of activity, the transport sector is broken down into freight and passenger transport (Figure 4-1 and Figure 4-2).

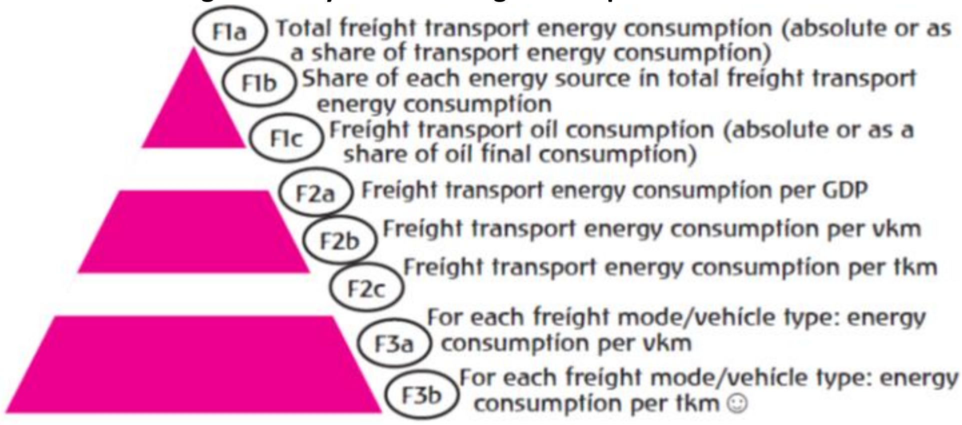
For each activity type, we estimate the indicators in a bottom-up manner. Based on the survey results, we estimate the EEIs starting from the vehicle type. For example, in passenger road transport, we start estimating the indicators for road vehicles with sedans, buses, and taxis whilst for freight road, we start with trucks.

Figure 4-1 Pyramid of Passenger Transport Indicators



Source: IEA (2014b).

Figure 4-2 Pyramid of Freight Transport Indicators



Source: IEA (2014b).

For passenger transport, EEIs are calculated in gigajoules/passenger-km (GJ/pass-km). For freight transport, the indicators are given in gigajoules/ton-km (GJ/ton-km). For both passenger and freight transport, calculation results of EEIs are in terms of GJ/vehicle-km.

Multiplying the estimated EEIs with transport demand in terms of vehicle-km, passenger-km (for passengers), and ton-km (for freight), we can move up to the higher level of the pyramid to calculate the total energy consumption of the transport sector, i.e. in totality as well as by modes.

Finally, we also calculate transport efficiency or intensity that relates energy consumption with the economy of the country. For passenger transport, the indicator is energy consumption per GDP/capita whilst that for freight, it is energy consumption per GDP.

2. Effective Sampling Survey

The research team collected 203 questionnaires on the road and transport sector from 871,350 registered vehicles, 138 locomotives, 34 aircraft, and 60 ships using random sampling. In July 2019, the joint working group, which included experts from ERIA, decided to exclude ship research, so the remaining 200 sampling surveys were considered useful.

3. Transport Sector Characteristics

The transport sector is one of the most important sectors for the economy of Mongolia, considering the country's relatively sparsely settled populations and wide steppes. Mongolia has 3,423 business entities and organisations operating in four main modes, which is land (road, rail), air, and water (shipping) transport, 48.7% of which are operating regularly.

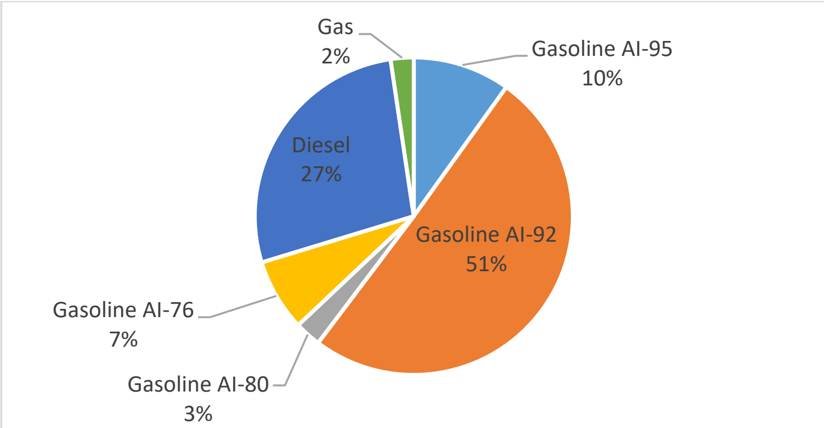
3.1. Road transport mode statistics

Road transport in Mongolia consists of sedans, taxis, trucks, buses, and special purpose vehicles. In 2018, the total number of registered road vehicles was 871.3 thousand, an increase of 56.3 thousand or 6.9% from 2017.

Of those registered in Mongolia, 53.2% are right-hand drive vehicles (i.e. the steering wheel is on the right side) and 46.8% are left-hand driven. Road vehicles aged 10+ years comprise 75.9%; those aged 7–9 years, 14.03%; those aged 4–6 years, 6.3%; and those aged 0–3 years, 3.74%. In terms of engine capacity, 32.77% have up to 1,500 cm^3; 38.04% have 1,501–2,500 cm^3; 14.16% have 2,501–3,500 cm^3; 4,18% have 3,501–4,500 cm^3; and 10.85% have 4,501 cm^3 and above.

Road transport vehicles run on the following types of fuel: 31.86%, on AI-92 gasoline; 9.89%, on AI-95; 2.67%, onAI-80; 7,34%, on A-76; 27.36%, on diesel fuel; 2.34%, on gas; and 0.02%, on electricity.

Figure 4-3. Share of Fuel Type Used by Road Vehicles (%)



Source: MEEI.

Of the total registered road vehicles in Mongolia, 67.2% passed through governmental technical inspection in 2018. Cars that did not pass through governmental technical inspection were not excluded from the state registration database.

Table 4-1 shows the total number of registered and those that passed through governmental technical inspection vehicles in provinces, in the capital, and in regions. Ulaanbaatar has the highest number of road vehicles; it comprises more than 57% of the total registered road vehicles in Mongolia and around 68% road vehicles that passed through technical inspection. Amongst the road vehicles that passed through technical inspection in Ulaanbaatar in 2018, 72.8% or 309.8 thousand are passenger cars (sedans); 57.2% or 75.3 thousand are trucks; 55.5% or 10.3 thousand are buses; and 69.4% or 6.4 thousand are special purpose vehicles.

Table 4-1. Total Number of Registered Road Vehicles and Those that Passed through Governmental Technical Inspection (2018)

Provinces/Capital	Registered	Passed through Governmental Technical Inspection
Western region	**75,935**	**44,988**
Bayan-Ulgii	17,501	17,941
Gobi-Altai	12,557	4,545
Zavkhan	14,424	5,037
Uvs	13,958	9,452
Khovd	17,495	8,013
Khangai region	**122,062**	**54,783**
Arkhangai	14,717	6,135
Bayankhongor	19,969	4,986
Bulgan	12,743	7,896
Orkhon	25,994	19,226
Uvurkhangai	23,917	5,346
Khuvsgul	24,722	11,194
Central region	**129,450**	**67,905**
Gobisumber	3,557	2,311
Darkhan-Uul	24,133	8,941
Dornogobi	19,554	11,909
Dundgobi	10,829	2,818
Umnugobi	28,521	22,700
Selenge	25,038	11,219
Central region	17,818	8,007
Eastern region	**41,969**	**15,962**
Dornod	15,565	6,121
Sukhbaatar	12,052	6,083
Khentii	14,352	3,758
Ulaanbaatar	**501,934**	**401,725**
Total	**871,350**	**585,363**

Source: National Statistics Office of Mongolia (2018a).

Table 4-2. Types of Vehicles that Passed through Technical Inspection (2018)

Types	2016	2017	2018
Bus	18,912	18,550	18,570
Truck	111,431	120,751	131,573
Car	360,513	388,448	426,065
Special	8,296	8,650	9,155
Total	**499 152**	**536 399**	**585,363**

Source: National Statistics Office of Mongolia (2018a).

According to the National Statistics Office of Mongolia (2018b), in 2018, there were around 196.6 million passengers, and passenger turnover was 2.125 billion passengers- km. The number of passengers from 2017 decreased by 15.3 million or 7.3% whilst turnover increased by 84.8 million passengers-km or 4.2%.

Total cargo transported in 2018 was 441,389,000 tons, which increased by 12,926,000 tons or 41.4% from 2017. Cargo turnover reached 6.8 billion tons-km in 2018, which increased by 1.083 billion tons-km or 19% from the previous year.

3.2 Statistics on railway sector

In 2018, the total railway length nationwide was 1,920 km, which means a density of 1.22 km/km^2. In 2018, government and private companies provided freight and passenger services with 138 locomotives; 3,571 freight wagons; and 608 passenger wagons.

According to the National Statistics Office of Mongolia (2018a), in 2018, railway transport carried 2.6 million passengers, which decreased by 578,000 persons or 2.2% from 2017. Of the total number, 2.5 million people or 95.4% travelled domestically and 1,182,000 or 4.6% travelled abroad. The number of international passengers increased by 0.6% over the previous year, and local passengers decreased by 0.6%. Railway turnover reached 993.7 million passengers-km in 2018, which increased by 20.5 million passengers-km or 2.11% from 2017.

The same statistics source shows that 25.763 million tons of freight were transported by railway, which increased by 3.0 million tons or 13.2% from the previous year. International freight transport by railway was 59.9% and locally transported freight was 40.1%. From the total number of freights transported internationally by railway, exports comprised 60.1% or 9.3 million tons; imports comprised 18.1% or 2.8 million tons; and transit transport comprised 21.8% or 3.4 million tons. The freight turnover of railway reached 15.3 billion tons-km, which increased by 1.8 billion tons-km or 13.5% from 2017. From these, 2.9 billion tons-km or 18.7% are local, 7.3 billion tons-km or 47.7% are exports, 1.4 billion tons-km or 9.2% are imports, 3.7 billion tons-km or 24.4% are transit freight.

3.3 Aircraft statistics

The number of aircraft registered in Mongolia is 34. In 2018, the number of certified aircraft was 18, with a total of 8 large aircraft, 6 medium-sized aircraft, and 4 small aircraft.

The National Statistics Office of Mongolia (2018a) shows that the aircraft sector transported a total of 1.4 million passengers in 2018: an increase of 1.707 million people or 13.6% over the previous year.

The number of passengers by domestic flight reached 4.016 million people, increased by 7.657 million passengers or 23.5% compared to 2017. International flights were taken by 1.02 million people, an increase of 9.415 million people or 10.16% over the previous year.

Table 4-3. Main Indicators of Auto Transport

Indicator	2015	2016	2017	2018
Auto transport				
Number of passengers, million	256.5	260.7	212.2	196.9
Turnover of passengers, million passengers-km	1,940.5	1,959.9	2,040.9	2,125.7
Transported freight, million tons	13,043.7	20,406.2	31,212.9	44,138.9
Freight turnover, million tons-km	2,374	4,236.2	5,661.3	6,744.9
Transport revenue, billions ₮	345.1	467.2	506.4	627.83
Railway transport				
Number of passengers, million	2.79	2.64	2.63	2.57
Turnover of passengers, million passengers-kilometres	996.7	955.5	973.2	993.7
Transported freight, million tons	19,150.8	19,989.1	22,765	25,763.3
Freight turnover, million tons-kilometres	11,462.6	12,371	13,493.3	15,315.3
Transport revenue, billions ₮	387.9	441.8	530	616.48
Air transport [a]				
Number of passengers, million	0.9	1	1.2	1.42
Turnover of passengers, million passengers-kilometres	1,123.3	1,156.5	1,363.2	1,573.5
Transported freight, million tons	4.7	4.8	5.3	5.7
Freight turnover, million tons-kilometres	7.7	8.1	7.8	7.8
Transport revenue, billions of MNT	254.3	287.3	385.5	442.2

₮ = Mongolian currency *tugrik.*

[a] Information from Civil Aviation Authority of Mongolia.

Source: Ministry of Road and Transport Development (2018).

4. Calculation of Fuel Consumption and Efficiency Indicators

4.1 Road modes

For road freight and road passenger modes, fuel consumption is calculated using the following equation:

$$FC_{veh} = FCF_{veh}.DEM_{veh}.EC_{fuel}.10^4 \quad \text{(i)}$$

Where

FC_{veh} = fuel consumption (megajoule or MJ)

FCF_{veh} = fuel consumption factor (litre/ 100 km)

DEM_{veh} = transport demand (millions of vehicles-km)

EC_{fuel} = energy content (MJ/litre)

veh are all vehicle types included in the survey, i.e. passenger road vehicles (cars or sedans, buses, taxis) and freight road vehicles (trucks).

Table 4-4. Fuel Types in Relation to Road Vehicle Types

Fuel Type	Vehicle Type
Gasoline	Cars (sedans), taxi
Diesel	Buses, trucks, rail passenger, rail freight

Source: Authors' elaboration.

Table 4-5. Energy Content of Each Fuel Type

Fuel Type	Energy Content (MJ/litre)
Gasoline	35.2
Diesel	37.3

Source: Authors' elaboration.

The fuel consumption factor (FCF_{veh}) is calculated based on the vehicle survey results of the Mongolian Energy Economics Institute (MEEI) (Table 4-6).

The average technical norm consumption of gasoline of cars (sedans) is 10.3 litres/ 100 km whilst that of buses is 35.4 litres/100 km. For trucks, the sample survey was taken from 70 trucks, of heavy-carrying capacity diesel engines, from Nord Benz, Howo and Beiben of China, which are widely used in Mongolia. Trucks included in the survey have an average technical norm consumption of 62.1 litres/100 km, and aged 0–15 years.

Table 4-6. Calculated Average Fuel Economies (Fuel Consumption Factors)

Mode		Vehicle Type	Fuel Consumption Factor (litres/100 km)
Road passenger		Cars	10.3
		Buses	35.4
		Taxis	8.0
Road freight		Trucks	62.1

Source: Authors' calculation.

Road transport demand (DEM_{veh}) in millions of vehicles-km is calculated by the following equation.

$DEM_{veh} = NB_{veh}.DIST_{veh}.UR_{veh}.10^{-6}$ (ii)

NB_{veh} = number of vehicles which is taken from data (Table 4-2)

$DIST_{veh}$ = average yearly distance (km/vehicle)

UR_{veh} = average fleet utilisation rate

The survey conducted by the MEEI gives some information on the average annual distance travelled by each vehicle type ($DIST_{veh}$) (Table 4-7). A study conducted by Batjargal and Matsumoto (2017) also provide information on the average annual distance of some vehicle types in Mongolia. Each information shows some differences.

For passenger cars, the MEEI survey shows an average mileage of nearly 23,700 km/year whilst Batjargal and Matsumoto's (2017) value is 12,000 km. The latter value was selected as the study focused on road emission in Ulaanbaatar and should give more precise estimate of the annual distance (in kilometres) than the MEEI survey.

Table 4-7. Average Trip Distance of Vehicles based on MEEI Survey

Vehicle Type	Assumed Fuel	Average Distance of Trip (km/vehicle)		
		Per day	Per month	Per year
Cars (sedans)	Gasoline	49	1,974	23,690
Buses	diesel	241	5,712	68,545
Taxis	Gasoline	234	7,450	89,400
Trucks	diesel	292	3,288	39,458

Source: Authors' calculation.

Furthermore Amarsaikhan (2016) stated that around 60% of all motor vehicles were registered in Ulaanbaatar, which confirmed statistics shown in the section 0.

For taxis, the values of both sources do not differ much. For the same reason as for passenger cars, the value of Batjargal and Matsumoto (2017), i.e. 73,000 km, was selected.

The two resources show different values for trucks' yearly distance travelled. Calculating transport demand and using Batjargal and Matsumoto's (2017) value of 12,000 km and comparing it to the transport demand data – i.e. 6.775 billion tons-km (section 0) – would give an average carried load of 10.7 tons per truck. MEEI survey results would give an average carried load of 1.8 tons per truck, which is relatively too low. Herewith, 12,000 km was selected as the average yearly distance travelled (in kilometres) of trucks.

For buses, the values from both sources differ quite a lot: 39,458 km per MEEI survey and 6,000–12,000 km per Batjargal and Matsumoto (2017). An old study from JICA (1994) mentioned that in the early 1990s, buses' average mileage in Mongolia was around 317 km/day or around 116,000 km/year. Using that information, the value of MEEI results, i.e. 86,546 km, was chosen.

Table 4-8. Annual Average Mileage for Road Vehicles

Vehicle Type	Annual Distance per Vehicle (km)		
	MEEI survey (2019)	Batjargal and Matsumoto (2017)	Selected value
Cars	23,690	12,000	12,000
Taxis	89,400	73,000	73,000
Trucks	39,458	6,000–12,000	12,000
Buses	68,546	6,000–15,900	68,546

Source: Authors' elaboration.

The average utilisation rate (UR_{veh}) is the ratio of vehicles in active operation to the total number of vehicles in the fleet. There is no data on Mongolian utilisation rates of road transport modes. Even if this aspect is understudied in Asia, this study tried to look for some available references to be used as inputs for Mongolia.

The World Bank (2005) estimated that between 2000 and 2003, the utilisation rates of buses in Chennai, India are 78%–81% whilst for Bangalore the rates are 95%–96%. Karali et al. (2019) concluded that in India, the utilisation rates of buses nationwide are about 90% for the last decade whilst for trucks, the rates are much lower, 55%– 70%.

For passenger road modes, we assume that utilisation rates in Mongolia are significantly lower than those of India. Departing from that assumption, we used the total road passenger transport turnover of 2,126 passengers-km (see section 0) as the benchmark to calculate a reasonable road passenger transport demand (DEM_{veh}) in millions of vehicles-km and found the following utilisation rates reported in Table 4-9.

Table 4-9. Assumed Road Vehicle Fleet Utilisation Rates

Vehicle Type	Fleet Utilisation Rate
Cars	0.1
Buses	0.3
Taxis	0.3
Trucks	0.4

Source: Authors' elaboration.

Finally, the total energy efficiency for road passenger modes (road pass) in terms of MJ/passenger-km is calculated as follows:

$$EE_{roadpass} = (FC_{sedans} + FC_{buses} + FC_{taxis}).10^{-6}/TO_{roadpass} \quad \text{(iii)}$$

Where $TO_{roadpass}$ is road passenger transport turn-over (million passengers-km) from section 0 .

For trucks, the calculation is as follows:

$$EE_{roadfreight} = (FC_{trucks}).10^{-6}/TO_{roadpass} \quad \text{(iv)}$$

4.4.2 Rail modes

For road freight and road passenger modes, fuel consumption is calculated using the following equation:

$$FC_{veh} = FCF_{veh}.DEM_{veh}.EC_{fuel}.10^{-2} \quad \text{(v)}$$

Where

FC_{veh} = fuel consumption (megajoule or MJ)

FCF_{veh} = fuel consumption factor (litre per 100 km)

DEM_{veh} = transport demand (vehicles-km)

EC_{fuel} = energy content (MJ/litre) of diesel fuel, i.e. 37.3

veh or vehicle in rail transport in this study is in fact the sets of trains consisting of locomotive and their tracked wagons. *veh* consists of two modes, i.e. rail freight and rail passenger.

Transport demand DEM_{veh} is calculated by multiplying the number of vehicles, the average yearly kilometre, and the fuel consumption.

$$DEM_{veh} = NB_{veh}.(\frac{RAILCAR_{veh}}{\sum_{veh} RAILCAR_{veh}})DIST_{veh}.UR_{veh} \qquad \text{(vi)}$$

Where

$RAILCAR_{veh}$ = the number of railcars for each used, i.e. freight and passenger.

Table 4-10. Results of Vehicles Survey (Average Value)

Vehicle Type	Assumed Fuel	Norm l/100 km	Distance of Trip/Km		
			Per day	Per month	Per year
Railway locomotives	diesel	2,125	336	3,583	42,990

Source: MEEI.

We assume a value of 0.9 as the utilisation rate of both rail freight and rail passenger modes.

EEIs are calculated the same way as in the road modes (section 0).

4.3 Air passenger modes

For air passenger mode, fuel consumption is calculated using the following equation:

$FC_{veh} = FCF_{veh}.DEM_{veh}.EC_{fuel}.10^4$ (vii)

Where

FC_{veh} = fuel consumption (megajoule or MJ)

FCF_{veh} = fuel consumption factor (kg per vehicle-km)

DEM_{veh} = transport demand (millions of vehicles-km)

EC_{fuel} = energy content which is assumed to be 43 MJ/kg jet fuel.

Passenger air transport demand (DEM_{veh}) in vehicles-km is calculated in the same way as in the road modes, i.e. multiplying the number of aircraft with the average annual distance (kilometres per aircraft) and the assumed utilisation rate of the fleet (assumed to be 0.95).

The fuel consumption factor (FCF_{veh}) in terms of kilogram of fuel per vehicle-km is calculated as the fuel consumption weighted average of the aircraft types included in the survey performed by the MEEI. However, as we used external sources of information on aircraft fuel consumption and cruising speed, i.e. Purwanto et al. (2017), the MEEI results show some inconsistencies.

Table 4-11. Average Aircraft Fuel Consumption Factors

Type of Aircrafts Surveyed	Average Fuel Consumption (kg/hour)	Average Cruising Speed (km/h)
B737	3,340	605
B767	6,449	639
B767	6,449	639
B737	3,340	605
F-50	1,011	321
10-360L2A	916	271
ERJ-145	2,360	444
B767-300	6,449	639
Forcer-50	1,011	321
B767-300	6,449	639
B767-300	6,449	639

Source: Purwanto et al. (2017).

5. Calculation Results

5.1 Energy efficiency

Table 4-12 to Table 4-16 show the results of transport sector EEIs. For passenger transport, the EEIs are calculated in gigajoules/passenger-km (GJ/pass-km); for freight transport, the indicators are given in gigajoules/ton-km (GJ/ton-km).

For both passenger and freight transport, the calculation results of EEIs in terms of GJ/vehicle-km are given (Table 4-12).

Table 4-12. Calculation Results of Road Passenger Mode

Vehicle Type	Number of Vehicles	Average yearly (km)	Average Fuel Consumption Factors (litre/100 km)	Assumed Utilisation Rate	Transport Volume (million vehicles-km)	Assumed Fuel Type	Assumed Energy Content (MJ/litre)	Fuel Consumption (GJ)	Road Passenger Turnover (million passengers-km)	Energy Efficiency (GJ/passengers-km) indicators (GJ/pass-km)	Energy Efficiency Indicators (GJ/vehicle-km) (GJ/veh-km)
Sedans	426,065	12,000	10.3	0.1	511.278	gasoline	35.2	1,852,875			0.0036
Buses	18,570	16,000	35.4	0.3	89.136	diesel	37.3	1,177,720			0.0132
Taxis	800	73,000	8.0	0.3	17.52	gasoline	35.2	49,585			0.0028
Road Passenger					617.934			3,080,180	2,125.70	0.0014	0.0050

Source: Authors' calculation.

Table 4-13. Calculation Results of Roadc Freight Mode (Trucks)

Vehicle Type	No. of Vehicles	Average Yearly Distance (km)	Average Fuel Consumption (litre/100 km)	Assumed Utilisation Rate		Transport Volume (vehicles-km)	Assumed Fuel	Assumed Energy Content (MJ/litre)	Fuel Consumption (GJ)	Freight Turnover (million tons-km)	Energy Efficiency Indicators (GJ/ton-km)	Energy Efficiency Indicators (GJ/vehicle-km)
Trucks	13,1573	12,000	12.0	0.4		631,550,400	diesel	37.3	14,625,887	6,744.9	0.0021	0.0231

Source: Authors' calculation.

Table 4-14. Calculation Results of Rail Passenger Mode

Vehicle Type	Total no. of Locomotives	No. of Passenger Wagons	Average Annual Distance (km)	Utilisation rate	Average Fuel Consumption Factor (litre/100 km)	Transport Volume (locomotives-km)	Assumed Fuel	Assumed Energy Content (MJ/litre)	Fuel Consumption (GJ)	Passenger Turnover (million passengers-km)	Energy Efficiency Indicators (GJ/passengers-km)
Locomotives	138	608	42,990	0.9	2,215	776,820	diesel	37.3	641,775	993.70	0.00065

Source: Authors' calculation.

Table 4-15. Calculation Results of Rail Freight Mode

Vehicle Type	Total no. of Locomotives	No. of Freight Wagons	Average Annual Distance (km)	Utilisation Rate	Average Fuel Consumption Factor (litre/100 km)	Transport Volume (Locomotives-km)	Assumed Fuel	Assumed Energy Content (MJ/litre)	Fuel Consumption (GJ)	Freight Turnover (million tons-km)	Energy Efficiency Indicators (GJ/tons-km)
Locomotives	138	3,571	42,990	0.9	2,215	4,562,538	diesel	37.3	3,769,374	15,315.30	0.00025

Source: Authors' calculation.

Table 4-16. Calculation Results of Air Passenger Mode

Vehicle Type	No. of Vehicles	Average Annual Distance (km)	Average Fuel Consumption Factor (kg fuel/vehicle hour)		Assumed Utilisation Rate (kg fuel/vehicle-km)	Transport Volume (vehicles-km)	Assumed Fuel	Assumed Energy Content (MJ/kg fuel)	Fuel Consumption (MJ)	Fuel Consumption (GJ)	Passenger Turnover (million passengers-km)	Energy Efficiency Indicators (GJ/passengers-km)
Air passenger	18	510,327.27	5,022	8.16	0.95	8,726,596	jet fuel	43	3,062,454,294	3,062,454	1,573.50	0.0019

Source: Authors' calculation.

Table 4-17 compares the results of the international study on energy efficiency in the transport sector.

Table 4-17. Comparison of Energy Efficiency of the Transport Sector

Research	Road Passenger MJ/pkm	Road Freight MJ/tkm	Air Passenger MJ/pkm	Rail Passenger MJ/pkm	Rail Freight MJ/tkm	Car MJ/vkm	Bus MJ/vkm	Taxi MJ/vkm
Mongolia - 2018	**1.44**	**2.17**	**1.95**	**0.65**	**0.25**	**3.62**	**13.21**	**2.83**
IEA - Japan - 2005		7		0.2	0.12			
IEA - Japan - 2015		5		0.18	0.1			
IEA - Korea - 2005		4.1		0.3	0.6			
IEA - Korea - 2015		3.2		0.2	0.05			
PWC - Europe - 2005	1.45			0.46				
ECF EU28 - 2015			2	0.3		3	17	
IEA/ESTSAP 2010 - China				0.2	0.3			
IEA/ESTSAP 2010 - India				0.3	0.2			
Non-OECD Asia 2015				1.3	1.3			
France - 2010						1.87		
IEA			3.1	0.17				

ESTSAP = Energy Technology Systems Analysis Program, IEA = International Energy Agency, OECD = Organisation for Economic Co-operation and Development, PWC = PriceWaterhouse and Coopers.
Source: Various sources (Authors' elaboration).

There is certain comparability of the results of Mongolia's rail transport EEIs that we have calculated to those produced in the studies of Japan, Korea, China, and India. The high values of rail passenger and freight in Mongolia indicate that the development of modern vehicles (locomotives) have not yet penetrated the country and more outdated technology is still in use in Mongolia.

It is not easy, however, to find studies on other modes from other Asian countries. Nevertheless, comparing the transport EEIs of the world, the European region, and some European countries such as France, with the results shown for Mongolia indicates that the methodology we used in this study is in the right direction. Some improvements need to be conducted, however, especially in the quality of survey results and in validating the process of data collection. These improvements should result in more reliable and robust efficiency indicators' values for Mongolia to be compared with those of other countries or regions.

5.2 Total energy consumption

Table 4-18. Estimated Energy Consumption of the Transport Sector (GJ and %)

Transport Mode	Fuel Consumption (GJ)	Share (%)
Road passenger	3,080,180	12.2
Road freight	14,625,887	58.1
Rail passenger	641,775	2.5
Rail freight	3,769,374	15
Air passenger	3,062,454	12.2

Total transport	25,179,671	100

Source: Authors' calculation.

According to the estimation results (Table 4-18), 58% of the total fuel consumption in the transport sector goes to road freight mode, i.e. trucks, and 15% goes to rail freight modes. Air and road passenger modes consume around 12% each, and rail passenger mode consumes around 2.5%.

5.3 Energy intensity: relating energy consumption to the economy

Based on IEA (2014b) using the nominal GDP per capita 2018 data for Mongolia of 4,122 US$/capita and the calculated total energy consumption in passenger transport of 6,784,409 GJ, the passenger transport energy intensity in Mongolia is calculated at 1,646 GJ/US$ per capita. This means that for each US dollar per capita, Mongolia needs to consume energy in terms of its passenger transport activity of around 1,646 GJ or about 39 tonnes of oil equivalent (toe) by.

For freight transport, Brunel (2005) and IEA (2014b) define transport intensity as the ratio between the number of tons-km realised in a country by freight vehicles and the value of the GDP of this country. It represents the number of transport units (ton-km) made by freight vehicles necessary to produce one unit of output, i.e. GDP (US$1.00).

For Mongolia, with the 2018 industry GDP of about US$4,970 and a total freight transport turnover of 22,060 million ton-km, the freight transport intensity is around 0.004 ton-km/US$. This means that in 2018 Mongolia needed 4 kg-km of goods to be transported by freight vehicles to produce US$1.00 of GDP.

As the total freight transport in Mongolia consumed about 18.4 million GJ in 2018, then the freight transport energy intensity of Mongolia was estimated at 3.7 kJ/US$ or around 0.103 litre of diesel fuel/US$. This signifies that, in 2018, Mongolia's freight transport needed to consume around 0.103 litres of diesel fuel to produce US$1.00 of GDP.

Chapter 5
Commercial Sector

1. Energy Efficiency Indicators in the Commercial Sector

Energy efficiency indicators (EEIs) in the commercial sector are intensities, presented as a ratio between yearly energy consumption (measured in energy unit, kWh) and gross floor area (measured in square metre). This ratio is referred to as building energy intensity (BEI) in this chapter. For meaningful comparison, the BEI values are compared only amongst the same building sub-sector or building category. In other words, the BEIs of office buildings, retail buildings, hotels, hospitals, etc. are compared within the same category or type of building. Therefore, BEIs are computed at the sub-sectoral level and are computed as follows:

$$Building\ Energy\ Intensity = \frac{Yearly\ energy\ consumption}{Gross\ floor\ area}$$

Where:

1) Yearly energy consumption is the total energy usage in a building in one year.

2) Gross floor area is the gross build-up area of a building including common areas such as reception area, corridors inside buildings, etc. but excludes any covered carpark area.

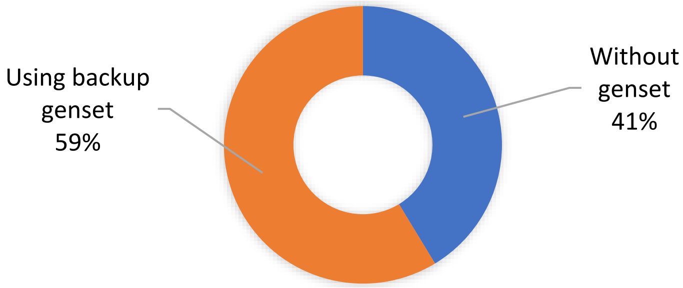
2. Effective Samples

Amongst the 200 survey data collected from the commercial sector, four survey s questionnaire had insufficient data. The remaining 196 survey questionnaires were considered valid samples for analysis. The heat energy usage was estimated using a calculation method. The segregation of electricity usage by appliance was not considered in this study.

3. End-Use of Energy of Sub-sectors

All business entities involved in the survey are mainly connected to the central power grid and most entities use backup power from gensets, which use diesel fuel.

Figure 5-1 Share of Generator Set Installations as the Commercial Sector's Backup Energy Source



Source: MEEI.

In total, 59% of the entities used a backup power source, and only 41% entirely relied on electricity from the centralised network.

Table 5-1 shows the consumption of different types of energy – electricity, heat, diesel, and gas – used in the commercial sector (Table 5-1).

Table 5-1. Energy Consumption of Each Sub-sector (kWh)

Type of Energy	Restaurant	Hotel	Office	Shopping Mall	Hospital
Electricity	2,296,885	23,929,114	43,241,914	75,633,432	14,656,147
Diesel generator	-	303,610	269,660	122,899	793,363
LPG	7,379,789	-	-	-	-
Heat	8,801,068	43,645,983	359,783,676	79,467,285	30,774,046
Total energy consumption	**18,477,743**	**67,878,708**	**403,295,251**	**155,223,616**	**46,223,557**

LPG = liquefied petroleum gas.
Source: MEEI.

The percentage breakdown of energy sources for each sub-sector is shown in Table 5-2. It should be highlighted that liquefied petroleum gas (LPG), which takes up about 40% of the total energy consumption in this sub-sector, is mainly used in restaurants for cooking.

Table 5-2. Percentage Share of Energy Sources, by Subsector

Type of Energy	Restaurant, % (22 samples)	Hotel, % (23 samples)	Office, % (108 samples)	Shopping Mall, % (23 samples)	Hospital,% (24 samples)
Electricity	12	35.3	10.7	48.2	34.1
Diesel (for generators)	-	0.4	0.1	0.1	2
LPG	40	-	-	-	-
Heat (space heating)	48	64.3	89.2	51.2	63.9
Total energy consumption	**100**	**100**	**100**	**100**	**100**

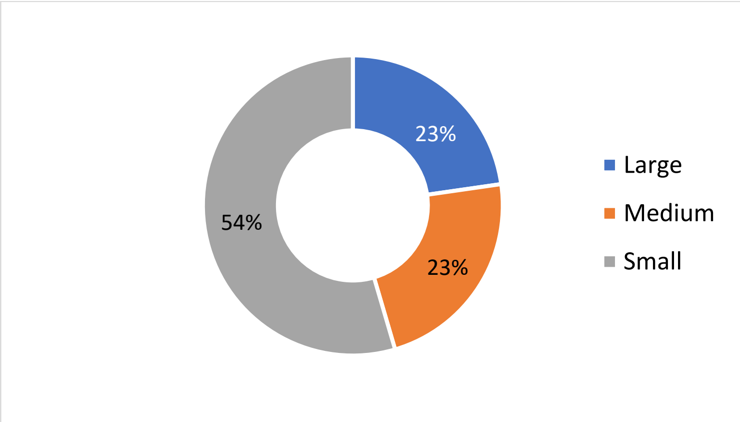
LPG = liquefied petroleum gas.

Source: MEEI.

3.1. Restaurant

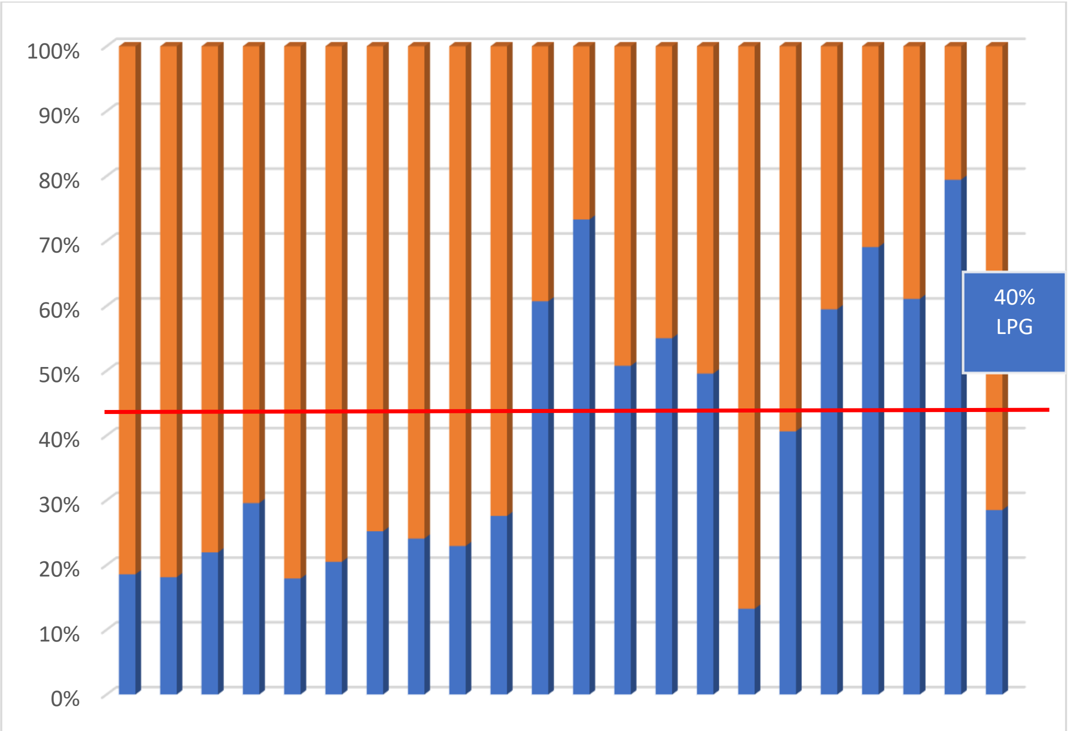
Businesses entities in this sub-sector use substantial LPG for cooking. About 54% of the surveyed entities are small restaurants; the other 23% are medium, and the remaining 23% are large restaurants, including large banquet halls.

Figure 5-2 Restaurants, by Size



Source: MEEI

Figure 5-3 Percentage Share of LPG vs Other Energy Sources Used in Restaurants



LPG = liquefied petroleum gas.

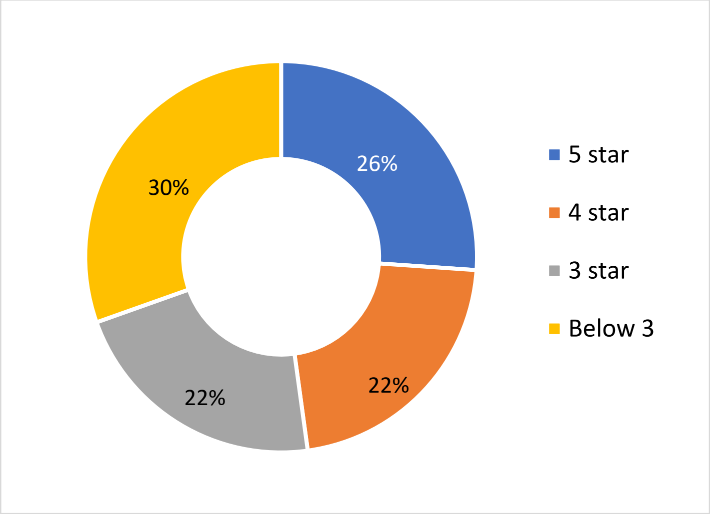
Source: MEEI.

According to the survey, 40% of the energy consumption of restaurants and banquet halls come from LPG (Table 5-2 and Figure 5-3).

3.2 Hotel

The majority of hotels are three stars or above, and the remaining 30% are smaller hotels. All these smaller hotels operate in the countryside and do not use any power source and LPG. Large hotels use backup energy sources and most of them operate in Ulaanbaatar Figure 5-4).

Figure 5-4 Percentage Breakdowns of Hotel Ratings

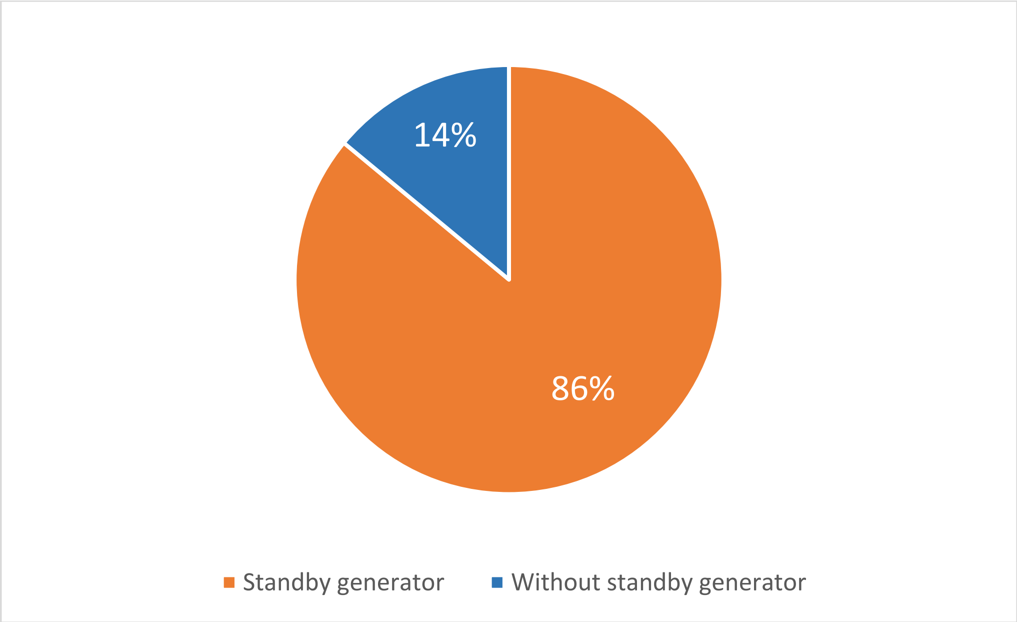


Source: MEEI.

3.3 Office

Most of the surveyed entities do not use any additional backup power source; only 14% use an additional backup source of energy.

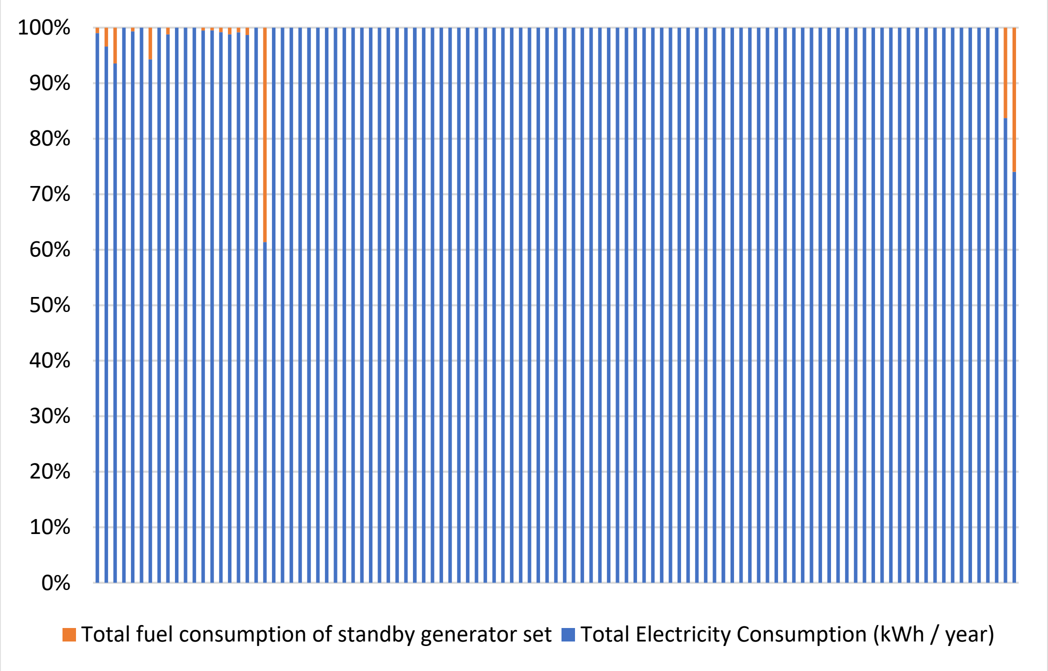
Figure 5-5 Use of Power Source



Source: MEEI.

Companies use backup energy generators for an average of only 10% per year ().

Figure 5-6 Percentage Share of Electricity Consumption vs Fuel Energy Source Used in Office Buildings

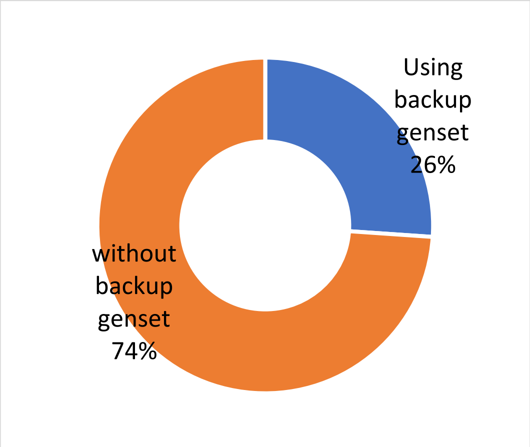


Source: MEEI.

3.4 Shopping mall

About 26% of the shopping malls involved in the survey use backup diesel generators

Figure 5-7 Use of Backup Gensets in Retail Stores and Shopping Centres

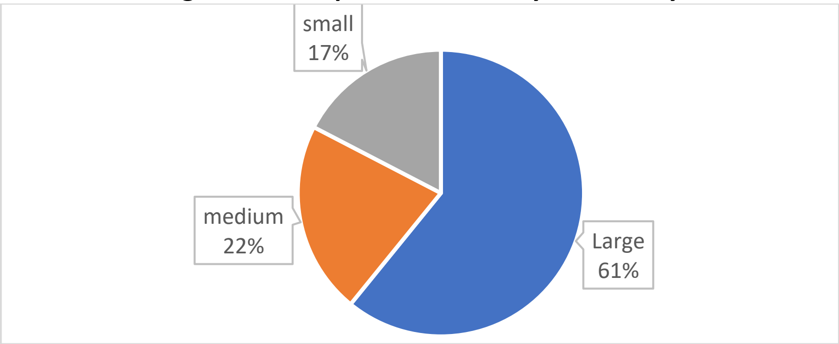


Source: MEEI.

3.5 Hospital

Sixty-one percent of the sample survey was obtained from large hospitals, and all hospitals involved in the survey use backup power sources, as illustrated in Figure 5-8.

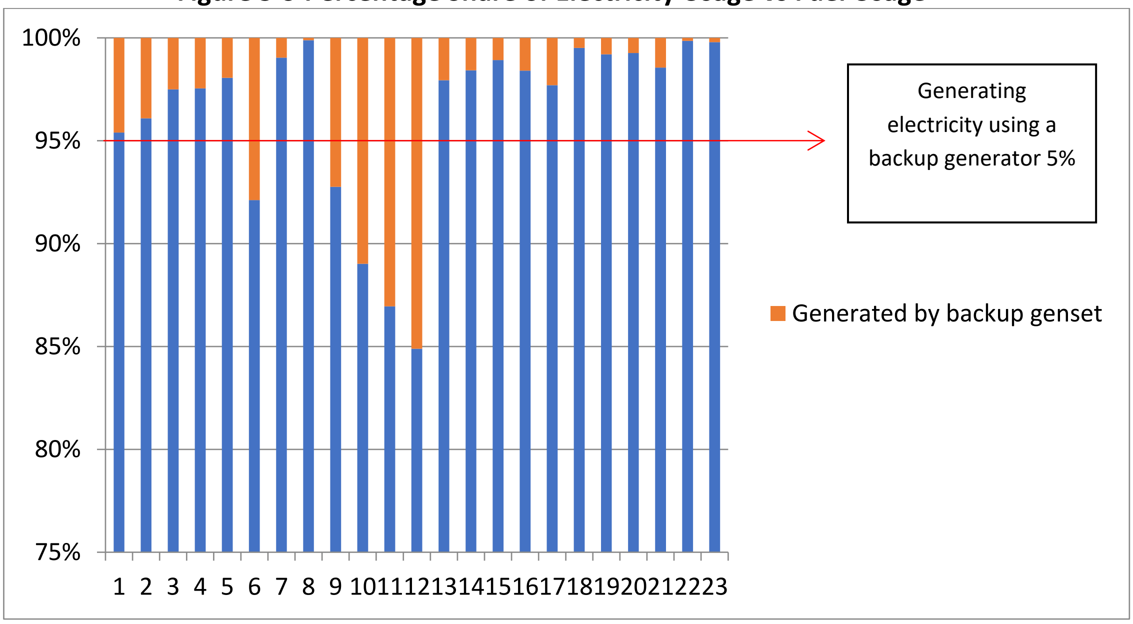
Figure 5-8 Hospitals Covered by the Survey



Source: MEEI.

Figure 5-9shows that hospitals covered in the survey had 5% of the total electricity consumption relying on a backup power source.

Figure 5-9 Percentage Share of Electricity Usage vs Fuel Usage



Source: MEEI.

4. Building Energy Intensity

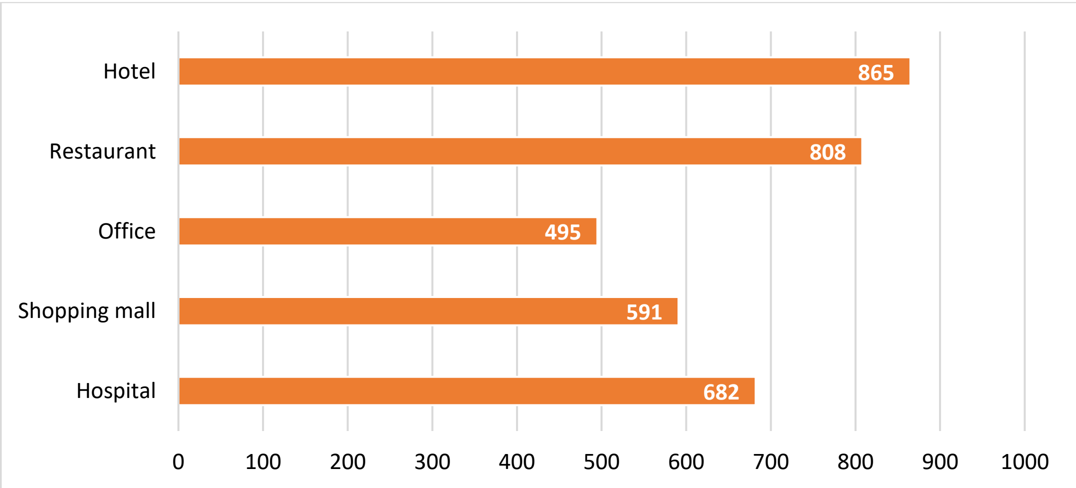
Calculation of the BEI of the commercial sector is based on total yearly energy consumption divided by gross floor area, which is expressed in kWh/m^2/year. The average energy intensity of each sub-sector calculated from the survey data is shown in Table 5-3. It should be highlighted that the values of the average BEIs derived from this survey for the various sub-sectors are only indicative. For more accurate establishment of BEI values, continuous effort to collect quality data is necessary. A larger pool of data with updated review and analyses would improve the accuracy of BEI values that would provide more accurate information on the energy performance of the respective sub-sectors.

Table 5-3. Average Building Energy Intensity

Sector	Average BEI (kWh/m^2/year)
Hotel	865
Restaurant	808
Office	495
Shopping mall	591
Hospital	682

Source: MEEI.

Figure 5-10 Average Building Energy Intensity of Each Sub-sector (kWh/m2/year)



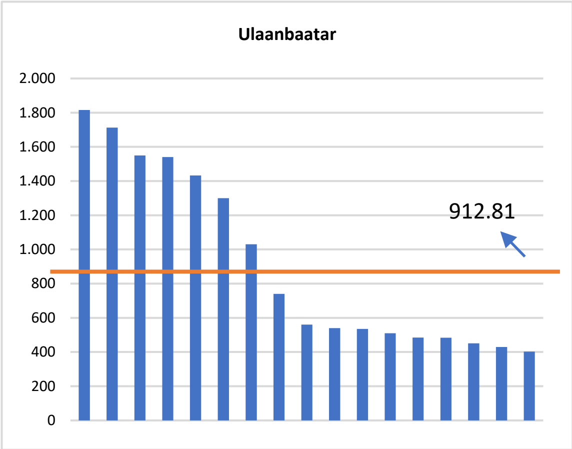
Source: MEEI.

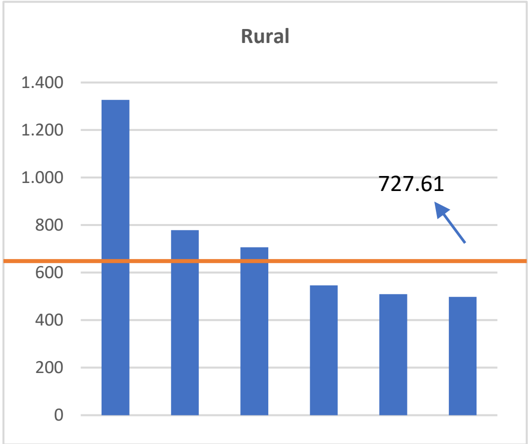
The survey found that the average BEI of hotels is the highest whilst the office sub-sector has the lowest level of energy intensity at 495 kWh/m^2/y. However, it is not correct to compare the BEI of hotels and offices because they are different sub-sectors and their functions are different. First, the operating hours are different: hotels operate 24 hours per day throughout the year compared with 8–10 hours per day during working days for office buildings. Second, hotels have more energy-intensive facilities and services than office buildings. In other words, the comparison of BEIs should be confined to buildings within the same sub-sector or building category.

It is interesting to note that the average BEI for restaurants at 808 kWh/m^2/y is higher than that of shopping malls at 591 kWh/m^2/y although both sub-sectors are expected to have similar operating hours. The difference in this case is possibly due to the large consumption of LPG reported in the restaurant sub-sector. However, more data are required in the future for further validation and verification.

The average BEI of each sub-sector in Ulaanbaatar and rural areas was analysed. Companies operating in Ulaanbaatar consume more energy than rural entities. Comparing the EEIs in both urban and rural areas (Figure 5-11 to Figure 5-15, the average BEI for hotels, offices, hospitals, and restaurants in urban (Ulaanbaatar) areas are generally higher than their respective sub-sectors in rural areas.

Figure 5-11 Average Building Energy Intensity of hotels (kWh/m2/year)

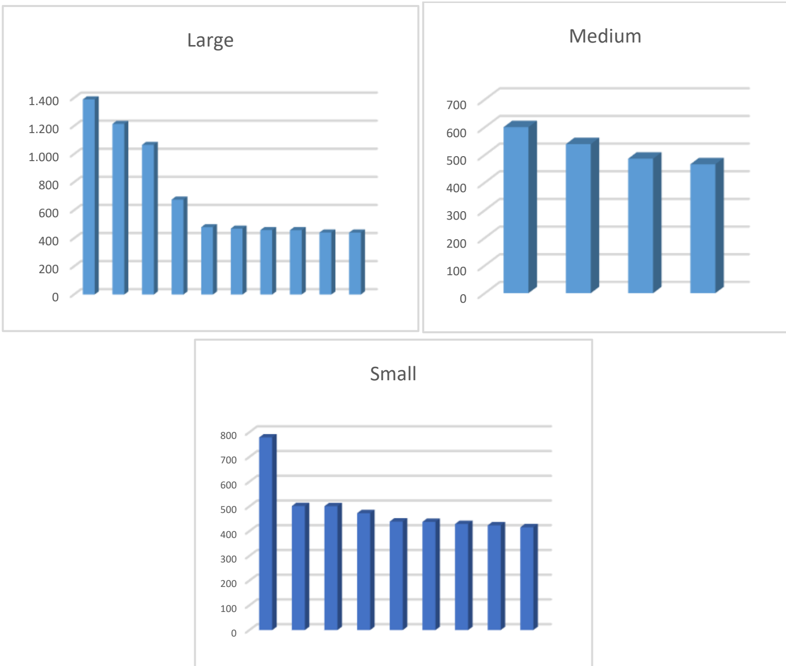




Source: MEEI.

Figure 5-15 5-11shows that hotels in urban areas generally consume more energy than that of rural areas. This is expected because hotels in urban areas are usually equipped with more energy-intensive facilities and services. Figure 5-12 shows the comparison of the average BEI of large, medium, and small retail buildings. In general, large retail buildings are more energy intensive, compared with medium and small retail buildings. It should be noted that the sampling size of the survey of medium-sized retail buildings is insufficient to make a conclusive statement about their energy performnce. However, based on the data available, the their average energy intensity seems to be marginally higher than that of small retail buildings.

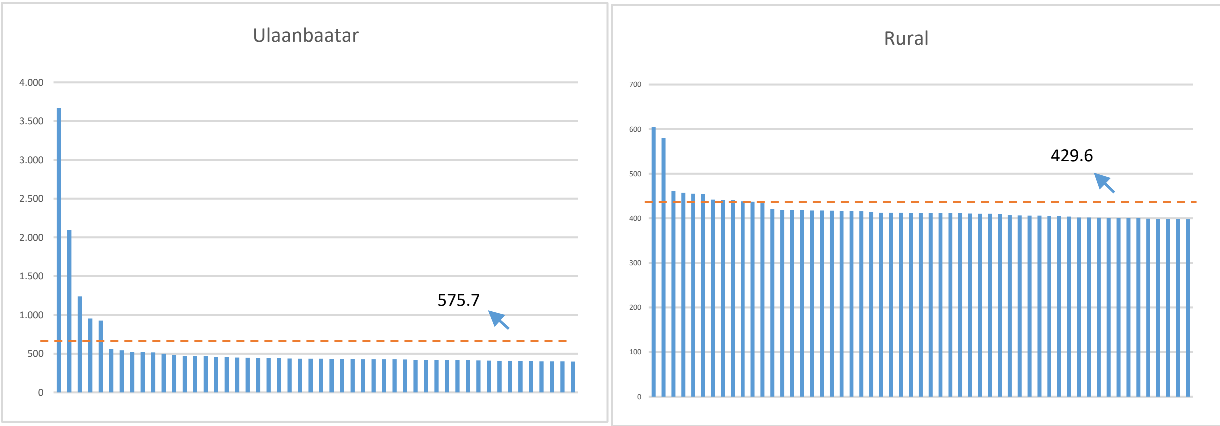
Figure 5-12 Average Building Energy Intensity of Shopping Centres and Stores (kWh/m2/year)



Source: MEEI.

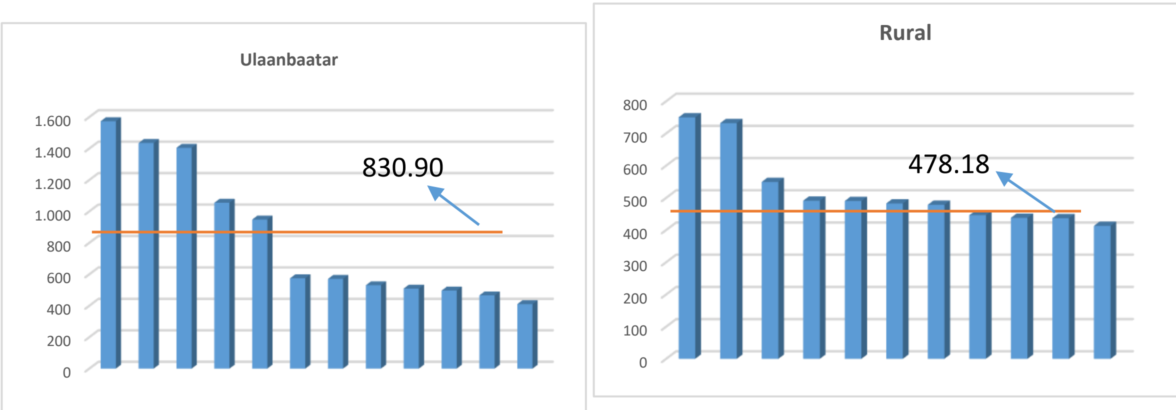
Figure 5-13compares office energy performance between urban and rural areas. The average BEI of urban office buildings is higher than rural office buildings. Similarly, the average BEI of hospitals in urban areas is much higher than that in rural areas, as shown in Figure 5-14. This is likely due to the difference in the range of hospital services in urban areas, compared with that of rural area hospitals. Figure 5-15compares the average BEIs of restaurants in urban and rural areas.

Figure 5-13 Average Building Energy Intensity of Office Buildings (kWh/m2/year)



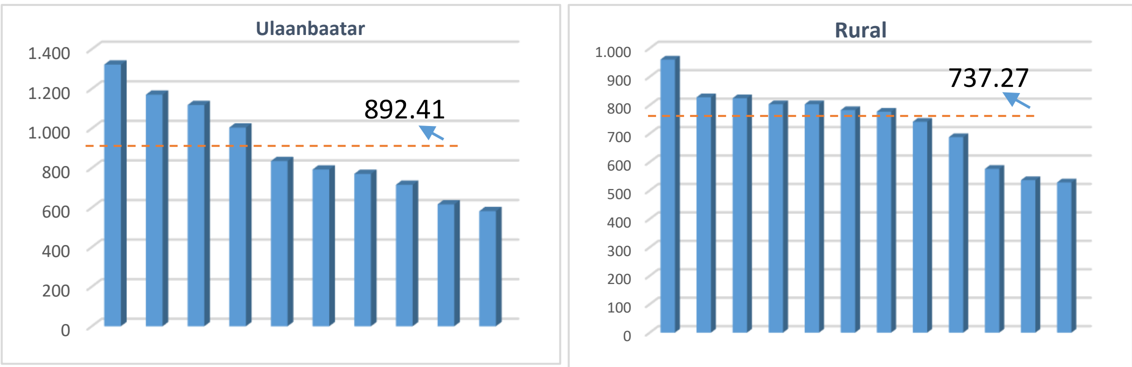
Source: MEEI.

Figure 5-14 Average Building Energy Intensity of Hospitals (kWh/m²/year)



Source: MEEI.

Figure 5-15 Average Building Energy Intensity of Restaurants (kWh/m²/year)



Source: MEEI.

Chapter 6

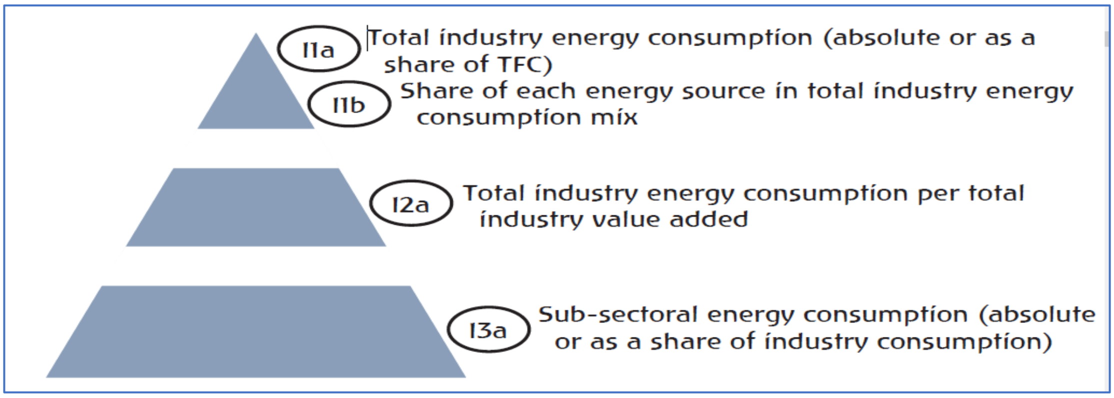
Industry Sector

1. Energy Efficiency Indicators in the Industry Sector

In principle, energy efficiency indicator (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. Since the industry sector is very complex, a detailed understanding of the various processes or product types would be necessary to monitor energy efficiency.

The Manual on Energy Efficiency Indicators (IEA, 2014b) of the International Energy Agency differentiates the aggregate indicators and the disaggregate indicators. The aggregate indicators (Figure 6-1) refer to the overall energy consumption of industry expressed either in absolute terms or as the share in total final consumption and to the share of each energy source in the total industry consumption mix. These two indicators are enough to provide a high-level picture of the sectoral consumption and allow a first comparison across countries, as well as a preliminary assessment of the importance of the various sub-sectors and energy sources.

Figure 6-1 Pyramid of Industry Indicators

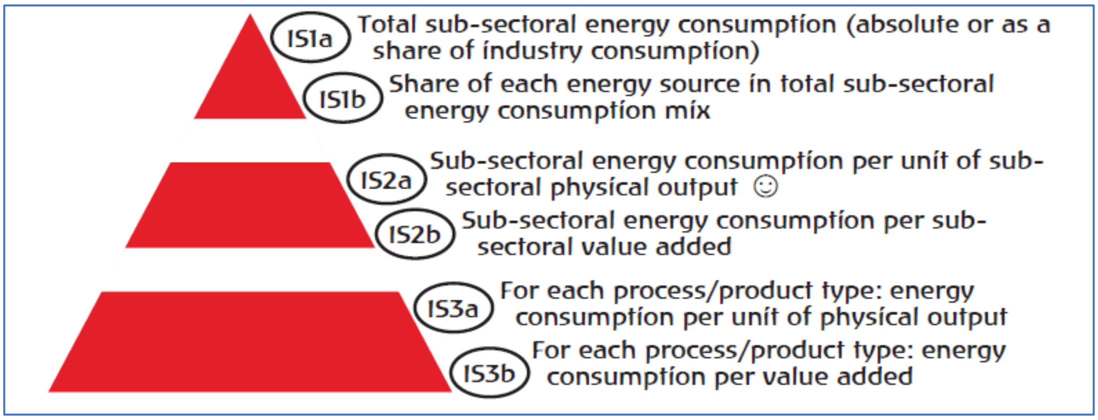


Note: TFC = total final consumption.
Source: IEA (2014b).

Another indicator at the aggregate level refers to intensity, which 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 homogeneous. The value added should be in constant currency to avoid bias induced by fluctuations in the monetary market.

The last level of the pyramid refers to the energy consumption of each sub-sector, as a total or as a share of industry consumption. This level corresponds to the top level of the sub-sectoral pyramid (Figure 6-2).

Figure 6-2 Pyramid of Freight Transport Indicators



Source: IEA (2014b).

As in the aggregate pyramid, the next level refers to the intensity of the sub-sectors. These can be consumption per unit of physical output or consumption per value added. The first indicator is meaningful only when the output is homogeneous, such as crude steel or cement. If the output is heterogeneous production output, such as in textile or petrochemical facility, the latter indicator, which is the intensity per value added, can be used or moved to the next level of disaggregation with data per individual type of product.

At the last level, the indicators refer to a specific production process or product type, instead of the sub-sector as a whole. These will either be the consumption per unit of physical output or per value added for each sub-sectoral process or product type. The difficulty for the energy efficiency analysis at this level is the lack of availability of data or the difficulties in allocating energy consumption to specific physical output values when outputs are heterogeneous in the same establishment.

Conducting the survey on the energy consumption of the industry sector is an attempt to obtain the energy consumption data at the sub-sector level. The result of the industry survey will describe how energy is being consumed by the sub-sectors surveyed. The unit consumption per product output or value can be derived from the survey result.

The accuracy of the sub-sector energy intensity is limited to the samples. In this regard, preparation of the industry sector EEI of Mongolia will require larger samples of the different sub-sectors and must be inflated to the national level using the national statistics on industrial production output in physical unit or monetary value.

2. Effective Samples

The Mongolian industry sector is divided into three main sub-sectors: (i) mining and quarrying; (ii) manufacturing; and (iii) electricity, thermal energy, and water supply (ETEWS).

During the research work, 120 sample surveys were conducted from the industry sector. The collected data was summarised and 89 of them were counted as useful samples.

3. Main Indicators of the Industry Sector

The industry sector survey collected the energy consumption of the sector from six different areas of the country. Fuel consumption was classified as coal, diesel, wood, liquefied petroleum gas (LPG), lubricants, and motor gasoline.

Although the industries provided detailed information on their electricity consumption, they provided limited information on their thermal power consumption. Thus, thermal energy consumption cannot be calculated.

3.1. Mining and quarrying Sector

The mining and quarrying sector plays a major role in Mongolia's industry sector. The study classified this as the coal and others sub-sector.

The coal sub-sector covers nine mining factories located in the western, eastern, southern, and northern regions of Mongolia. Information on energy consumption, sources, and fuel consumption was collected and analysed.

Samples for the energy consumption survey of this sector were taken from factories such as zinc, tungsten, iron, and copper concentrate. The LPG factory of Oyu-tolgoi was not included in this sector because its energy consumption was too high for the energy consumption structure (outlier).

3.2. Manufacturing sector

The manufacturing sector covers the factories in Ulaanbaatar, eastern, southern, western, and northern Mongolia. The study analysed the energy consumption data by fuel source of 75 entities as follows:

- Food – 31
- Construction materials – 13
- Basic metals – 5
- Other – 26
-

During the survey, detailed information on electricity and fuel consumption was collected; however, information on heat energy consumption was insufficient. The energy consumption of the subsector was calculated for three fuel types: coal, electricity, and wood. Fuel used in vehicles was excluded from the survey.

The food sub-sector included meat products, flour, fresh water, beverage, and candy companies; the units are in cube, cubic metre, and so on. The energy intensities, defined as consumption per output, were calculated based on the sales revenue rather than the physical quantities.

The construction sub-sector included windows, bricks, blocks, and wood production companies with outputs measured in metre, cubic metre, ton, etc. The energy intensities were calculated by comparing sales with physical quantities.

Copper, cathode copper, iron-enriched steel products, and steel ball bearers were included in the basic metals sub-sector. Although it was possible to quantify the intensities by quantity, these could not be accounted for in the manufacturing sector compared to sales revenue.

Other sub-sector includes a wide variety of business entities, such as clothing, textile products, leather products, shoes, and furniture, and are measured in terms of unit quantities, such as set, unit, and bill because they are calculated based on sales rather than physical quantities.

4. Energy Consumption in the Manufacturing and Mining and Quarrying Sectors

Industry sector energy consumption was estimated for four types of fuels – coal, electricity, diesel, and wood – for both the mining and quarrying and manufacturing plants (Table 6-1).

Table 6-1. Energy Consumption in the Industry Sector (toe)

Energy Type	Manufacturing	Mining and Quarrying	Total
Coal	19,358.42	27,304.81	**46,663.24**
Electricity	8,668.75	13,194.61	**21,863.36**
Diesel (for generators)	0.00	86.47	**86.47**
Wood	12.16	7.93	**20.09**
Total	**28,039.33**	**40,593.82**	**68,633.15**

Source: Elaboration and calculation of MEEI authors.

The energy consumption of manufacturing plants was 28,039 toe whilst that of mining and quarrying was almost 40,600 toe. The main fuel used in both sectors was coal. Coal share in the total energy consumption of the manufacturing sector was 69% whilst for mining and quarrying, the share was 67.3% (Table 6-2). The electricity share was 30.9% in the manufacturing sector and 32.5% in the mining and quarrying sector. Diesel was only consumed by the mining and quarrying sector for generators. The share in the total mining and quarrying consumption was 0.21%. Only a small amount of wood is consumed by the manufacturing and mining and quarrying sectors, 0.04% and 0.02%, respectively.

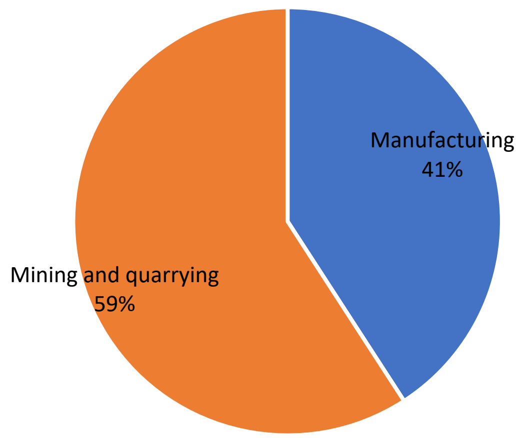
Table 6-2. Energy Consumption in the Industry Sector (%)

Energy Type	Manufacturing	Mining and Quarrying	Total
Coal	69	67.3	68
Electricity	30.9	32.5	31.9
Diesel (for generators)	0	0.21	0.13
Wood	0.04	0.02	0.03
Total	**100**	**100**	**100**

Source: Elaboration and calculation of MEEI authors.

Overall, the total energy consumption of the industry sector was 68,633 toe; 41% of this was consumption of the manufacturing plants and 59%, that of the mining and quarrying sector (Figure 6-3).

Figure 6-3 Industrial Energy Consumption , by Sector



Source: Elaboration and calculation of MEEI.

5. Energy Consumption and Intensities of Sectors

5.1 Manufacturing sector

Business entities in the manufacturing sector are classified into four sub-sectors: food, construction materials, basic metals, and others. In terms of consumption structure, diesel fuel is excluded, and calculations of three types of energy – coal, electricity, and wood – are made.

The EEIs are calculated for each fuel used by each sector, and the fuel consumption is expressed in tonne of oil equivalent (toe) (Table 6-3).

Table 6-3. Energy Consumption in the Manufacturing Sector (toe)

Type of Fuel	Food	Construction Materials	Basic Metals	Other	Total
Coal	374.87	298.06	18,470.77	214.73	**19,358.42**
Electricity	1,579.16	66.44	5,622.88	1,400.27	**8,668.75**
Wood	9.69	0.35	0.00	2.11	**12.16**
Total	**1,963.72**	**364.85**	**24,093.65**	**1,617.11**	**28,039.33**

Source: Elaboration and calculation of MEEI authors.

The total energy consumption of the manufacturing sector reached 28,039 toe which was mainly the consumption of the basic metals sub-sector (24,094 toe). The remaining energy consumption of the industry was that of food (1,964 toe), construction materials (365 toe), and others (1,617 toe).

As earlier mentioned, coal share is the highest, at 69%, of the total energy consumption of the manufacturing sector. This was due to coal consumption in construction materials and basic metals plants. Coal share in the total consumption of construction materials was 81.7% whilst that in the total basic metal consumption it was 76.7% (Table 6-4).

As to the energy consumption of the total food industry and the other industry, the share of coal was not dominant, only 19.1% and 13.3%, respectively. Electricity has the dominant share in these two sectors, i.e. 80.4% for food industries and 86.6% for the other sub-sector. Wood is consumed in the food, construction materials, and other sub-sector. No wood is consumed in the basic metals sub-sector. Wood share was 0.49% in the food subsector, 0.1% in the construction materials sub-sector, and 0.13% in the other sub-sector.

Table 6-4. Energy Consumption in the Manufacturing Sector (%)

Specification	Food (31)	Construction Materials (13)	Basic Metals (5)	Other (26)	Percentage
Coal	19.09	81.69	76.66	13.28	69.04
Electricity	80.42	18.21	23.34	86.59	30.92
Wood	0.49	0.10		0.13	0.04
Total	**100**	**100**	**100**	**100**	**100**

Source: Elaboration and calculation of MEEI authors.

The basic metal sub-sector accounted for 95.4% of the total coal consumption of the manufacturing industry. The remaining shares are that of the food (2%), construction materials (1.5%), and other (1.1%) manufacturing industries (Table 6-5).

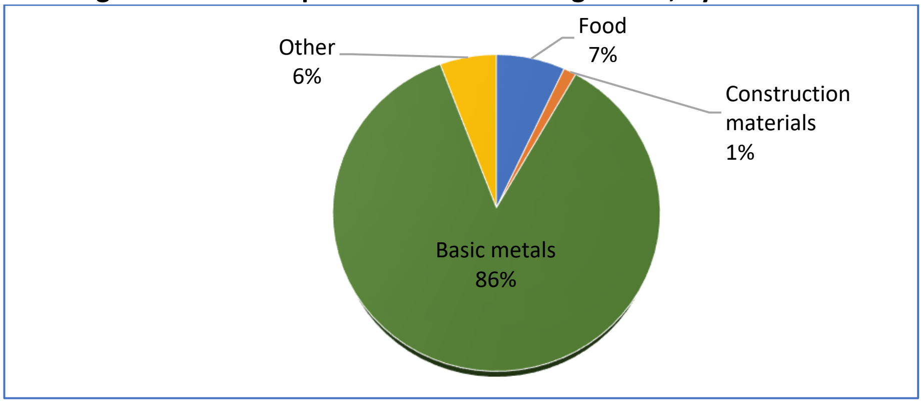
Table 6-5. Energy Consumption of the Manufacturing Sector (%)

Sub-sector	Coal	Electricity	Wood	Total
Food (31)	1.94	18.22	79.71	**7.00**
Construction materials (13)	1.54	0.77	2.90	**1.30**
Basic metals (5)	95.41	64.86		**85.93**
Other (26)	1.11	16.15	17.39	**5.77**
Total (75)	**100**	**100**	**100**	**100**

Source: Elaboration and calculation of MEEI authors.

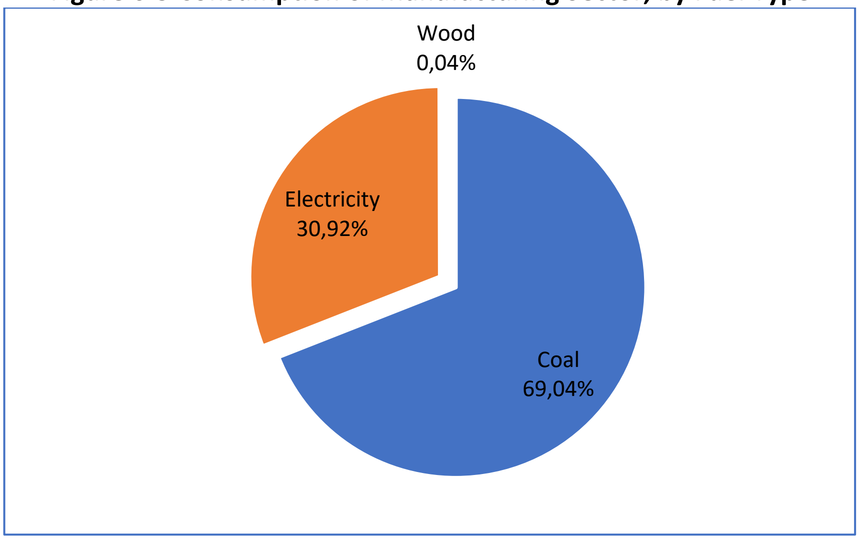
Electricity is also mainly consumed by the basic metals sub-sector (64.9%) whilst wood consumption is the highest in the food sub-sector (79.7%). Figure 6-4 shows the energy consumption of the manufacturing sector by sub-sector, and Figure 6-5 by energy type.

Figure 6-4 Consumption of Manufacturing Sector, by Sub-sector



Source: Elaboration and calculation of MEEI authors.

Figure 6-5 Consumption of Manufacturing Sector, by Fuel Type



Source: Elaboration and calculation of MEEI authors.

Energy intensity of the manufacturing sector is determined by comparing the total energy consumed to the size of the sales revenue. The result is shown in Table 6-6 with different units. Per ₮1 million output, the average energy intensity of the manufacturing sector was 0.0096 toe. By sub-sector, the energy intensity was 0.0007 toe for the food industries; 0.065 toe for the basic metal industries; 0.037 for the building materials; and 0.00097 for the other manufacturing industries. These results indicate that for the manufacturing sector, more energy efficiency measures will be needed on the construction materials and basic metals sub-sectors.

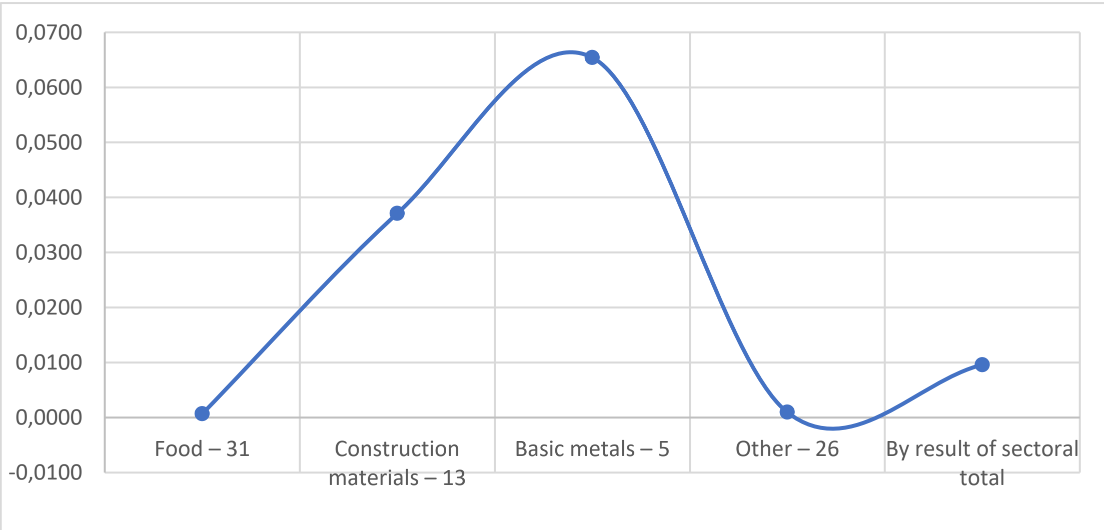
Table 6-6. Energy Intensity

Energy Type	Unit	Food	Building Materials	Metals	Other	Total
Energy intensity	toe/million tugrik (₮)	0.00067	0.03708	0.06542	0.00097	0.00959
	toe/'000 US$	0.00178	0.09803	0.17294	0.00256	0.27531
	kWh/million ₮	7.8	431.3	760.8	11.3	111.5
	kWh/thousand US$	20.6	1,140.1	2,011.3	29.8	3,201.8

Source: Elaboration and calculation of MEEI authors.

Figure 6-6 is the graphic form of energy intensity of the manufacturing sector in toe/ million ₮.

Figure 6-6 Energy intensity of the Manufacturing Sector (toe/million *tugrik* [₮])



Source: Elaboration and calculation of MEEI authors.

Table 6-7 shows the total sales of the various manufacturing sub-sectors – food, construction materials, basic metals, and other sub-sectors.

Table 6-7. Sales of Manufacturing Sector (million *tugrik* [₮])

Specification	Food	Construction Materials	Basic Metals	Other	Total
Sales revenue	**876,806.4**	**9,839.2**	**368,318.7**	**1,669,082.5**	**2,924,046.7**

Source: Elaboration and calculation of MEEI authors.

5.2 Mining and quarrying sub-sector

The business entities of the mining and quarrying sector are classified into coal and other. In terms of consumption structure, the types of energy considered are diesel, coal, electricity, and wood. Diesel is basically for generators.

Similar to the manufacturing sector, this sector's EEIs are calculated for each sub-sector by fuel usage in tonne of oil equivalent (toe). The resulting energy consumption of the mining and quarrying sector is shown in Table 6-8.

Table 6-8. Energy Consumption in Mining and Quarrying Sub-sector (toe)

Type of Fuel	Coal-9	Other-5	Total
Coal	1,108.60	26,196.22	**27,304.81**
Electricity	2,417.62	10,776.99	**13,194.61**
Diesel generator	71.34	15.13	**86.47**
Wood	0.00	7.93	**7.93**
Total	**3,597.55**	**36,996.27**	**40,593.82**

Source: Elaboration and calculation of MEEI authors.

The sector's total energy consumption was almost 40,600 toe; the consumption was mainly that of the other mining and quarrying sub-sector (around 37,000 toe). The energy consumed by this sub-sector is mainly coal (70.8%) and electricity (29.1%). The remaining fuel consumed is diesel for generators and wood.

In the coal mining and quarrying sub-sector, the main fuel is electricity, not coal, with share accounting for 67.2% of the total sub-sector consumption. The other fuel share is that of coal (30.82%) and diesel generator (1.98%). The energy consumption share of the sub-sector is shown in Table 6-9.

Table 6-9. Energy Consumption Shares of the Mining and Quarrying Sub-sector (%)

Type of Energy	Coal-9	Other-5	Total Amount
Coal	30.82	70.81	67.26
Electricity	67.20	29.13	32.50
Diesel generator	1.98	0.04	0.21
Wood	0.00	0.02	0.02
Total	**100**	**100**	**100**

Source: Elaboration and calculation of MEEI authors.

In terms of energy type consumed by the mining and quarrying sector, coal consumption in the other sub-sector accounted for 95.9% of the total coal consumption of the mining and quarrying sub-sector (Table 6-10). The other sub-sector also consumed most of the electricity (81.7%) and wood (100%) used by the mining and quarrying sector. In terms of diesel for generator, the coal sub-sector consumption represented 82.5% of the total sector consumption.

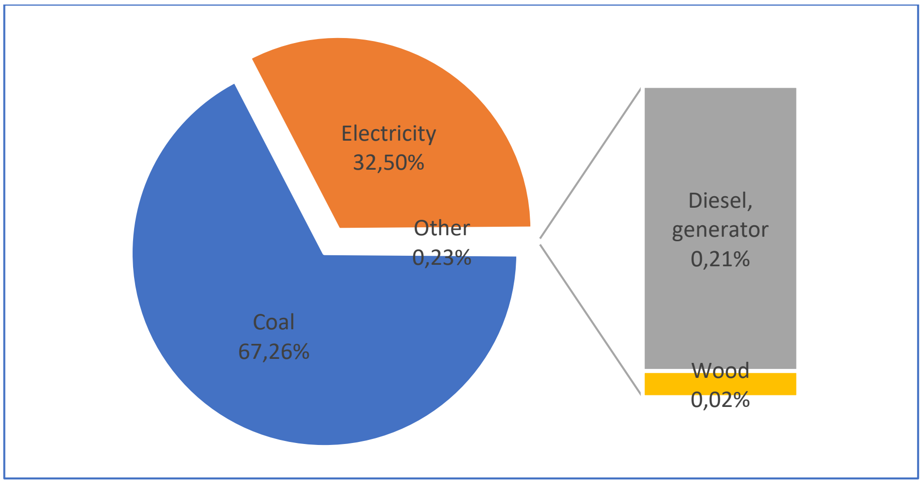
Table 6-10. Energy Consumption in Mining and Quarrying Sector, by Sub-sector (%)

Specification	Coal	Electricity	Diesel, Generator	Wood	Total
Coal-9	4.1	18.3	82.5	0.0	8.9
Other-5	95.9	81.7	17.5	100.0	91.1
Total-14	100	100	100	100	100

Source: Elaboration and calculation of MEEI authors.

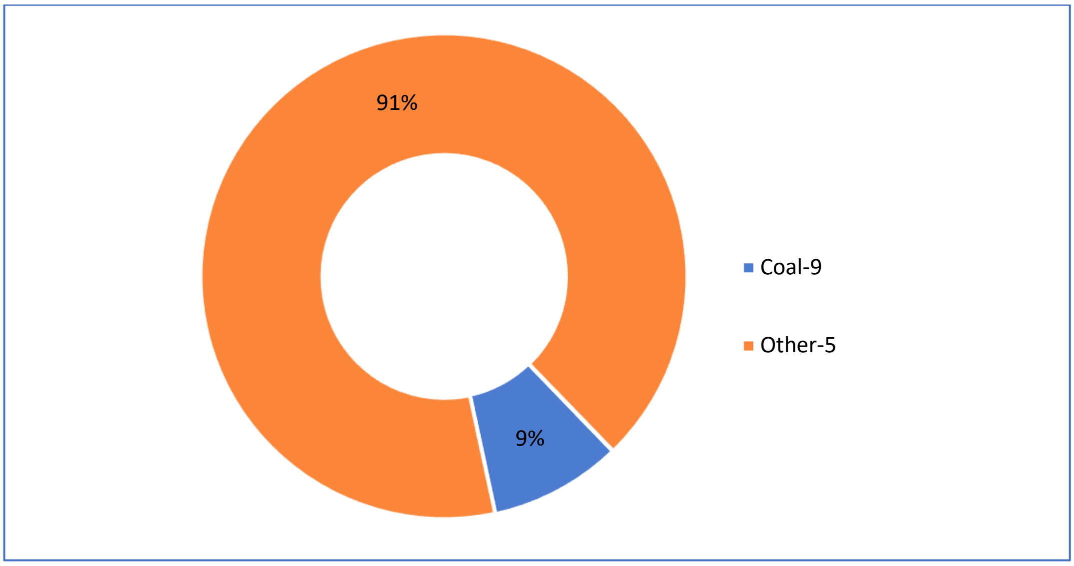
Figure 6-7 shows the total mining and quarrying energy consumption by fuel type whilst Figure 6-8 by sub-sector.

Figure 6-7 Type of Energy Consumption of the Mining and Quarrying Sector



Source: Elaboration and calculation of MEEI authors.

Figure 6-8 Energy Consumption for Mining and Quarrying, by Sub-sector



Source: Elaboration and calculation of MEEI authors.

As for the manufacturing sector, the energy intensity of the mining and quarrying sub-sector is determined by comparing the energy consumed by the mining and quarrying sector to the size of the sales revenue. Table 6-11 shows the resulting energy intensity by the different units.

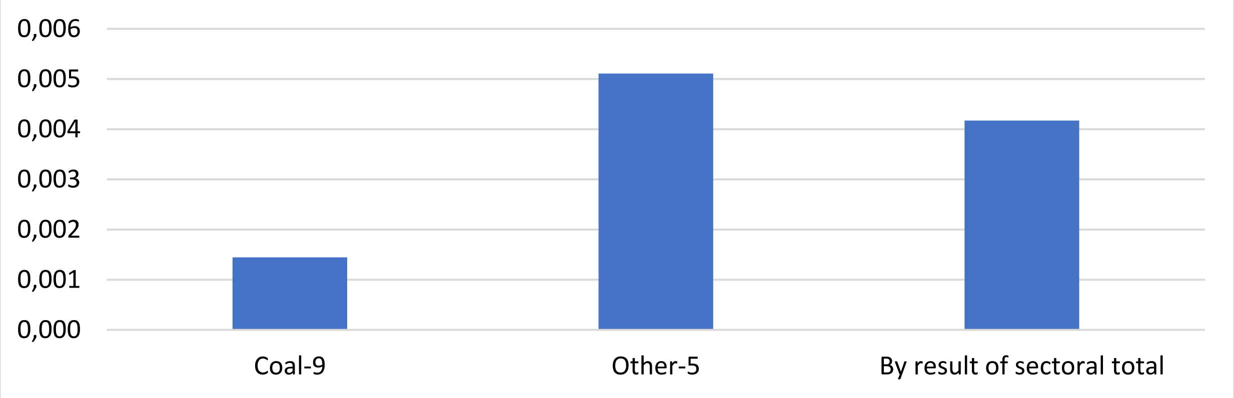
Table 6-11. Energy Intensity

Type of Energy	Unit	Coal-9	Other-5	Total
Energy intensity	**toe/million *tugrik* (₮)**	0.0014	0.0051	0.0042
	toe/thousand US$	0.0038	0.0135	0.0110
	kWh/million ₮	16.82	59.43	48.53
	kWh/thousand US$	44.45	157.11	128.30

Note: US$1 = ₮2,643.69.
Source: Elaboration and calculation of MEEI authors.

In terms of toe/million ₮, the energy intensity of mining and quarrying was on average 0.0042. The energy intensity for the coal mining and quarrying sub-sector is lower at 0.0014 toe/million ₮ whilst for the other sub-sector, it was higher at 0.0051 toe/million ₮. These results indicate that energy efficiency measures will be needed more for the other mining and quarrying sub-sector compared to the coal sub-sector. Figure 6-9 shows the energy intensity of the mining and quarrying sector and its sub-sectors in toe/million ₮.

Figure 6-9 Energy Intensity of the Mining and Quarrying Sector, by Sub-sector (toe/million tugrik [₮])



Source: Elaboration and calculation of MEEI authors.

Total sales of the mining and quarrying sector (coal and other) is shown in Table 6-12.

Table 6-12. Mining and Quarrying Sales (million *tugrik* [₮])

Specification	Coal-9	Other-5	Total
Sales revenue	2,488,202.960	7,240,022.850	9,728,225.810

Source: Elaboration and calculation of MEEI authors.

Chapter 7
Electricity, Thermal Energy, and Water Supply Sector

1. Effective Samples

Twenty sample surveys were conducted for the electricity, thermal energy and water supply (ETEWS) sector Eleven of them were studied separately from the industry sector because the production volume was not fully included, the differences in fuel and energy consumption were high, and the relevant sources were unclear.

2. Electricity, Thermal Energy, and Water Supply Sector

The following sub-sector survey reports were prepared for the ETEWS sector:

- Electricity and thermal energy (ETE)
- Other

The energy consumption and resource/generation data from five different combined heat and power (CHP) plants was analysed for the ETE sub-sector study. The power plants were in the central and southern regions of Mongolia. The plants provided detailed data on fuel consumption including that of coal, diesel, wood, liquefied petroleum gas (LPG), lubricants, and motor gasoline. Note that some power plants collected the heating consumption data from the coal consumption amount and the billing payment.

The other sub-sector includes heating boilers, power plants, heating distribution companies.

3. Energy Consumption in the Electricity, Thermal Energy, and Water Supply Sector

The estimation of the energy consumption of the ETEWS sector includes power and heat plants. In terms of consumption structures, the following three types of energy were considered: coal, electricity, and other (lubricants, heavy fuel oils/mazut/and diesel).

The energy efficiency (conservation) in the sector is calculated by the fuel usage by each sub-sector, and the fuel unit is in tonne of oil equivalent (toe). Table 7-1 shows the results of the energy consumption in the ETEWS sector.

Table 7-1. Energy Consumption in the ETEWS Sector (toe)

Energy Type	Unit	Electricity and Thermal Energy	Other	Total
Coal	toe	1,916,234.97	226,208.43	2,142,443.39
Electricity	toe	62,108.25	5,517.14	67,625.39
Other	toe	3,144.88	1,195.70	4,340.58
Total		1,981,488.09	232,921.27	2,214,409.36

ETEWS = electricity, thermal energy, and water supply.
Source: Elaboration and calculation of MEEI authors.

As shown above, the role of coal is dominant in the energy consumption of the ETE sub-sector. The share of coal in the total consumption of the ETE sub-sector was 96.7% whilst it was 97.1% for the other sub-sector. Overall, coal accounted for 96.8% of the total ETEWS consumption whilst electricity accounted for 3.1% and the other fuel, 0.2% (Table 7-2).

Table 7-2. Share of Fuel Consumption in the ETEWS Sector (%)

Energy Type	Electricity and Thermal Energy	Other	Total
Coal	96.7	97.1	96.8
Electricity	3.1	2.4	3.1
Other fuel	0.2	0.5	0.2
Total	100	100	100

Source: Elaboration and calculation of MEEI authors.

By sub-sector, 89.5% of the total energy consumption of ETEWS is the consumption of the ETE sub-sector (Table 7-3).

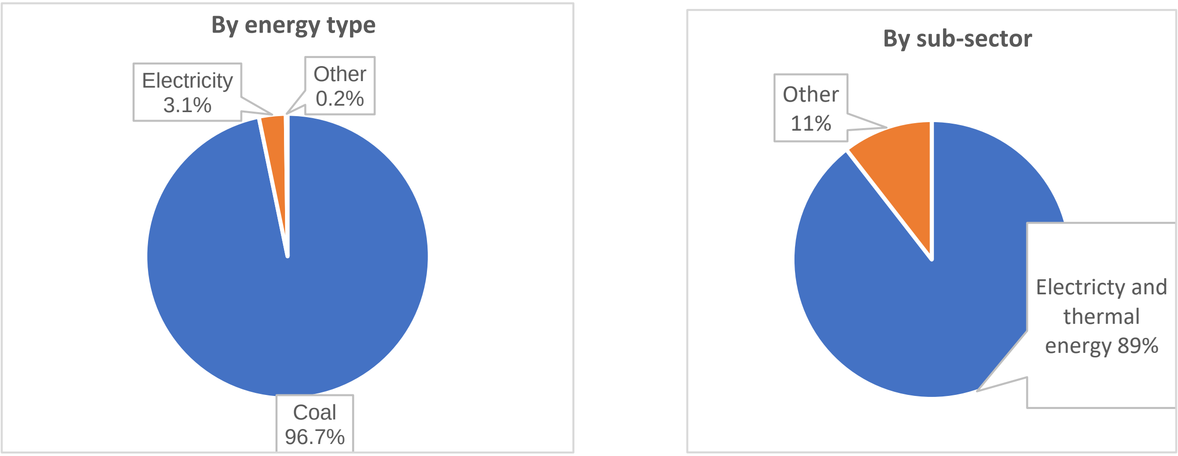
Table 7-3. Share of Sub-sector of Energy Consumption in the ETEWS Sector (%)

Sub-sector	Coal	Electricity	Other Fuel	Share of Total
Electricity and thermal energy	89.44	91.84	72.45	89.48
Other	10.56	8.16	27.55	10.52
Total	100.0	100.0	100.0	100.0

Source: Elaboration and calculation of MEEI authors.

Figure 7-1 shows the energy consumption in the ETEWS sector by sub-sector and energy type.

Figure 7-1 Energy Consumption in the ETEWS Sector, by Energy Type and Sub-sector



Source: Elaboration and calculation of MEEI authors.

Energy intensity of the ETEWS sector is determined by comparing its consumption with the size of the sales revenue. Total intensity of the sector is shown in Table 7-4 in different units.

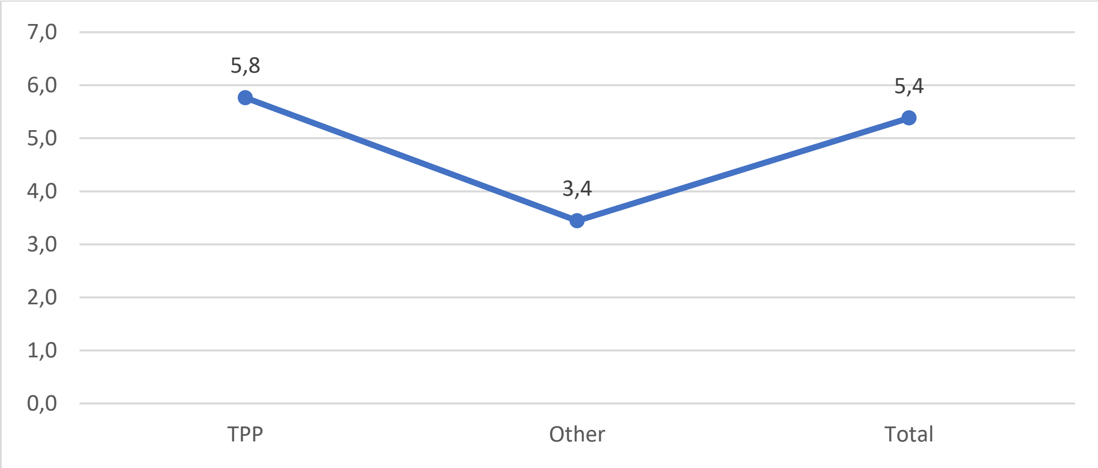
Table 7-4. Energy Intensity

Energy Type	Unit	Electricity and Thermal Energy	Other	Total
Energy intensity	toe/million tugrik (₮)	5.76	3.44	5.38
	toe/thousand US$	15.24	9.11	14.23
	kWh/million ₮	67,043.22	40,064.30	62,608.64
	kWh/thousand US$	177,241.48	105,917.58	165,517.82

Source: Elaboration and calculation of MEEI authors.

In terms of toe/million ₮, the energy intensity of the ETEWS sector was 5.38. The ETE sub-sector had an energy intensity of 5.76 toe/mil ₮ which is 0.07% more than in the sector total. The energy intensity of the other sub-sectors was 3.44 toe/mil ₮ or 0.56% less in the sector total. This indicates the significant impact of the ETE sub-sector on the energy consumption of the ETEWS sector. Figure 7-2 shows the energy intensity of the ETEWS sector in toe/million ₮.

Figure 7-2 Energy Intensity (toe/million ₮)



Source: Elaboration and calculation of MEEI authors.

Total sales of the ETEWS sector, including ETE and other sub-sectors, is shown in Table 7-5.

Table 7-5. Sales of ETEWS Sector (million ₮)

Indicator	Electricity and Thermal Energy	Other	Total
Sales revenue	343,729.13	67,613.18	**411,342.31**

Source: Elaboration and calculation of MEEI authors .

Chapter 8
Conclusion

Energy efficiency indicators (EEIs) are different from energy intensities defined by energy consumption per gross domestic product (GDP). Usually energy intensity is calculated as TPES (total primary energy supply (TPES)/GDP or TFEC (total final energy consumption)/GDP; it basically shows the energy performance nationwide and the result of socio- economic activities in a year. The energy intensities never suggest appropriate energy efficiency policies and action plans. Thus, we need EEIs to plan appropriate energy efficiency and conservation (EEC) activities.

All energy is finally consumed by final users – industry, transport, commercial, and residential sectors. The agriculture, forest, and fishery sector consumes energy for its production activities but its energy consumption is very small compared to the four sectors mentioned above. In addition, an electricity-generation sector as a typical transformation sector consumes fossil fuels, such as coal, to generate electricity. The energy performance of this sector is gauged by thermal efficiency which depends on power generation technologies such as clean coal technologies (CCT) and combined cycle gas turbine (CCGT), etc. Similarly, we need EEIs to gauge the energy performance of each final sector and, based on these EEIs, the government can plan and set up appropriate and implementable EEC activities and action plans. If we want to get EEI benchmarking by each final sector, we must conduct a detailed energy consumption survey in the respective sectors.

The industry sector consists of several sub-industry sectors. We obtained the EEI of each sub-sector defined as energy consumption (tonne of oil equivalent [toe]) per main production amount (tonne) or sectoral GDP (monetary unit). If the EEI is very high, we classify this sub-sector as energy intensive and need to apply EEC action plans to mitigate its energy consumption.

For transport, generally since the road transport sector is dominant in terms of fuel consumption, such as gasoline and diesel oil, we get the overall or national average of fuel economy defined as litre/100 km by each type of vehicle – car (mainly sedan), bus, and truck – as the EEI of the road transport sector. If we increase the number of more efficient cars, such as those with small internal combustion engines, and hybrid cars, the EEI of the road sector surely improves. Also, idling stop technology is another option to mitigate transport fuel consumption. Based on the EEI of the road sector, government can apply appropriate and effective policies and action plans to mitigate transport fuel consumption.

The EEIs of the residential and commercial sectors are defined as energy consumption (toe or kWh) per floor area (m^2). In addition, what kinds of energy are consumed for what purpose, and how electricity is consumed for what purpose (heating space, lighting, refrigerator, etc.) are important feedback from the survey. Space heating is the main energy used in Mongolia and its energy consumption depends on attributes of houses and buildings. Thus, we get the EEI by types of house (standalone, apartment, and *ger*) and building types (hotel, office, restaurant, shopping mall, and hospital). Based on the EEIs of both sectors, government can apply various EEC policies and action plans to mitigate energy consumption, especially electricity consumption, including the Minimum Energy Performance System for appliances and Building Energy Code, such as Green Building Index for commercial buildings.

In order to get indicative EEIs of each final sector, the Mongolian Energy Economics Institute (MMEI), with support of the Economic Research Institute for ASEAN and East Asia (ERIA) conducted a detailed energy consumption survey in whole of Mongolia in 2019. The sample size of each final sector is as follows: 88 samples from the industry sector (14 samples for mining and 75 for manufacturing); 203 samples from the transport sector including rail, air, and ship but mainly from the road sector (170 samples); 400 samples from the residential sector (140 samples in Ulaanbaatar as an urban area, 260 from the rest of the country as rural and herder areas); and 200 from the commercial sector (108 samples for offices, 23 for hotels, 23 for shopping malls, 22 for restaurants, and 24 for hospitals). The sample sizes are not significant but, of course, not too small. The MEEI, with some local consultants, conducted the survey in significant parts of Mongolia, so that experience and skill on the energy consumption survey would remain with MEEI staff. In case of sample surveys, minimising bias is very important. Consequently, random sampling is usually applied in the sample survey. But the limited population of the industry and the commercial sectors makes random sampling unavailable to these sectors.

The energy consumption survey usually uses a specific questionnaire for each sector, and ERIA provided the MEEI four questionnaires for the four final sectors. The questionnaires consist of mainly two parts: (i) fact sheet and (ii) energy consumption sheet. The fact sheet contains attributes of each four sectors – International Standard Industry Classification number of employees; production amount of main product or gross revenue in the industry sector; vehicle type, engine capacity, and driving distance in the road transport sector; house type, family size, and floor area in the residential sector; and type of building and floor area in the commercial sector. On the other hand, the energy sheet contains the kind of energy, energy consumption, and its usage. These questionnaires from ERIA were accepted by the MEEI and used for the energy consumption survey in Mongolia.

After collection of the questionnaires, all collected data from the survey were entered in an Excel file for validation and analysis. Through validation, outliers are removed through statistical application, with charts. Basically, outliers are due to mistyping, misunderstanding of units, etc. After validation, the EEIs are calculated based on the screened sample data. After this calculation, we evaluated the indicators. But for this evaluation, we needed overall knowledge to cover energy consumption, economic growth, industrial transition, and change of lifestyle. In addition, an international comparison of the EEIs is also a good way to evaluate them. But these EEIs are not well produced globally and can refer only to indicators of the Organisation for Economic Co-operation and Development.

Through this project, the MEEI obtained lots of experience on the EEIs and the technical skill in producing and assessing the EEIs. The EEIs will be changed year by year due to changes in social behaviour, economic growth, lifestyle, and technology development. In this regard, the MEEI should continue to produce EEIs every 3 to 5 years to reflect or improve current EEC policies and action plans with greater effectiveness and economic benefits. ERIA would like to support the MEEI continuously and technically in terms of promoting EEC in Mongolia.

References

Amarsaikhan, B. (2016), '60 Percent of All Motor Vehicles Registered in UB', *Mongolian News Agency (Montsame),* https://montsame.mn/en/read/3589 (accessed 12 November 2019).

Batjargal, B. and T. Matsumoto (2017), 'Estimation and Prediction of Road Traffic Emissions in Ulaanbaatar', Inventory of Traffic Emission Project, January, https://www.researchgate.net/publication/319734514_Estimation_and_Prediction_of_Road_Traffic_Emissions_in_Ulaanbaatar (accessed 24 June 2020)

Brunel, J. (2005), *Freight Transport and Economic Growth: An Empirical Explanation of the Coupling in the EU Using Panel Data*. https://halshs.archives-ouvertes.fr/halshs-00004826/document (accessed 22 September 2020)

Energy Regulatory Commission (2018), *Energy Statistics.* Ulaanbaatar: Energy Regulatory Commission.

Gansukh, M. (2015), *Current Situation and future planning of Mongolian Energy Sector*, The Government of Mongolia, Ministry of Energy, August https://eneken.ieej.or.jp/data/6234.pdf (accessed 22 September 2020)

International Energy Agency (IEA) (2014a), *Energy Efficiency Indicators: Essentials for Policy Making*. Paris: IEA.

International Energy Agency (IEA) (2014b), *Energy Efficiency Indicators: Fundamentals on Statistics*. Paris: IEA.

JICA (1994), Untitled, Open JICA Report, https://openjicareport.jica.go.jp/pdf/11281748_02.pdf (accessed 24 June 2020)

Karali, N., N. Abhyankar, B. Sharpe, A. Bandivadekar (2019), Improving Fuel Efficiency for Heavy-Duty Vehicles of 3.5–12 Tonnes in India: Benefits, Costs, and Environmental Impacts, Energy Analysis and Environmental Impacts Division, Lawrence Berkeley National Laboratory, February.

Ministry of Road and Transport Development (2018), *Statistics of Road and Transport Sector.* Ulaanbaatar: Ministry of Road and Transport Development.

National Statistics Office of Mongolia (2018a), *Mongolian Statistical Information Service*. Available at https://www.1212.mn (accessed 1 March 2020).

National Statistics Office of Mongolia (2018b), *Statistical Yearbook of Mongolia 2018*. Ulaanbaatar: National Statistics Office of Mongolia

ODYSSEE-MURE (2018), Energy Efficiency Indicators at Sub-sector End-Use Level, Regional Training on Indicators, May 2018.

Purwanto, A.J., G. De Ceuster, K. Vanherle (2017), 'Mobility, Vehicle Fleet, Energy Use, and Emission Forecast Tool *(MOVEET)'*, *Transportation Research Procedia* (2017) 25, pp.3421–34.

World Bank (2005), *Towards a Discussion of Support to Urban Transport Development in India*, Energy & Infrastructure Unit South Asia Region. Washington, DC: World Bank.

Appendix – Questionnaire

Appendix 1. Residential Sector

General

Urban / Rural	How many persons are there in your household (including you)? (person)	Type of Dwelling	What is your monthly household income? (*Tugrik* [₮])	Do you have a household - based income-generating activity?	What is the floor area of your house/dwelling? (m^2)	Number of Rooms	How much approximately do you spend for electricity at your house/dwelling per year? (₮/year)	How much approximately do you spend for space heating? (for apartment users) ₮/year)	How much approximately do you spend for other energy sources at your house/dwelling per year? (₮/year)	How frequently do you experience outages in a month?	How long on average do the outages last in a month?
Urban											

Other Fuels

	Coal		LPG		Wood		Dry Dung Fuel		Pellets		*Khurzun*		Others	
Do you use any other fuel type?	Use of Fuel	How much is your consumption (tons/year)	Use of Fuel	How much is your consumption? (litre/year)	Use of Fuel	How much is your consumption? (m^3/year)	Use of Fuel	How much is your consumption? m^3/year	Use of Fuel	How much is your consumption? kg/year	Use of Fuel	How much is your consumption m^3/year	Use of Fuel	How much is your consumption? litre/year
Yes														

Lighting

Type of Lamp				Average Hours of Daily Usage hour/day				Average Power Rating watts/lamp				Annual Consumption kWh/year
LED	CFL	Fluorescent lamp	Incandescent bulb	LED	CFL	Fluorescent lamp	Incandescent bulb	LED	CFL	Fluorescent lamp	Incandescent bulb	

Refrigerator

Type of Equipment	No. of Years in Use	Manufacturer or Brand	Power Rating (watts)	Load Factor	Annual Consumption kWh
Refrigerator					
Freezer					

Washing machine

Kind of Equipment	No. of Years In Use	Capacity (kg)	Manufacturer or Brand	Power Rating (watts)	Frequency of Washing/day	Number of Days/week	Hours of Usage Per Week	Load Factor	Annual Consumption (kWh)

TV

Type of Equipment	No. of Years In Use	Manufacturer or Brand	Model	Size (inch)	Power Rating (watts)	Hours of Daily Usage	Days of Weekly Usage	Annual Consumption (kWh)

Rice cooker

Manufacturer or Brand	No. of Years in Use	Power Rating (watts)	Frequency of Cooking/day	Days of Daily Usage/week	Annual Consumption (kWh)

Computer

Type of Equipment	No. of Years in Use	Manufacturer or Brand	Model	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Annual Consumption (kWh)
Personal computer							
Laptop							

Electric stove

Type	No. of Years in Use	Manufacturer pr Brand	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Annual Consumption (kWh)
Electric stove						

Iron

Manufacturer or Brand	No. of Years in Use	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Annual Consumption (kWh)
Russian					

Electric kettle

Manufacturer or Brand	No. of Years in Use	Model	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Annual Consumption (kWh)
Akira						

Electric heater

Type	No. of Years in Use	Manufacturer or Brand	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Load Factor	Annual Consumption (kWh)

Fan

Manufacturer or Brand	No. of Years in Use	Model	Power Rating (watts)	Hours of Daily Usage	Days of Daily Usage	Load Factor	Annual Consumption (kWh)

Appendix 2. Transport Sector

Road vehicles (sedan, taxi, bus, and truck)

<table>
<tr><th colspan="2" rowspan="4">Classification</th><th rowspan="4">Driver</th><th rowspan="4">Gender</th><th rowspan="4">How many years ago did you obtain a driver’ s license?</th><th rowspan="4">Name, Type, and Purpose of Vehicles</th><th rowspan="4">Engine</th><th rowspan="4">How many years have you driven your current vehicle?</th><th rowspan="4">What is the vehicle age? (in years)</th><th rowspan="4">Property Type</th><th colspan="5">Fuel Consumption (l/100 km)</th><th colspan="2">The distance of trip (km)</th></tr>
<tr><th rowspan="3">Norm</th><th colspan="4">Consumption</th><th rowspan="3">Per day</th><th rowspan="3">Per month</th></tr>
<tr><th colspan="2">Loaded</th><th colspan="2">Not Loaded</th></tr>
<tr><th>Winter</th><th>Summer</th><th>Winter</th><th>Summer</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Railway

Classification		Age	Gender	How many years ago did you become a locomotive driver?	Name, Type, and Purpose of Locomotive	Engine	How many years have you driven your current locomotive?	What is the locomotive age? (in years)	Property Type	Fuel Consumption (l/100 km)					The distance of trip (km)	
										Norm	Consumption				Per day	Per month
											Loaded		Not Loaded			
											Winter	Summer	Winter	Summer		

Airplanes

Classification		Age	Gender	How many years ago did you become a pilot?	Name, Type, and Purpose of Airplane	Engine	How many years have you piloted your current airplane?	What is the airplane age? (in years)	Property Type	Fuel Consumption (kg/h)					The distance of trip /km/	
										Norm	Consumption				Per day	Per month
											loaded		Not loaded			
											Winter	summer	Winter	summer		

Appendix 3. Commercial Sector

Office questionnaire

Name of Office & Address (indicate Township)	Description of Building					Total Electricity Consumption (kWh / year)	Total Fuel Consumption of Standby Generator Set			Heat Consumption (kWh/yr)	Weekly Operational Hours	Yearly Operational Hours	Total Gross Floor Area (m^2 - excl. car park & data centre)	Total Building Energy Consumption (kWh/yr)	Average BEI (kWh/m^2/yr)
	Specify Other Usage	Occupancy Rate	Storey	Link / Detached	Location (Urban/Rural)		Fuel Type	Litre/year	Energy Consumption/Year (kWh/ ear)						

Hospital questionnaire

Name of Hospital and Address	Description of Hospital			Total Electricity Consumption (kWh/year)	Total Fuel Consumption of Standby Generator Set			Heat Consumption (kWh/yr)	Total Gross Floor Area (m² - excl. car park and data centre)	Total Energy Consumption (electricity + other fuels) (kWh/yr)	Average BEI (kWh/m²/yr)
	Location (Township, Urban/Rural)	No. of Hospital Beds	Large/Medium/Small		Fuel Type	Litre/year	kWh/year				

Hotel questionnaire

Name of Hotel and Address	Description of Hotel					Total Electricity Consumption/year (kWh/year) [To obtain consumption for 1 whole year]	Total Fuel Consumption of Standby Generator Set			Energy Consumption of Other Fuels	Heat Consumption (kWh/yr)	Total Gross Floor Area (m² - excl. car park and data centre)	Total Energy Consumption (electricity + other fuels) (kWh/yr)	Average BEI (kWh/m²/yr)
	Star rating	Location (Township)	No. of bedrooms	Storey	Link/Detached		Fuel Type	Litre/year	kWh/year	Equivalent Consumption (kWh/year)				

Restaurant questionnaire

Name of Air-Conditioned Restaurants and Address (Indicate Township)	Description of Building				Total Electricity Consumption (kWh/year)	Energy Consumption of Other Fuels			Heat Consumption (kWh/yr)	Weekly Operational Hours	Total Gross Floor Area (m^2 - excl. car park and data centre)	Total Energy Consumption (incl. other fuels and electricity)(kWh/year)	Average BEI ($kWh/m^2/yr$)
	No. of Storey	Link / detached	Small/Medium/Large	Location (Urban/Rural)		Fuel Type	Quantity/year	Equivalent consumption (kWh/year)					

Shopping mall questionnaire

Name of Mall/Shop and Address (Indicate Township)	Description of Building				Total Electricity Consumption (kWh/year)	Total Fuel Consumption of Standby Generator Set			Heat Consumption (kWh/yr)	Weekly Operational Hours	Yearly Operational Hours	Total Gross Floor Area (m^2 - excl. car park and data centre)	Total Building Energy Consumption (kWh/year)	Average BEI (kWh/m2/yr)
	No. of Storey	Link/Detached	Small/Medium/Large	Location (Urban/Rural)		Fuel Type	Litre/year	kWh/year						

Appendix 4. Industrial and Electricity, Heat, and Water Supply Sector

General information

Interview Date	:										
Name of Factory	:								ISIC :	Aabbcc	
Address	:										
Major Product *)	:								*) Specify types detail		
Total Workers	:		Persons								
Monthly Production Rate	:				Unit :	Pieces	*)		*) Please Select :	1	Pieces
										2	Ton
Yearly Production Rate					Unit :		*)			3	Specify 1
										4	Specify2
Gross Revenue (Annual)					Unit :	Thousand USD	**)		**)Please Select	1	Million Kip
										2	Thousand USD

Average monthly consumption or purchasing amount questionnaire

Fuel Type	Fuel Unit	As Fuel				
		TOTAL	Production	Non-production*)	Transportation	Notes*)
Coal	Kg	-				
Wood	Kg	-				
Other Biomass	Kg	-				
LPG	Kg					Labour kitchen office, factory, housing
Electricity	MWh					
Diesel	Litre	-				
Gasoline	Litre					
Fuel Oil	Litre					
Lubricants	Specify					
Other Petroleum Products		-				
Naphtha	Specify	-				
Specify 1		-				
Specify 2	Specify	-				

Non-energy		
Feedstock	Additive	Others

Electricity purchase questionnaire

Source of Power	Amount	Value	
	MWh	Tugrik (₮)	US$
State company			
Private company			
Total			

Self-generation questionnaire

Generation Unit	Capacity	Generator Operation	Electricity Generation
	(MW)	(hr/year)	(MWh)

Generator 1			
Generator 2			
Generator 3			
Generator 4			
TOTAL			

Sale (MWh)		**Fuel Use**			**NOTE**
GRID	**OFF GRID**	**Type**	**Consumption**	**Unit**	
		Diesel		litre	

Heat purchase questionnaire

Source of Heat	**AMOUNT**	**VALUE**	
	Gcal	Tugrik (₮)	**USD**
State company			
Private company			
TOTAL			

Co-generation questionnaire

Parameters	**Electricity**	**Unit**	**Thermal Energy**	**Unit**
Capacity/Throughput				
Production				
Fuel Type				
Fuel Consumption				

Heat process questionnaire

Type	**Capacity/ Throughput (kg/Hr)**	**Boiler/furnace Operation (Hr/year)**	**Heat Production (Kg/Hr)**
Boiler 1			
Boiler 2			
Burner/Furnace 1			
Burner/Furnace 1			

Fuel Use			NOTE
Type	Consumption	Unit	