# Chapter 3
# Energy Consumption Survey

## Introduction

An energy consumption survey was conducted for the industry, road transport, residential, and commercial sectors. The objective of the survey was to collect the necessary consumption data for the estimation of the Lao PDR's energy consumption by sector and by type of energy source. The estimated unit consumption of the different types of fuel consumed by the sectors served as the basis to estimate the total fuel consumption of the country. The survey result was inflated by multiplying the specific energy consumption (intensity) of the respective sector's activity. In view of the voluntary nature of this survey, the limited time frame, and the relatively new experience of an energy consumption survey in the Lao PDR, the study team experienced constraints and difficulties due to the lack of full understanding of some of the questions and the lack of cooperation by the survey subjects. The overview of the data also appeared to lack consistency and some results were erratic. To eradicate the impact of outlier data, the study team made objective interpretation and judgement to achieve reasonable results in accordance with building practices in other countries of the Association of Southeast Asian Nations (ASEAN) with a similar climate. The assumptions and logic deployed in the analysis of data are discussed in the following sections.

## Methodology

To achieve the consumption survey objective, the following methodologies were undertaken:

### Preparation of Questionnaire

A questionnaire was prepared in close consultation with study team members consisting of a national consultant, an expert from the Economic Research Institute of ASEAN and East Asia (ERIA), staff from the Department of Energy Policy and Planning (DEPP) and other departments under the Ministry of Energy and Mines (MEM) of the Lao PDR, and representatives from the Lao State Fuel Company and the country's national electricity utility, Électricité du Laos (EDL).

The questionnaire consisted of two parts: general information and energy consumption. For the industry sector, general information on the manufacturing industry such as the name of the factory, major products, the International Standard Industrial Classification code, the yearly production amount of the major product, and the industry's annual gross revenue were collected.

The questionnaire was tested during the enumerator training and was adjusted and finalised with suggestions from experts.

## Sampling and Sampling Size

The industry sector sampling consisted of six major industry sub-sectors: i) cement; ii) food, beverage, and tobacco; iii) wood and wood products; iv) construction; v) textile and leather; and vi) steel. At around 20 samples per sub-sector, the samples totalled 117.

The transport sector sampling used the parking lot survey. The types of vehicles sampled covered sedans, sport utility vehicles (SUVs), pickups, trucks, buses, motorcycles, private vehicles, taxis, and tuk-tuks. The sample size was 200 vehicles in 10 parking lot locations (around 20 samples per location). The buses in parking lots were not the big ones. For the big buses, the researchers approached a bus company in Vientiane.

The residential sector survey targeted urban and semi-urban areas. The sample totalled 200 residential dwellings.

The commercial sector survey consisted of four types of commercial buildings, namely: i) offices, ii) hotels, iii) malls/shops, and iv) hospital buildings. The sample totalled 200 commercial buildings.

All of the samples were located in Vientiane and its outer areas. The sample frame was based on the available list of establishments that the survey team sought from various sources (such as hotel and restaurant associations, chambers of commerce and industry, and garment associations). The sampling used both random and purposive techniques. For each sector and sub-sector, certain criteria were developed in consultation with the ERIA team members during the training workshop before researchers started the field survey.

### Distribution and Collection of Survey Questionnaire

The researchers used questionnaires to collect data on the fuel consumption of the different sectors. The target respondents who were available during the survey were interviewed face-to-face. Those unavailable were requested to respond to the questionnaire at their convenience. In this case, the questionnaire was emailed or was left with administration officers. The enumerators went back to collect and check the questionnaire. The letter of introduction about the survey provided by MEM was attached to the questionnaire.

In addition to face-to-face interviews, information on actual figures of electricity consumption were collected from EDL.

The quality of information was key to this survey. The following steps were undertaken for quality assurance: i) checking by individual enumerators, ii) second checking by supervisors, and iii) call back or revisit (random and spot check) by the team leader/supervisor.

## Industry Sector

The energy consumption survey in the industry sector was conducted to estimate the energy consumption of selected industry sub-sectors.

### Survey Result

There were 117 establishments surveyed under the industry sector. Of these, 40 establishments came from the wood and wood products sub-sector; 30 from the food, beverage, and tobacco sub-sector; and 25 establishments from the textile and leather sub-sector (Table 3.1).

The survey collected the fuel consumption of the sub-sectors not only for the production process but also for other purposes such as lighting, transportation, stand-by power (auto generator/captive), feedstock, etc. Fuel consumption was estimated based on the fuel consumed for the production process.

**Table 3.1.** Overview Information on the Industry Sector

| Sub-sector | Sample | Total Workers | Average Worker/ Factory | Main Products |
|---|---|---|---|---|
| i. Cement | 14 (12%) | 525 | 37.5 | cement, ready-mixed concrete, concrete Pole, brick, CPAC roof |
| ii. Food, Beverage, and Tobacco | 30 (26%) | 1,815 | 60.5 | beer, drinking water, whisky, tobacco, Pepsi, Coca-Cola, ice, noodles, meat ball |
| iii. Wood and Wood Products | 40 (34%) | 284 | 7.1 | sawed timbre/lumber, furniture |
| iv. Construction | 4 (3%) | 52 | 13 | building |
| v. Textile and Leather | 25 (21%) | 6,903 | 276.12 | cloth, fabric, shoes |
| vi. Steel | 4 (3%) | 234 | 58.5 | steel, nail, steel barbed wire, zinc/ steel roof |
| **Total** | **117** | **9,813** | | |

CPAC = Concrete Products and Aggregate Co., Ltd. (subsidiary of Thailand's Siam Cement Group).

Source: Industrial survey results for the Lao PDR.

The fuels consumed by the sub-sectors were recorded in their physical unit. For coal, it was in kilogram (kg); for petroleum products, except LPG, in kilolitre (kl), for liquefied petroleum gas (LPG), in ton; and for electricity, in kilowatt-hour (kWh). The fuels had to be converted to the energy unit before summation. Density and heating values of the different fuels are shown in Table 3.2.

**Table 3.2.** Density and Heating Values of Different Fuels

| Type of Fuel | Density | | Heating Value | |
|---|---|---|---|---|
| | Unit | Value | Unit | Value |
| Coal | - | - | kcal/kg | 6,000 |
| Wood/ Biomass | - | - | kcal/kg | 3,820 |
| Electricity | - | - | kcal/kWh | 860 |
| LPG | kg/l | 0.510 | kcal/kg | 11,778 |
| Diesel | kg/l | 0.839 | kcal/kg | 10,236 |
| Gasoline | kg/l | 0.737 | kcal/kg | 10,450 |
| Fuel Oil | kg/l | 0.890 | kcal/kg | 10,105 |
| Lubricant | kg/l | 0.858 | kcal/kg | 9,929 |
| OOP | kg/l | 0.858 | kcal/kg | 9,929 |
| Naphtha | kg/l | 0.740 | kcal/kg | 10,750 |

kcal = kilocalorie, kg = kilogram, kWh = kilowatt-hour, LPG = liquefied petroleum gas, l = litre, OOP = other oil products.

Source: Association of Southeast Asian Nations/Asia-Pacific Economic Cooperation/International Energy Agency Joint Energy Format.

The activities of the sampled factories were represented by the sales revenue. Thus, the survey estimated the factory units' fuel consumption per sales revenue. Some of the sampled factories, however, considered sales revenue confidential. In these cases, the samples only provided their consumption data. In some cases, the samples had their sales revenue data, but their consumption data was only for purposes other than production. Note that it is necessary to have both the revenue and the fuel consumption data for the production process to estimate the average unit consumption per sales revenue.

The average fuel consumption and sales revenues of the sampled factories in each sub-sector are shown in Table 3.3. The sampled industry sub-sector included construction but it did not provide information on sales revenue. Therefore, the construction sector was excluded in the estimation of the unit fuel consumption per sales revenue.

**Table 3.3. Average Sales Revenue and Fuel Consumption**

| Industry | Sales Revenue (Mil. US$) | Total Consumption (ktoe) | Ktoe/ Mil US$ | Fuel Share (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Coal | Wood/ Biomass | Electricity | LPG | Diesel | Fuel Oil |
| Food Processing, Beverage, and Tobacco | 23.2323 | 21.8436 | 0.9402 | 18.74 | 57.91 | 20.84 | 0.83 | 2.19 | 56.43 |
| Textile | 2.3263 | 0.2520 | 0.1083 | 2.88 | 91.91 | 5.17 | 0.00 | 0.04 | 0.00 |
| Cement | 0.6478 | 0.1856 | 0.2866 | 20.62 | 0.10 | 72.69 | 0.31 | 6.29 | 0.00 |
| Wood | 0.0118 | 0.0026 | 0.2200 | 0.00 | 28.28 | 70.96 | 0.76 | 0.00 | 0.00 |
| Steel | 0.5076 | 1.1908 | 2.3458 | 0.00 | 0.00 | 95.82 | 4.18 | 0.00 | 0.00 |

LPG = liquefied petroleum gas, ktoe = thousand ton of oil equivalent.

Source: Authors' calculation.

## Inflation to National Total

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

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

where:

*ECi* is the total energy consumption for sector i;
*IECi* is the energy consumption per revenue for sector i (intensity);
*GDPi* is the total GDP for sector i; and
*VARi* is the value-added ratio for sector i (assumed to be 0.5 for all sectors).

The Lao PDR GDP structure consists of the agriculture, industry, and service sectors (Table 3.4). Data were collected by DEPP from the Lao Statistics Bureau for 2012 to 2016.

The industry sector's contribution to total GDP reached around 34% in 2016, increasing from its 32% share in 2012. The manufacturing sector was separated into: i) food; ii) beverage and tobacco; iii) textile, cloth, shoes, and leather; and iv) other manufacturing. There was no further breakdown into the cement, wood, and steel sub-sectors.

## Table 3.4. Lao PDR Gross Domestic Product
(KN billion, at 2012 constant price)

| Main Activity | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| **Agriculture** | **15,138** | **15,567** | **16,213** | **16,791** | **17,254** |
| Planting | 9,423 | 9,770 | 10,485 | 10,946 | 11,289 |
| Livestock | 1,942 | 2,003 | 2,079 | 2,171 | 2,301 |
| Forestry | 1,748 | 1,668 | 1,420 | 1,314 | 1,229 |
| Fishing | 2,025 | 2,126 | 2,229 | 2,360 | 2,435 |
| **Industry** | **26,471** | **28,509** | **30,594** | **32,738** | **36,667** |
| Mining and Quarrying | 9,379 | 9,805 | 10,625 | 10,617 | 11,052 |
| Food | 1,368 | 1,462 | 1,545 | 1,620 | 1,645 |
| Beverage and Tobacco | 1,182 | 1,298 | 1,518 | 1,568 | 1,627 |
| Textile, Cloth, Shoes, and Leather | 1,300 | 1,311 | 1,348 | 1,357 | 1,368 |
| Other Manufacturing | 3,481 | 3,518 | 3,918 | 4,152 | 4,331 |
| Electricity | 5,265 | 6,185 | 6,160 | 6,856 | 9,539 |
| Water and Waste Treatment | 232 | 252 | 267 | 276 | 285 |
| Construction | 4,264 | 4,678 | 5,213 | 6,292 | 6,820 |
| **Sevice** | **32,768** | **35,957** | **38,874** | **41,992** | **43,944** |
| Wholesale and Retail Trade, Repairs | 9,759 | 10,860 | 12,393 | 13,622 | 14,516 |
| Transport and Storage | 1,148 | 1,253 | 1,334 | 1,482 | 1,606 |
| Hotels and Restaurants | 2,460 | 2,681 | 2,913 | 3,199 | 3,162 |
| News and Communication | 1,331 | 1,509 | 1,676 | 1,932 | 2,013 |
| Financial and Insurance | 1,496 | 1,995 | 2,154 | 2,288 | 2,466 |
| Immovable Property | 6,100 | 6,133 | 6,725 | 7,137 | 7,401 |
| Colleges Service | 1,071 | 1,170 | 1,258 | 1,417 | 1,518 |
| Defence and National Protection | 6,063 | 6,649 | 6,519 | 6,888 | 7,128 |
| Education | 1,432 | 1,677 | 1,794 | 1,852 | 1,892 |
| Health Care and Welfare | 421 | 486 | 499 | 516 | 519 |
| Others Service | 1,487 | 1,544 | 1,609 | 1,659 | 1,723 |
| **Gross Value Added** | **74,377** | **80,033** | **85,681** | **91,521** | **97,865** |
| Tax on Product, Net | 7,233 | 8,125 | 9,190 | 10,248 | 11,051 |
| **GDP at 2012 Constant Price** | **81,610** | **88,158** | **94,871** | **101,769** | **108,916** |

GDP = gross domestic product, KN = kip.

Source: Department of Energy, Policy and Planning, based on data from Lao Statistics Bureau.

To calculate the national energy consumption of the industry sector, the survey results for the cement, wood, and steel sub-sectors were combined as 'Other Manufacturing' sub-sector. The survey result was applied only for the 2015 values for comparison with the figures in the 2015 Lao PDR Energy Balance Table (EBT).

**Table 3.5. Estimated Total Consumption of the Industry Sector**

| Industry | GDP 2015 | | Survey Result | Estimated Energy Consumption (ktoe) |
|---|---|---|---|---|
| | KN Billion | US$ Million | ktoe/US$ Million | |
| **Manufacturing** | **8,697** | **1,061** | | **432.45** |
| Food, Beverage, and Tobacco | 3,188 | 389 | 0.94022 | 182.77 |
| Textile, Cloth, Shoes, and Leather | 1,357 | 165 | 0.10835 | 8.97 |
| Other Manufacturing | 4,152 | 506 | 0.95079 | 240.71 |

GDP = gross domestic product, KN = kip, ktoe = thousand ton of oil equivalent.
Note: US$1.00 = KN8,200.
Source: Authors' calculation.

Using the fuel shares calculated from the survey as shown in Table 3.3, the estimated fuel energy consumption in 2015 shows that majority of the fuel consumed by the manufacturing sector is electricity followed by oil, which is mainly fuel oil (Table 3.6).

**Table 3.6. Estimated Total Consumption by Fuel (ktoe)**

| Main Activity | Estimated Energy Consumption (ktoe) | Coal | Biomass | Electricity | Oil | LPG | Diesel | Fuel Oil |
|---|---|---|---|---|---|---|---|---|
| Industry | 432.45 | 74.04 | 12.52 | 222.71 | 123.18 | 4.05 | 15.99 | 103.13 |
| Food, Beverage, Tobacco | 182.77 | 34.44 | 1.42 | 38.08 | 108.83 | 1.70 | 3.99 | 103.13 |
| Textile, Cloth, Shoes,Leather | 8.97 | 0.26 | 8.24 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other Manufacturing | 240.71 | 39.34 | 2.86 | 184.17 | 14.35 | 2.35 | 11.99 | 0.00 |

LPG = liquefied petroleum gas, ktoe = thousand ton of oil equivalent.
Source: Authors' calculation.

The 2015 Lao PDR EBT shows that the total energy consumption of the total industry was around 644 ktoe (Table 3.7). Since no data was available for sub-sector consumption, total consumption was entered as non-specified industry consumption. The estimated energy consumption was just for the manufacturing industry consumption and should thus be smaller than that for the total industry. In this case, the difference is around 212 ktoe (almost one-third of the EBT value).

**Table 3.7.** Estimated Total Energy Consumption by Fuel (ktoe)

| Sector | Coal | Petroleum Products | Gas/ Diesel Oil | Fuel Oil | LPG | Others | Electricity | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **Industry Sector** | **392** | **46** | **37** | **10** | | **56** | **150** | **644** |
| Iron and Steel | | | | | | | | |
| Chemical (incl. Petrochemical) | | | | | | | | |
| Non-ferrous Metals | | | | | | | | |
| Non-metallic Mineral Products | | | | | | | | |
| Transportation Equipment | | | | | | | | |
| Machinery | | | | | | | | |
| Mining and Quarrying | | | | | | | | |
| Food, Beverages, and Tobacco | | | | | | | | |
| Pulp, Paper, and Printing | | | | | | | | |
| Wood and Wood Products | | | | | | | | |
| Construction | | | | | | | | |
| Textile and Leather | | | | | | | | |
| Non-specified Industry | 392 | 46 | 37 | 10 | | 56 | 150 | 644 |

ktoe = thousand ton of oil equivalent, LPG = liquefied petroleum gas.

Source: 2015. Lao PDR Energy Balance Table.

The differences are due to the limitation of the GDP statistics. There was no breakdown of the GDP statistics for the cement, wood, and steel industries. In addition, some of the factories surveyed excluded their revenue data. This affected the estimation of the industry intensities.

This energy consumption survey of the industry sector is the first of its kind for DEPP. Therefore, there are differences in the estimated fuel consumption between the survey result and the DEPP data. In conclusion, there is plenty of room to improve the survey results in the future which will contribute to the breaking down of energy consumption in the industrial sub-sectors.

## Future Improvements

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

Sales revenue was confidential in some of the surveyed factories so it was not possible to calculate the unit energy consumption of these factories. In addition, there were outliers

in the sample results of the unit energy consumption. These two factors reduced the accuracy of the average unit energy consumption of each sub-sector.

In the future, prior to conducting the survey, DEPP needs to collect the list of manufacturing industries operating in the Lao PDR to understand the population of the different sub-sectors. The number of samples should also be more than 200 since some factories have missing sales revenue data and some are outliers.

At the national level, the gross added value of the sub-sector is the indicator of sub-sector activity. Therefore, to inflate the industrial survey result of the estimated energy consumption to the national level, the researchers had to break down the surveyed sub-sector's GDP. The current GDP structure of the Lao PDR combines the gross added value of the cement, wood and wood products, and steel under the Other Manufacturing sub-sector.

For future surveys, DEPP should request the breakdown of the GDP of Other Manufacturing sub-sector from the Lao Statistics Bureau. This information should be available since the gross added value of an industry is usually calculated as the difference between the output and input values of the industry.

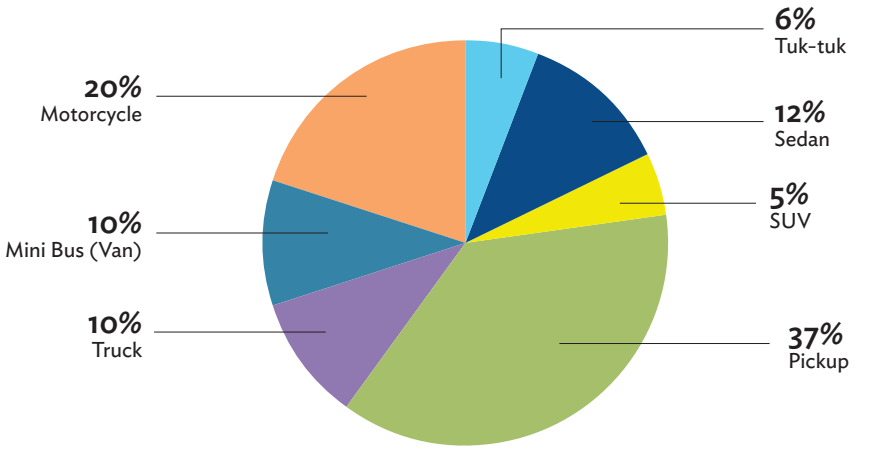
Another option to estimate the unit energy consumption is the production amount of each sub-sector surveyed. At the national level, this will also need the total production of the sub-sector. In conclusion, both the national production and gross added value of the sub-sectors surveyed are very important in estimating the total energy consumption of the Lao PDR from the demand side.

## Road Transportation Sector

### Survey Results

A parking lot survey was conducted in several locations in Vientiane (Anou Park, Aussie market, ITEC Shopping Mall, Khet Market, Kuadin Market, Nong Nieu Market, Sikhay Market, Victory Monument, View Mall, and VTE Center). The sample totalled 200 vehicles (Figure 3.1).

**Figure 3.1.** Types of Vehicles Sampled



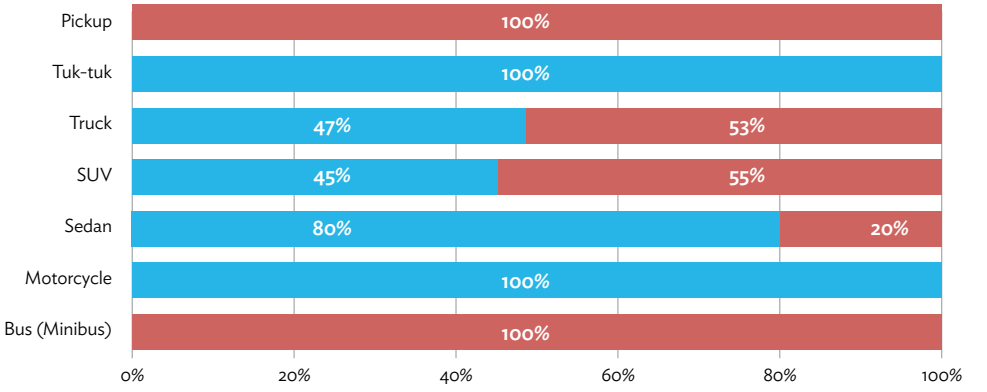

SUV = sport utility vehicle.

Source: Authors' calculation.

The pickup had the largest share of the vehicles sampled, followed by the motorcycle. All the pickups sampled consumed diesel oil while the motorcycles consumed gasoline. Figure 3.2 shows the fuel consumption of the sampled vehicles. Overall, 57% consumed diesel while 43% consumed gasoline. The share of the vehicles by type and their fuel share were the bases for estimating the national road transport consumption by vehicle type.

Based on the vehicle's weekly consumption and the distance travelled, it is possible to calculate the average fuel economy of the vehicle and its distance travelled over the year.

**Figure 3.2.** Breakdown of Vehicles by Fuel Consumed




| | Bus (Minibus) | Motorcycle | Sedan | SUV | Truck | Tuk-tuk | Pickup |
|---|---|---|---|---|---|---|---|
| Gasoline | | 40 | 20 | 5 | 9 | 12 | |
| Diesel | 19 | | 5 | 6 | 10 | | 74 |

SUV = sport utility vehicle.

Source: Authors' calculation.

The fuel economy of the vehicle is the relationship between the distance travelled and the amount of fuel consumed by the vehicle. Consumption can be expressed in terms of volume of fuel to travel a distance, or the distance travelled per unit volume of fuel consumed. Outliers in the samples were removed from the data set. An outlier is an observation that has an abnormal distance from the other values in a random sample from a population. Table 3.8 shows the calculated average fuel economy and distance travelled for gasoline and diesel vehicles according to the type of vehicle

The large bus values were based on the interview of a bus company, which indicated that the large buses use diesel. The company provided the monthly fuel consumption and distance travelled of the operating buses. Not all of the company buses operate every month. On average, 29 buses operate per month. The fuel economy was calculated based on this number.

**Table 3.8. Fuel Economy and Distance Travelled of Sampled Vehicles**

| Type of Vehicle | Average Km/Litre | | Average Km/Year | |
|---|---|---|---|---|
| | Gasoline | Diesel | Gasoline | Diesel |
| Sedan/Car | 9.6 | 9.5 | 15,236 | 16,276 |
| SUV | 9.9 | 9.3 | 16,006 | 16,995 |
| Bus (minibus) | | 9.2 | 0 | 18,206 |
| Pickup | | 9.1 | 0 | 16,712 |
| Truck | 9.8 | 9.8 | 31,633 | 14,080 |
| Motorcycle | 20.5 | | 5,104 | 0 |
| Tuk-tuk | 10 | | 15,974 | 0 |
| Large Bus | | 3,4 | | 4,990 |

km = kilometre, SUV= sport utility vehicle.

Source: Authors' calculation.

## Inflation to National Total

Based on the unit fuel consumption of the different types of vehicles surveyed, the total oil consumption for road transport was estimated as follows:

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

where:

*OILi* is the total gasoline/diesel consumption for vehicle type *i;*

*FEi* is the fuel economy of vehicle type *i;*

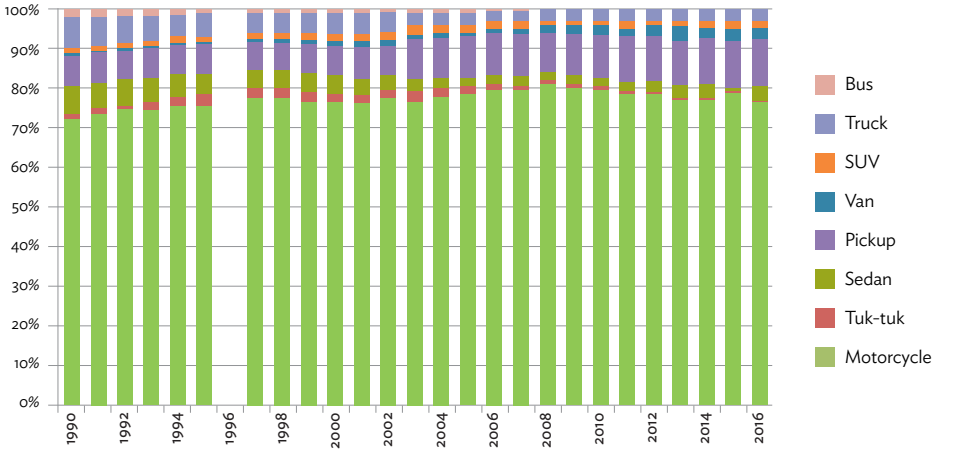
*DISi* is the distance travelled of vehicle type *i;* and

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

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

The total number of vehicles is the activity data for the road transport sector. The data was based on annual vehicle registrations. DEPP provided the vehicle population by type from 1990 to 2016 (Figure 3.3). Based on this data, total vehicle population in the Lao PDR increased by 13% per year, from around 80,000 in 1990 to almost 1.8 million in 2016. No data was available in 1996.

**Figure 3.3. Vehicle Population in the Lao PDR, 1990–2016**




SUV= sport utility vehicle.

Sources: Department of Energy, Policy and Planning Ministry of Energy and Mines, Lao PDR; Department of Transport, Ministry of Public Works and Transport, Lao PDR.

The majority of the vehicles surveyed were motorcycles. The shares of motorcycles in the total vehicle population were 72% in 1990 and 77% in 2016.

DEPP did not specify the vehicle type by fuel consumption in its vehicle population data. Hence, the breakdown of vehicles by type of fuel consumed was based on the survey conducted in 2017. Since no vehicle population data was available for 2017 and the latest DEPP petroleum product consumption data at the time of the survey was 2015, the number of vehicles by type in 2015 was used to estimate the total fuel consumption by type of vehicle using the vehicles' intensity (consumption per vehicle per year).

## Table 3.9. Estimated Total Consumption on Road Transport

| Vehicle Type | Number of Vehicles | | Vehicle Intensity (l/vehicle) | | Total Consumption (kl) | | |
|---|---|---|---|---|---|---|---|
| | Gasoline-Fuelled Vehicle | Diesel-Fuelled Vehicle | Gasoline-Fuelled Vehicle | Diesel-Fuelled Vehicle | Gasoline-Fuelled Vehicle | Diesel-Fuelled Vehicle | Total Fuel |
| Sedan/Car | 7,009 | 1,752 | 1,587 | 1,713 | 11,124 | 3,002 | 14,126 |
| SUV | 12,120 | 14,545 | 1,617 | 1,827 | 19,596 | 26,579 | 46,175 |
| Minibus (Van) | - | 47,553 | | 1,979 | | 94,103 | 94,103 |
| Pickup | - | 204,360 | | 1,836 | | 375,304 | 375,304 |
| Truck | 23,087 | 25,652 | 3,228 | 1,564 | 74,521 | 40,131 | 114,652 |
| Motorcycle | 1,318,107 | - | 249 | | 328,176 | | 328,176 |
| Tuk-tuk | 8,761 | - | 1,597 | | 13,995 | | 13,995 |
| Buses | - | 4,448 | | 1,465 | | 6,518 | 6,518 |
| **Total** | **1,369.084** | **298,310** | | | **447,412** | **539,119** | **986,531** |

kl = kilolitre, l = litre.

Source: Authors' calculation.

The result showed that the total consumption of petroleum products for road transport in the Lao PDR was 986,531 kl, consisting of 447,412 kl gasoline and 539,119 kl diesel fuel. However, the consumption of gasoline by fuel type was twofolds higher while that of diesel was lower. The DEPP consumption data was for total transport. In the case of gasoline, the DEPP data was only for road transport since gasoline was consumed only by road vehicles. Diesel fuel was consumed for road transport and water/river transport.

The estimated road energy consumption by fuel type was estimated based on the number of gasoline and diesel vehicles. The real share of these vehicles from the total vehicles in the country can be obtained by improving the transportation statistics to include the breakdown of the number of vehicles by the type of fuel consumed.

In terms of the total fuel consumption of the road sector, the difference was still statistically acceptable (below 10%). In this regard, the major study results (fuel economy and mileage) could be useful for the analysis of vehicles. The exception was the result of motorcycle consumption (328,000 kl), which was higher than the DEPP statistics on gasoline import for 2015 (234,000 kl).

**Table 3.10.** DEPP Statistics on Gasoline and Diesel Supply and Consumption

| Year | Gasoline | | Diesel Oil | | | | |
|---|---|---|---|---|---|---|---|
| | Import | Consumption | Import | Consumption | | | |
| | | Transport | | Transport | Agriculture | Industry | Total |
| 2000 | 101,676 | 100,476 | 214,461 | 201,569 | 232 | 12,660 | 214,461 |
| 2001 | 102,439 | 100,439 | 245,641 | 236,513 | 232 | 8,896 | 245,641 |
| 2002 | 108,002 | 107,002 | 247,574 | 238,059 | 232 | 9,282 | 247,574 |
| 2003 | 112,200 | 110,200 | 255,769 | 250,615 | 232 | 4,921 | 255,769 |
| 2004 | 119,879 | 117,879 | 262,904 | 257,323 | 232 | 5,348 | 262,904 |
| 2005 | 129,356 | 124,301 | 271,031 | 266,825 | 232 | 3,974 | 271,031 |
| 2006 | 143,473 | 134,654 | 375,295 | 282,850 | 232 | 92,213 | 375,295 |
| 2007 | 152,502 | 152,502 | 381,944 | 307,177 | 232 | 74,535 | 381,944 |
| 2008 | 159,455 | 159,455 | 457,327 | 365,013 | 232 | 92,082 | 457,327 |
| 2009 | 178,296 | 155,118 | 538,769 | 430,015 | 232 | 108,522 | 538,769 |
| 2010 | 187,755 | 152,885 | 538,769 | 436,034 | 232 | 102,502 | 538,769 |
| 2011 | 197,176 | 144,804 | 550,844 | 439,805 | 232 | 110,807 | 550,845 |
| 2012 | 208,205 | 139,559 | 601,588 | 510,293 | 232 | 91,062 | 601,588 |
| 2013 | 219,251 | 215,650 | 643,276 | 533,735 | 232 | 109,308 | 643,275 |
| 2014 | 212,950 | 210,416 | 688,907 | 654,122 | 232 | 34,553 | 688,908 |
| 2015 | 234,199 | 223,318 | 849,151 | 686,447 | 232 | 162,472 | 849,151 |

Source: Department of Energy Policy and Planning, Lao PDR.

## Future Improvements

The parking lot survey and transport company interview provided bases for the estimation of oil consumption in the road transport sector. The result for total oil consumption was slightly higher than the DEPP data (less than 10%). The breakdown by diesel and gasoline fuel was significantly different.

The estimate of the fuel economy and distance travelled of the sampled vehicles was the basis for calculating the total road consumption at the national level. The survey resulted in an overestimation of gasoline consumption while diesel consumption was on the lower side compared to the DEPP data.

The issue was that the total number of vehicles by type was not broken down by type of fuel consumed. An estimation of the breakdown was made based on the sampled survey.

In the future, DEPP can approach the division that handles motor vehicle registrations. Usually, when a vehicle is registered, it includes information on the engine size and the type of fuel it consumes. Based on this information, it would be possible to break down the vehicle population by type and fuel consumed.

The statistics on the number of vehicles need to be clarified – whether it is all in operation or just a cumulative number from previous years. DEPP should also collect the number of newly registered vehicles in addition to those already in operation. This will make the estimation of the fuel consumption at the national level more accurate.

For buses or trucks not covered in the parking lot survey, the transport company interview was the best approach. For comparison purposes, at least two transport companies should be interviewed for each vehicle type (buses, trucks, and taxis).

Lastly, the estimate of the fuel consumed by the transport sector needs to be compared with the sales of the oil companies at the pump stations. At the moment, DEPP sources its data from the fuel import data of the customs office. There is no breakdown of, for example, of the imported diesel by road or inland waterways (river transport). By collecting the oil companies' sales at the pump stations, the diesel consumption used in the road transport sector can be obtained.

## Commercial Sector

The commercial sector surveyed consisted of four types of buildings, namely, offices (100), hotels (50), shoping malls (35), and hospitals (15).

A useful method to evaluate the energy performance of commercial buildings is to derive a benchmark value in building energy intensity (BEI) from the survey data. BEI is expressed as kilowatt-hour per square meter ($kWh/m^2$) per year and can be determined by the following formula:

$$BEI = \frac{TBEC - CPEC - DCEC}{GFA - DCA - GLA \times FVR} \times \frac{52}{WOH}$$

where:

*TBEC* is the total building energy consumption (kWh/yr);
*CPEC* is the car park energy consumption (kWh/yr);
*DCEC* is the data centre energy consumption (kWh/yr);
*GFA* is the gross floor area ($m^2$);
*DCA* is the data centre area ($m^2$);
*GLA* is the gross lettable area ($m^2$);
*FVR* is the floor vacancy rate (%);
*WOH* is the weighted weekly operating hours (hr/week); and
*BEI* is the building energy intensity (kWh/$m^2$/yr).

Table 3.11 shows the typical benchmark values of BEI in Malaysia and the energy use intensity (EUI) in Singapore.

**Table 3.11. Comparison of Building Energy Intensity Values**

| Building Type | EUI for Green Mark, Singapore (kWh/$m^2$/year) | | BEI for GBI, Malaysia (kWh/$m^2$/year) | |
|---|---|---|---|---|
| | Conventional | Green Building Entry Level | Conventional | Green Building Entry Level |
| Office Buildings | 246 | 200 | 250 | • 150 |
| Hotels | 275 | 250 | N/A | • 200 for 3-star hotels<br>• below 290 for 4-star hotels and above |
| Retail Buildings | 543 | 474 | 345 | • 240 for malls consisting of general retail outlets and low-energy intensity outlets<br>• 350 for malls consisting of at least 10% (of its NLA) high-energy intensity outlets such as F&B, supermarkets, and outlets operating long hours such as cinema, etc. |
| Hospitals | 355 | 310 | 300 | • 200 for hospitals providing limited clinical services such as day surgery, etc.<br>• 290 for hospitals providing major clinical services (requiring high-energy intensity) |

BEI = building energy intensity, EUI = energy use intensity, F&B = food and beverages, GBI = Green Building Index, kWh = kilowatt-hour, $m^2$ = square meter, N/A = not available, NLA = net lettable area.

Source: ASHRAE, Malaysia Chapter, 2018.

## Office Buildings

The key data obtained in the survey were the following:

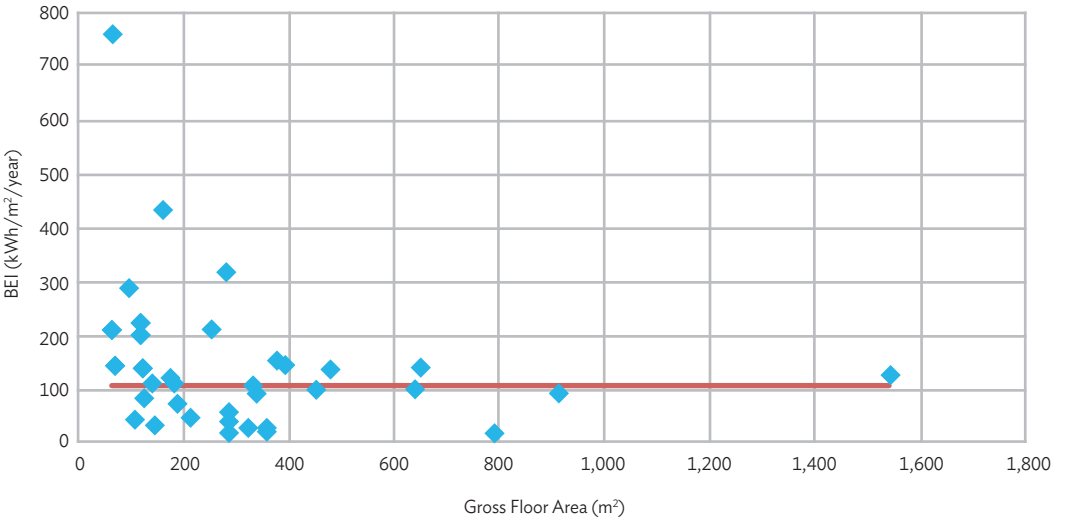
i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) daily operational hours;
v) total gross floor area ($m^2$ – excluding car park and data centre); and
vi) estimated percentage of air-conditioned area.

The maximum demand was supposed to be the highest load on the building's electrical system at a given time and was intended to be used to gauge the extent of electricity consumption in a building. The data obtained appeared to be the monthly electricity consumption of a building, which was not the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of the maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption in office buildings were not reflective of the actual yearly electricity consumption.

Operational hours of office buildings varied and that the average operational hours amongst the buildings surveyed was 2,160 hours per year. This value is lower than the 2,700 hours per year value adopted by the green building practices in Malaysia. The latter included working hours beyond the official operational hours in offices where air-conditioning systems were still operational. Nevertheless, based on this average value and after adding the consumption of other energy sources, the total energy consumption was adjusted to reflect the same operational hours of 2,160 per year to rationalise the energy consumption for comparison purposes.

The main energy source of office buildings was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey. Preliminary analysis showed exceptionally low BEI value compared with office buildings in Malaysia and Singapore, which have similar climatic conditions.

**Figure 3.4.** Preliminary BEI vs GFA Trend of Office Buildings

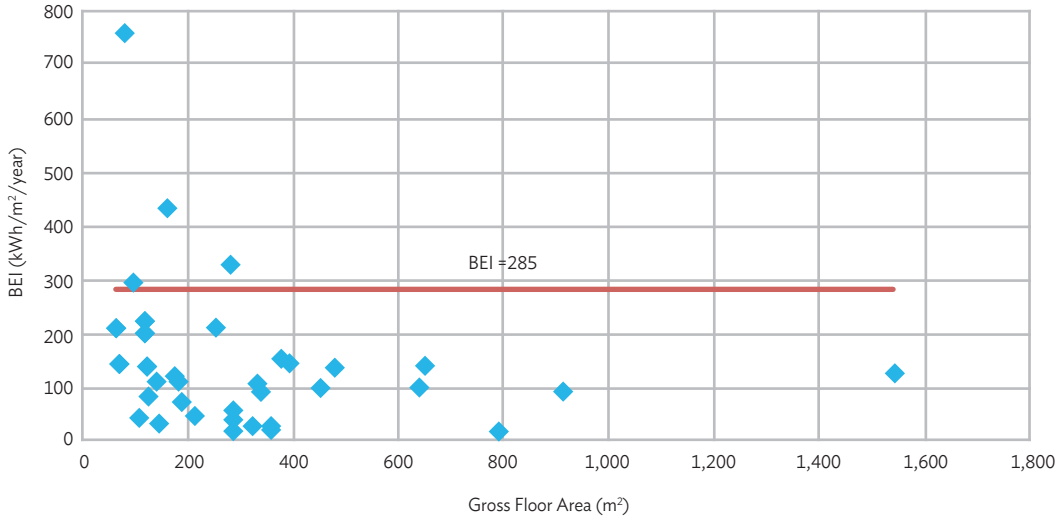



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.
Source: The Working Group's calculation of BEI from 2017 survey data 2017.

Figure 3.4 shows an average BEI value of about 106 kWh/$m^2$/year. This is good because the average conventional buildings without energy efficiency design and installations are in the range of 250 kWh/$m^2$/year in Malaysia and 246 kWh/$m^2$/year in Singapore. The discrepancies in the survey results could be due to the accuracy of the energy consumption values and the gross floor areas, and the average operational hours of office buildings. The average BEI in Figure 3.4 was derived from all the BEI values calculated from the survey data, except for BEI values exceeding 500 kWh/$m^2$/year.

Another analysis was conducted which invalidated BEI values below 200 kWh/$m^2$/year and only considered BEI values that fall between 200 kWh/$m^2$/year and 500 kWh/$m^2$/year. This assumption was made based on the established BEI and EUI values of office buildings in Malaysia and Singapore. The results are shown in Figure 3.5.

**Figure 3.5.** Final Analysis of BEI vs GFA of Office Buildings




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.
Source: The Working Group's calculation of BEI from 2017 survey data 2017.

Figure 3.5 shows an average BEI value of 284 kWh/$m^2$/year, which was rounded up to 285 kWh/$m^2$/year. For the purpose of this survey, the average benchmark value of energy consumption intensity in office buildings is 285 kWh/$m^2$/year.

## Hotels

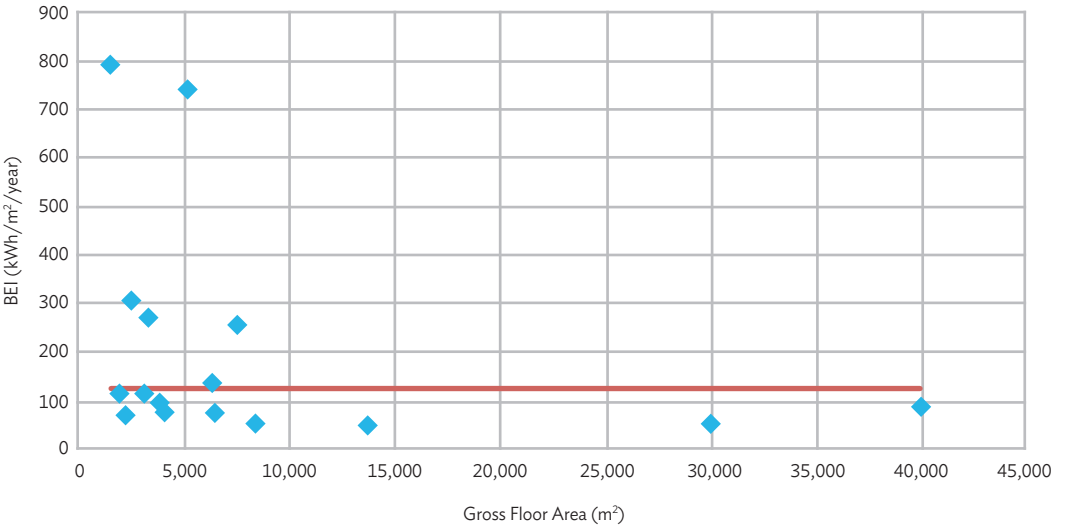
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) peak and off-peak periods;
v) star ratings of hotels;
vi) total gross floor area ($m^2$ – excluding car park and data centre); and
vii) estimated percentage of air-conditioned area.

Similar to office buildings, the maximum demand recorded appeared to be the monthly electricity consumption of the hotels, which was not in accordance with the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption of hotels were not reflective of their actual yearly electricity consumption. The maximum demand was meant to be the highest load on the building's electrical system at a given time and was intended to be used to gauge the extent of electricity consumption in a building.

The main energy source of hotels was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey. Preliminary analysis showed exceptionally low BEI value in compared with the BEI for hotels in Malaysia and Singapore.

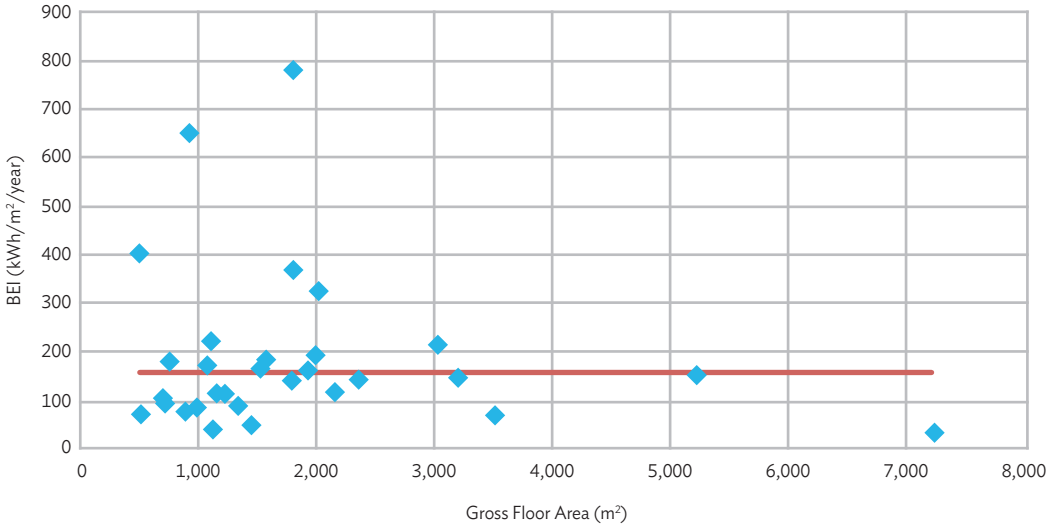
**Figure 3.6. Preliminary BEI vs GFA Trend of 4- and 5-Star Hotels**




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

**Figure 3.7.** Preliminary BEI vs GFA Trend of 1- to 3-Star Hotels

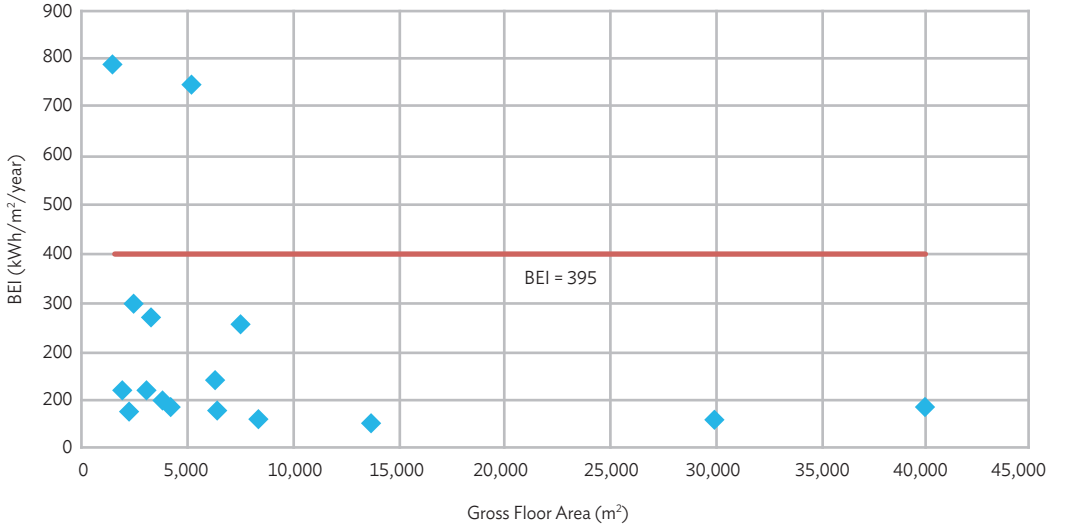



BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.
Source: The Working Group's calculation of BEI from 2017 survey data.

Preliminary analyses showed that the average BEI for 4- to 5-star hotels was about 126 kWh/$m^2$/year and about 159 kWh/$m^2$/year for 3-star hotels. These BEI values are rather low compared with the BEI values in Malaysia and Singapore. The BEI values of 4- to 5-star hotels are generally greater than those of 3-star hotels but the preliminary analyses showed the opposite.

In conducting further analyses, the same approach as that for office buildings was adopted. For 4- to 5-star hotels, the average BEI value was based on the 150 kWh/$m^2$/year to 750 kWh/$m^2$/year range. As shown in Figure 3.8, the average BEI value was 393 kWh/$m^2$/year, which was rounded to 395 kWh/$m^2$/year. Similarly, the BEI value for 3-star hotels was 262 kWh/$m^2$/year, which was rounded to 260 kWh/$m^2$/year.

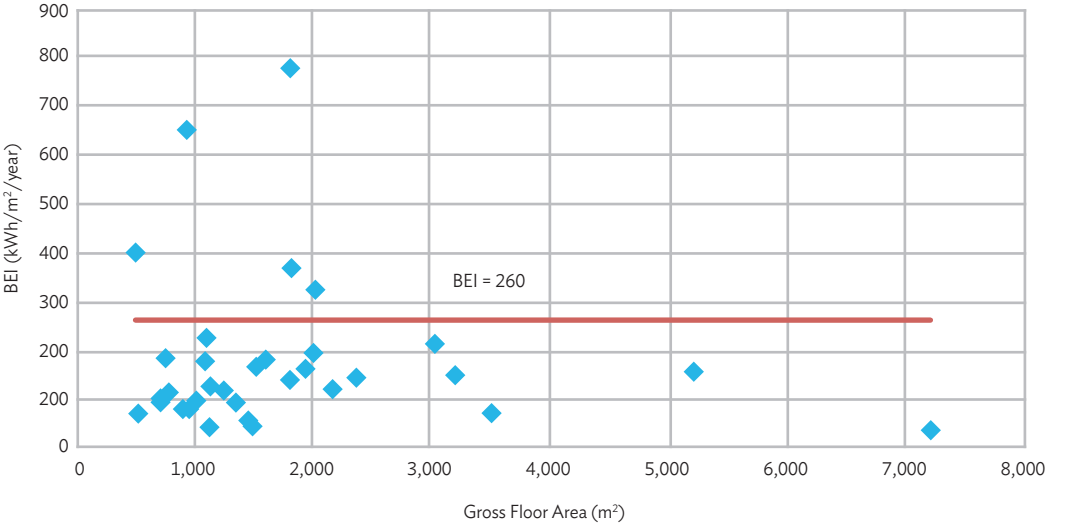
## Figure 3.8. Final Analysis of BEI vs GFA for 4- to 5-Star Hotels




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

## Figure 3.9. Final Analysis of BEI vs GFA for 3-Star Hotels




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

## Retail Buildings

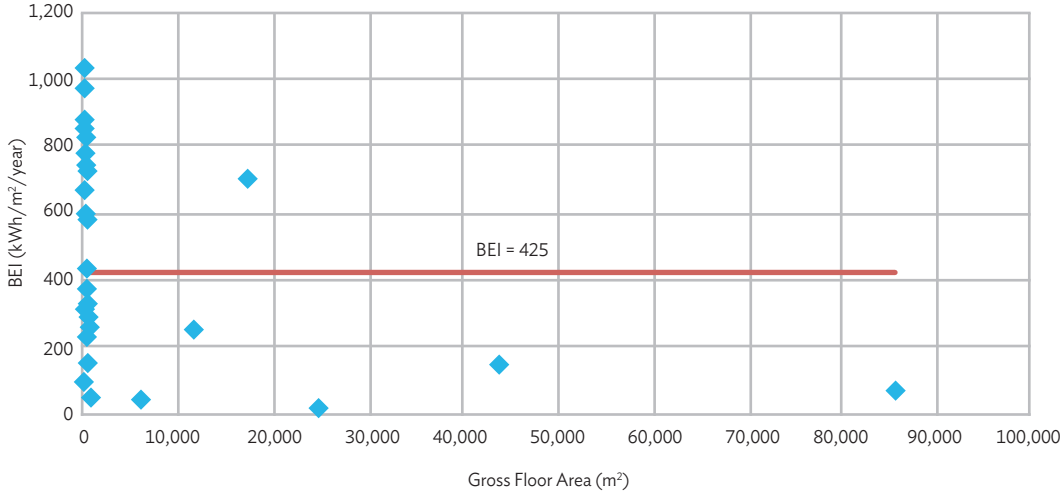
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) daily operational hours;
v) total gross floor area ($m^2$ – excluding car park and data centre); and
vi) estimated percentage of air-conditioned area.

Similar to office buildings, the operational hours of retail buildings varied. The average operational hour amongst the buildings surveyed was 6,068 hours per year, which was rounded up to 6,070 hours per year. This value is high compared with the 4,368 operational hours per year or 84 operational hours/week of green buildings in Malaysia. Based on this average value and after adding the consumption of other energy sources, the total energy consumption was adjusted to reflect the same operational hours of 6,070 per year to rationalise the energy consumption for comparison purposes.

Similar to other commercial buildings, the main energy source of retail buildings was electricity. BEI values were determined using the total energy consumption based on the rationalised operational hours and the gross floor area recorded in the survey.

**Figure 3.10. Analysis of BEI vs GFA of Retail Buildings**




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.

Source: The Working Group's calculation of BEI from 2017 survey data.

Figure 3.10 shows the diverse range of BEI values of small retail buildings. Since the sampling size was small, the determination of the average value of BEI was based on all the values obtained in the survey. The average BEI value for retail buildings was 423 kWh/$m^2$/year, which was rounded up to 425 kWh/$m^2$/year.

## Hospitals

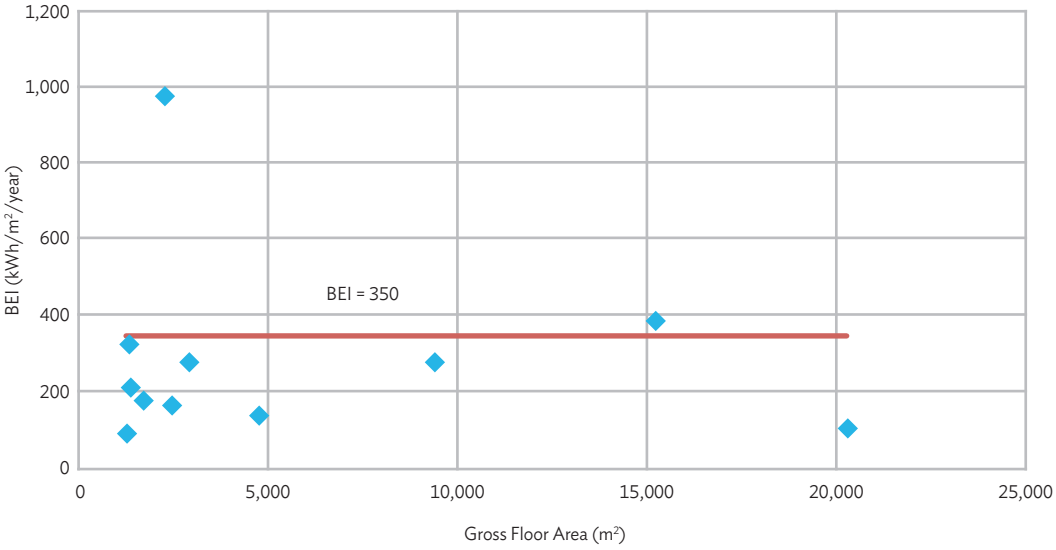
The key data obtained in the survey were the following:

i) maximum electricity demand (kW);
ii) total electricity consumption per year (kWh/year);
iii) energy consumption per year of other energy sources (i.e. fuel energy other than electricity);
iv) total gross floor area ($m^2$ – excluding car park and data centre); and
v) estimated percentage of air-conditioned area.

Similar to hotel buildings, the maximum demand recorded appeared to be the monthly electricity consumption of a building, which was not in accordance with the original intention. The yearly electricity consumption of a building recorded in the survey was obtained by multiplying the value of maximum demand by 12. As a result, the data obtained for the total yearly electricity consumption in office buildings were not reflective of the actual yearly electricity consumption in hotels. Nevertheless, the analysis of hospital energy consumption was based on the data obtained in the survey.

The hospitals were grouped according to size: i) large hospitals with gross floor area exceeding 2,000 $m^2$; ii) medium hospitals with gross floor area between 1,000 $m^2$ and 2,000 $m^2$; and iii) small hospitals with gross floor area less than 1,000 $m^2$. The BEI values for small hospitals appeared to be exceptionally low. The study group thinks that these buildings might be functioning as clinics rather than as hospitals. In view of this, the determination of the average value of BEI was based on the BEI values for large- and medium-sized hospital buildings. Figure 3.11 shows the average value of BEI for hospitals as 350 kWh/$m^2$/year.

**Figure 3.11.** Analysis of BEI vs GFA of Hospitals




BEI = building energy intensity, GFA = gross floor area, kWh = kilowatt-hour, $m^2$ = square meter.
Source: The Working Group's Calculation of BEI from 2017 survey data.

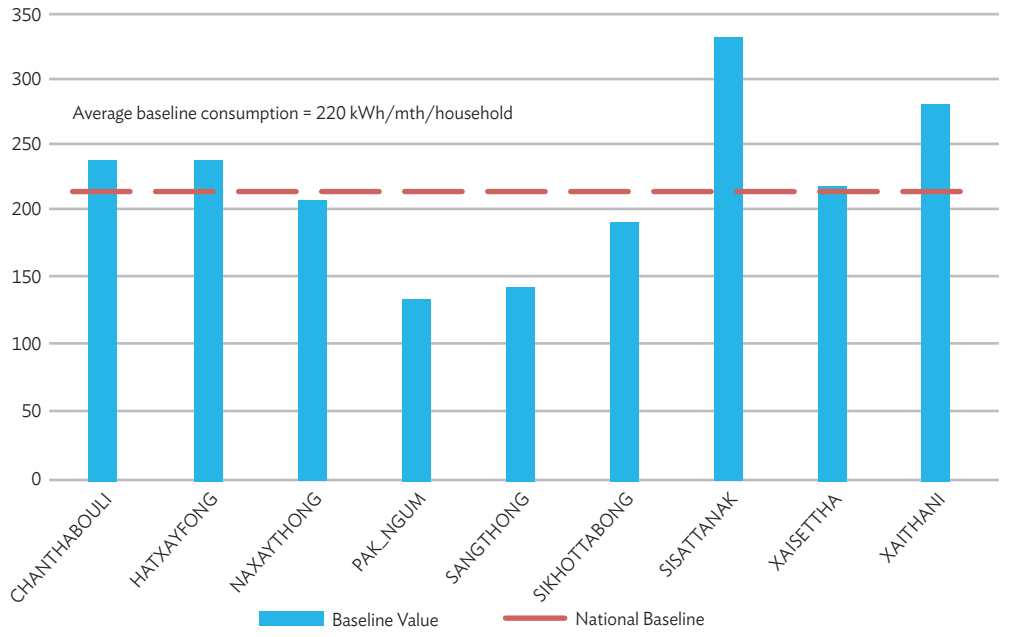
## Residential Sector

The samples for the energy consumption survey in the residential sector consisted of 102 urban and 98 sub-urban dwellings. Of these, 170 were stand-alone houses and 30 were apartments.

The consumption survey data were grouped into districts. Figure 3.12 shows the average electricity consumption in each district surveyed. An average baseline electricity consumption of 220 kWh/month/household was determined from these average electricity consumption values in the respective districts.

Similarly, Figure 3.13 shows the average total energy consumption, including electricity, and the fossil fuel and biomass consumption in each district. The average baseline total energy consumption amongst the districts was 705 kWh/month/household, which is more than three times the average baseline electricity consumption. This may indicate that Lao households consume much more fossil fuels and biomass than electricity. Table 3.12 shows the breakdown of the shares of energy sources consumed in the residential sector; this is illustrated in Figure 3.14.

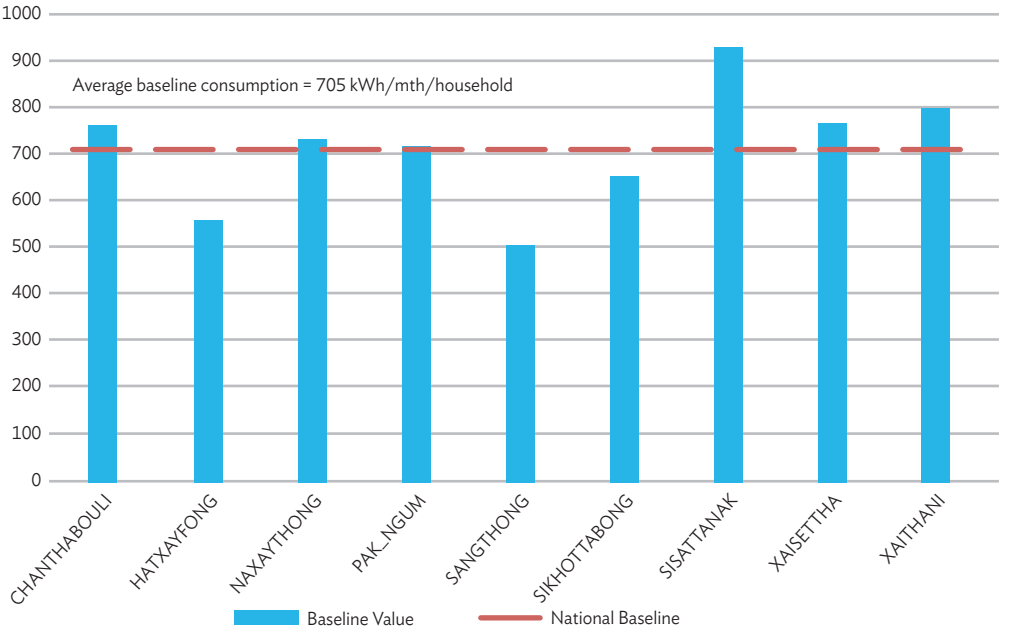
## Figure 3.12. Average Electricity Consumption by District per Household




kWh = kilowatt-hour, mth = month.

Source: The Working Group's calculation of BEI from 2017 survey data.

## Figure 3.13. Total Energy Consumption (including Electricity) by District per Month per Household




kWh = kilowatt-hour, mth = month.

Source: The Working Group's calculation of BEI from 2017 survey data.

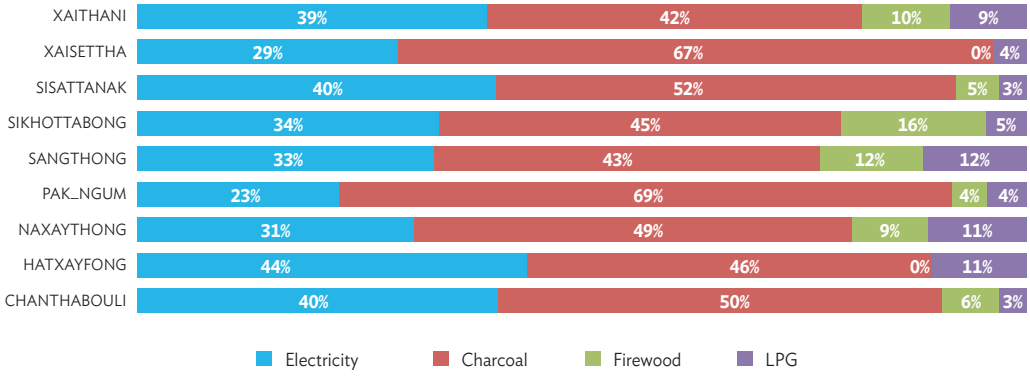
## Table 3.12. Average Share of Energy Sources Consumed by Each District (%)

| Districts | Category of Area | Electricity | Charcoal | Firewood | LPG |
|---|---|---|---|---|---|
| Chanthabouli | Urban/Inner City | 40 | 50 | 6 | 3 |
| Hatxayfong | Rural/Outer City | 44 | 46 | 0 | 11 |
| Naxaythong | Rural/Outer City | 31 | 49 | 9 | 11 |
| Pak_Ngum | Rural/Outer City | 23 | 69 | 4 | 4 |
| Sangthong | Rural/Outer City | 33 | 43 | 12 | 12 |
| Sikhottabong | Urban/Inner City | 34 | 45 | 16 | 5 |
| Sisattanak | Urban/Inner City | 40 | 52 | 5 | 3 |
| Xaisettha | Urban/Inner City | 29 | 67 | 0 | 4 |
| Xaithani | Rural/Outer City | 39 | 42 | 10 | 9 |

LPG = liquefied petroleum gas.

Source: The Working Group's calculation of BEI from 2017 survey data.

## Figure 3.14. Average Share of Energy Sources Consumed by Each District




LPG = liquefied petroleum gas.

Source: The Working Group's calculation of BEI from 2017 survey data.

Table 3.12 shows the shares of electricity, charcoal, firewood, and LPG consumed by the residential sector in each of the districts where the pilot survey was conducted. The pilot survey was essentially conducted in Vientiane areas. The inner city was deemed to be an urban area while the outer city, a rural area. However, it is noted that some rural areas in the country do not have access to electricity supply, but all the 'so-called' rural areas in the survey had access to electricity supply as shown in Table 3.12 and Figure 3.14. The share of fossil fuel and biomass consumption was much more than the share of electricity consumption at an average proportion of about 65% (average ranging from 57% to 77%) of fossil fuels and biomass consumption, compared with about 35% (average ranging from 23% to 44%) of electricity consumption (Figure 3.14).

Based on Table 3.12 and Figure 3.14, we cannot conclusively state that rural areas consume more fossil fuels and biomass than urban areas, although rural areas were expected to consume much more of such fuels as some rural areas in the Lao PDR have no access to electricity supply. The lack of evidence to show such phenomenon could be because the rural areas in the pilot survey were not strictly rural compared with other rural areas in the country. Therefore, the sampling of the energy consumption survey in the outer city (deemed as rural) in Vientiane was not truly representative of the rural areas and affected the projected national energy consumption estimates for the residential sector of the country.

## Estimates of National Energy Consumption in Commercial and Residential Sectors

### Commercial Sector

Based on the analyses on the road transportation sector (p. 47), the projected national energy consumption in the commercial sector can be derived (Table 3.13). The projected estimates were based on the BEI, which were derived from the analysis of the survey data, the total floor area obtained in the survey, and the national statistics on the number of respective buildings in the Lao PDR. However, statistics for office and shopping mall buildings were not available at the time of the analysis. In view of this, the study team assumed that the office and shopping mall buildings constituted about 30% each of the national energy consumption of the office and shopping mall buildings. The other assumption was that the projected estimates of energy consumption from the survey data constitute about 80% of the national energy consumption in the commercial sector. Therefore, the energy consumption of other commercial buildings not accounted for in the pilot survey was assumed to be 20% of the projected estimates derived from the survey data.

**Table 3.13.** Projected National Energy Consumption of the Commercial Sector

| | Hotels 1–3 Stars | Hotels 4–5 Stars | Hospitals | Office | Malls | Miscellaneous Commercial Buildings *Assumed 20% of survey projection | Projected Commercial Sector Energy Consumption |
|---|---|---|---|---|---|---|---|
| BEI (kWh/m²/year) | 260 | 395 | 350 | 285 | 425 | | |
| No. of Samples | 51 | 17 | 15 | 101 | 35 | | |
| Average BEI (kWh/m²/year) *Estimated considering the respective floor areas | 327 | | NA | NA | NA | | |
| Total Floor Area from Survey Data (m²) | 200,093 | | 65,914 | 154,807 | 199,939 | | |
| Estimated Yearly Consumption from Survey Data (MWh) *based on floor area and BEI | 65,430 | | 23,070 | 44,120 | 84,974 | | |
| National Statistics (No. of buildings) | 2,527 | | 162 | Not available | Not available | | |
| **Total Yearly Consumption (MWh)** | **2,431,510** | | **249,155** | **147,067** | **283,247** | **622,196** | **3,733,174** |
| **Total Yearly Consumption (ktoe)** | **209.07** | | **21.42** | **12.65** | **24.35** | **53.50** | **321.00** |

BEI = building energy intensity, kWh = kilowatt-hour, ktoe = thousand ton of oil equivalent, MWh = megawatt-hour, $m^2$ = square meter.

Source: The Working Group's Calculation of BEI from 2017 survey data.

Table 3.13 shows that the total energy consumption for the commercial sector projected from the survey data is 321 ktoe. Table 2.13 on the 2015 Lao PDR EBT shows that the total energy consumption for the commercial and public services sector was 351 ktoe. The projected estimates show that the total energy consumption derived from the survey data for the commercial sector was in the same order of magnitude as the corresponding EBT value. Therefore, the pilot survey demonstrates that it is possible to derive energy consumption for the commercial sector from the BEI. The accuracy can be improved if national statistics, such as number of buildings and total floor area for the various building categories, are available. The BEI values from the survey should be presented and deliberated on by the respective stakeholders in the commercial sector. If these BEI values could be accepted as the indicative benchmark values, then the energy efficiency roadmap and policy could be established to drive the energy efficiency agenda in the commercial sector.

## Residential Sector

Based on the analyses made on page 63, the projected national energy consumption can be derived as given in Table 3.14. The projected estimates were based on the average national baseline energy consumption for households, which were derived from the analysis of the survey data and the national statistics on the number of households in 2016.

**Table 3.14.** Projected National Energy Consumption of the Residential Sector

| | Projected National Electricity Consumption | Projected National Total Energy Consumption | Values based on 2015 Energy Balance Table (refer to Table 2.13) |
|---|---|---|---|
| **Number of Samples** | 200 | 200 | |
| **National Statistics, 2016 (Number of households)** | 1,203,000 | 1,203,000 | |
| **Average Baseline Energy Consumption per Household (kWh/month/household)** | 220 | 705 | |
| **Yearly Average Energy Consumption per Household (kWh/year/household)** | 2,640 | 8,460 | |
| **Projected Yearly Average Energy Consumption (GWh/year)** | 3,176 | 10,177 | |
| **Projected Yearly Average Energy Consumption (ktoe/year)** | **273.08** (overestimated due to survey sampling c.f. EBT) | **875.10** (underestimated due to survey sampling c.f. EBT) | • 137 for electricity<br>• 1,254 for total consumption |

c.f. = compared with, EBT = energy balance table, GWh = gigawatt-hour, ktoe = thousand ton of oil equivalent, kWh = kilowatt-hour.

Source: The Working Group's calculation of BEI from 2017 survey data.

Table 3.14 shows that the projected electricity consumption and the total energy consumption for the residential sector are 273.08 ktoe/year and 875.10 ktoe/year, respectively. In comparison, Table 2.13 on the 2015 Lao PDR EBT shows the electricity consumption and total energy consumption for the residential sector as 137 ktoe. It can be seen that the projected electricity consumption of 273.08 ktoe/year, based on the pilot survey, was higher than the electricity consumption in the 2015 Lao PDR EBT. As mentioned on page 53 (Commercial Sector), this could be due to the pilot survey sampling, which was mainly conducted in the urban and outer city areas of Vientiane where electricity is available and consumed much more than most rural areas in the country.

On the other hand, the projected total energy consumption of 875.1 ktoe in Table 3.14 above is much less than the 1,254 ktoe given in Table 2.13 on the 2015 Lao PDR EBT. This suggests that the pilot survey might not have captured fully the other fuels used. As already mentioned, this was probably due to the survey sampling coverage being confined to urban and outer city areas of Vientiane, which was not reflective of the actual scenario that rural areas consume much more biomass fuels. The consumption of other fuels recorded in the survey was much less, which resulted in lower average total energy consumption baseline values. The projected estimates of total energy consumption based on the pilot survey for the total national residential consumption was grossly underestimated compared with the corresponding EBT value. The projected estimates of total energy consumption for the residential sector can be improved if the survey coverage could be extended nationwide.