Chapter 1

Brunei Darussalam Household Energy Consumption Survey

June 2020

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Chapter 1

Brunei Darussalam Household Energy Consumption Survey

1. Objectives

The Brunei Darussalam Household Energy Consumption Survey (BDHECS), completed in December 2015, was the first comprehensive energy consumption survey in the country. Before 2015, data on energy consumption by end use were limited and residential electricity consumption was not broken down by end-use. Data on energy consumption, type of appliances, and their shares of energy use, as well as other data indispensable to implementing energy efficiency measures, were limited. Scenarios of energy use, energy consumption, and trending in energy demand must be understood. We, therefore, conducted the first comprehensive nation-wide household energy consumption survey, from April to December 2015.

The primary goal of BDHECS was to obtain comprehensive and reliable data that could be used to analyse end-use residential energy consumption, preferences, and trending of energy use. The survey results would be used to formulate and implement policies and programmes to improve sustainability through prudent and efficient use of electricity. Specifically, the survey was designed to accomplish the following:

(i) Determine the energy consumption profile for household and private transportation.
(ii) Establish the current efficiencies of household appliances and private vehicles.
(iii) Establish baseline end-use consumption data for energy efficiency policy analysis and future trends in energy consumption.
(iv) Improve the efficient use of residential energy.
(v) Establish national energy indicators such as, but not limited to, the following:
    (a) energy use intensity (EUI) (kWh/household/year),
    (b) end-use energy consumption per household by district,
    (c) percentage share of electricity use by appliance and establishment of priorities for MEPS for appliances,
    (d) average age of major appliances,
    (e) travel distance and fuel consumption, and
    (f) fuel economy by vehicle type.

The survey was the result of international cooperation. The Economic Research Institute for ASEAN and East Asia (ERIA) and the Institute of Energy Economics, Japan assisted with the technical aspects, including development of the survey questionnaire, its implementation, validation, and data analysis.

The Brunei National Energy Research Institute (BNERI) managed and implemented the survey, and coordinated with various higher education institutes to conduct interviews. The

Ministry of Energy of Brunei Darussalam (ME) guided and facilitated the overall survey implementation.

This report provides useful information for agencies formulating and implementing energy efficiency and conservation (EEC) policies.

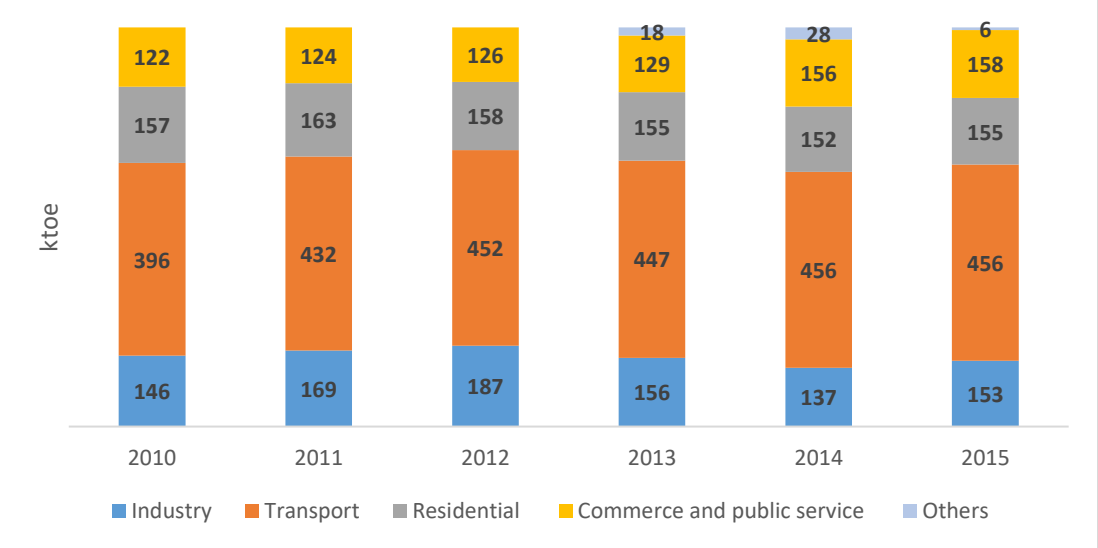
2. Energy Situation in 2015

Crude oil and natural gas were the main energy resources in Brunei Darussalam. In 2015, total primary energy was met mainly by natural gas (84%); oil's share remained at 16%. Total primary energy supply declined by 3% in 2014–2015, from 4,154 kilotons of oil equivalent (ktoe) to 4,034 ktoe.

Domestic needs are modest because the population is small. Consequently, most natural gas and crude oil produced in the country are exported. Only a small percentage of natural gas is allocated for domestic power generation and downstream petrochemical industries. About 12% of the crude oil produced is refined to manufacture petroleum products to meet domestic demand, whilst the rest is exported.

Brunei Darussalam's final energy consumption amounted to 928 ktoe in 2015, a slight decline of 0.1% from the previous year. Transport led total energy demand, with 456 ktoe or 49% of the overall amount (Figure 1). Other sectors (residential, commercial and public service, others) accounted for 34% of total final energy demand, and industry for 16%.

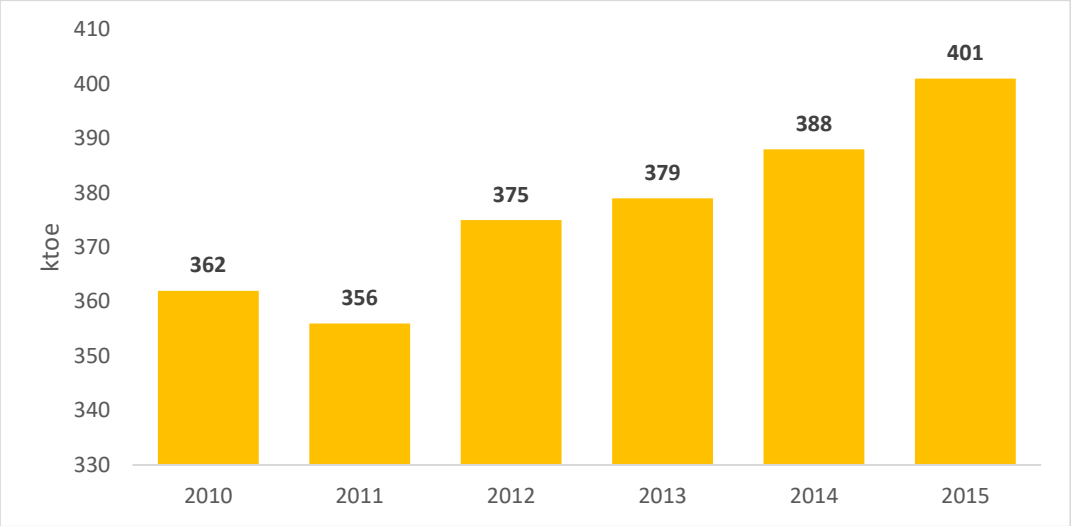
Figure 1.1: Final Energy Consumption by Sector, 2010–2015



Source: Author (2019).

In 2015, total installed power generation capacity of public utilities and autoproducers[2] reached 922 MW. Most of the electricity was generated by natural gas (4,666 GWh). Electricity grew steadily by about 11% over the previous 5 years, reaching 401 ktoe in 2015 (Figure 2).

Figure 1.2: Total Electricity Generation, 2010–2015

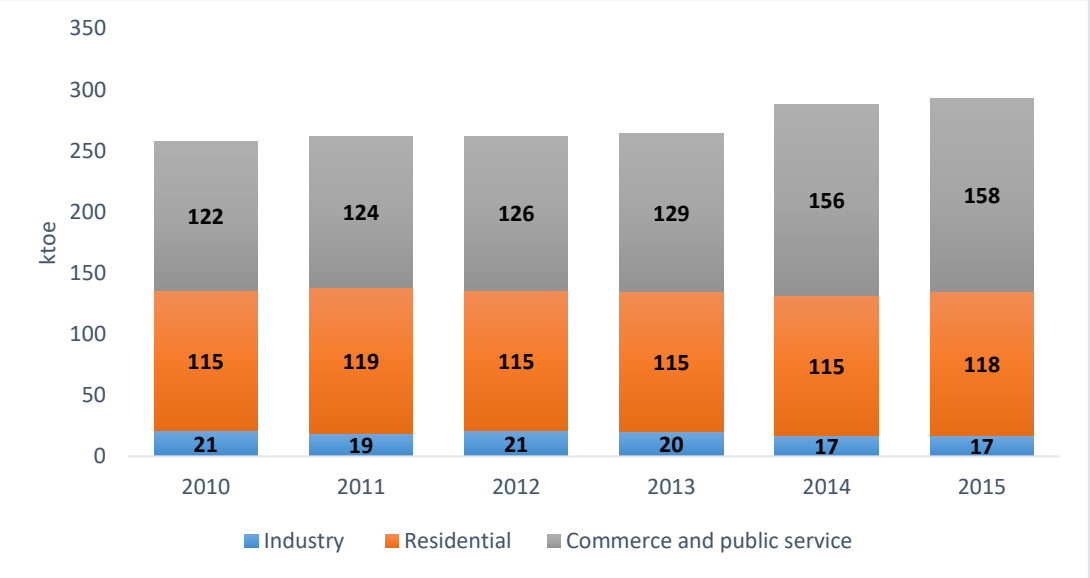


Source: Author (2019).

The residential sector was consistently the second-highest consumer of electricity since 2010, taking up 40% (118 ktoe) of total consumption in 2015. The commercial and public sector accounted for 53% (158 ktoe) and the industrial sector for 7% (17 ktoe) (Figure 3). Residential energy consumption was mainly of electricity (118 ktoe), whilst the rest was of natural gas (19 ktoe) and petroleum (18 ktoe) (Figure 4).

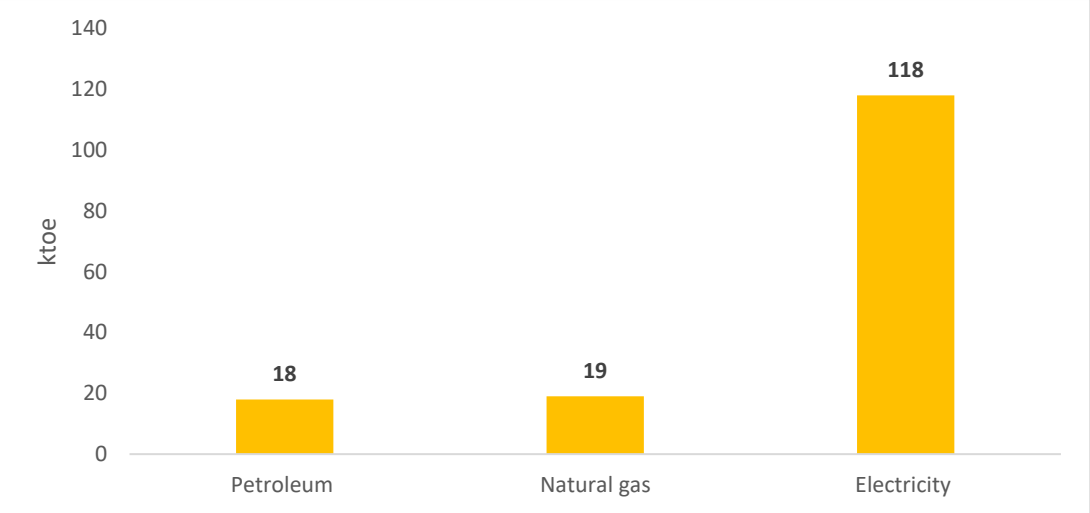
[2] Autoproducers generate electricity and/or heat, wholly or partly for their own use as an activity that supports their primary activity.

Figure 1.3: Final Electricity Consumption by Sector, 2010–2015



Source: Author (2019).

Figure 1.4: Residential Energy Consumption by Fuel Type



Source: Author (2019).

3. Survey Overview

3.1. Electricity Consumers in the Brunei Darussalam Household Energy Consumption Survey

The survey covered dwellings occupied as a primary residence. For random sampling purposes, an address list, obtained from the Department of Electrical Services (DES) and comprising households subscribed to DES Prepaid Electricity was used. The full list contained 67,306 addresses, according to DES's Prepaid Accounts in March 2015.

3.2. Household Energy Use Survey Method

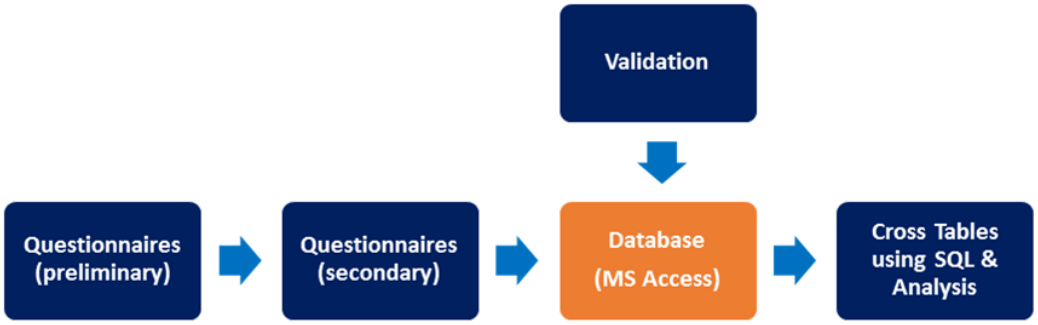
The BDHECS was based on random (probability) sampling. The survey was conducted with randomly selected households in four districts: Brunei-Muara, Belait, Tutong, and Temburong (Table 1.1). Data was collected using the questionnaire, which was designed to capture data to understand actual scenarios of energy use, with breakdowns of consumption by appliance. Trained interviewers, mainly ME officers, conducted face-to-face interviews, and ME interns recorded the data. The hardcopy questionnaire had pre-encoded data for certain standardised items to facilitate the interpretation of data. Interviewers were given a guidebook as a reference on common household appliances and familiarised with the various types and the type of data expected to be extracted from appliance nameplates.

One household member, usually the one responsible for the household, answered on behalf of the whole household. Several households living in the same housing unit were considered one household if electricity was not billed separately.

Questionnaire data was processed (Figure 5). Both preliminary and secondary questionnaires were gathered in a database (Microsoft Access) for validation. After validation, cross tables were produced using Structured Query Language (SQL) and analysed.

Potential savings were expected to be derived using information about household energy consumption and conservation and the pattern of electricity consumption of household appliances and equipment.

Figure 1.5: Data Process Flow



Source: Author (2019).

4. Survey Results

4.1. Response Rate

Based on the survey information, sample units were divided into three groups: respondents, non-respondents, and ineligible units or rejected samples. The initial quality indicator, i.e. the response rate, was found by considering the groups' sizes.

The survey sample target was set at 1,000 respondents. Of the 1,000 survey samples conducted, 608 responded, 15 of which were rejected, resulting in 593 validated samples. Measurement and processing errors were deemed one reason for the rejected samples. Difficulties in conducting the survey included reluctance to provide certain personal information because of privacy concerns and respondents' lack of knowledge about household appliances and technical information.

The number of validated samples were distributed as follows: about 55% in Brunei-Muara; 22% in Belait, the second-most populated district; 17% in Tutong; and 6% in Temburong, the least-populated district (Table 1.1).

The validated survey samples represented 1% sample coverage of the number of households based on DES Prepaid Account as of March 2015. Whilst the sample coverage was small, it was significant for observing household energy consumption patterns.

Table 1.1: Number of Validated Survey Samples by District

Districts	Number of Validated Survey Samples
Brunei Muara	324
Belait	132
Tutong	100
Temburong	37

Source: Author (2019).

4.2. Survey Items

The survey was divided into 11 categories (Table 1.2). The first part consisted of general background information on the household, household characteristics, and energy consumption and bills. Parts two to nine included selected home appliances and electronics that are common to an average household. Part 10 consisted of fuels other than those used for private transportation, i.e. natural gas, LPG, and others. Part 11 contained consumption profiles for private transportation.

Table 1.2: Brunei Darussalam Household Energy Consumption Survey Items

Districts	Number of Validated Survey Samples
Part 1: Identification of Household	Number of primary household members, monthly household income, household-based income-generating activity
Household Characteristics	Gross floor area, number of rooms
Energy Consumption and Energy Bills	Approximate spending for electricity per month (prepaid or post-paid), frequency of outages in a month, average duration of outages in a month
Part 2: Home Appliance: Air Conditioner	Type of air conditioner, number of years in use, manufacturer or brand, model, cooling capacity, power rating (watts), hours of daily usage, location of unit
Part 3: Home Appliance: Fan	Type of fan, number of years in use, manufacturer or brand, model, power rating, hours of daily usage
Part 4: Home Appliance: Lighting	Type of lamp, number of units, average hours of daily usage, average power rating (watts)
Part 5: Home Appliance: Refrigerator	Type of refrigerator and/or freezer, number of years in use, manufacturer or brand, model, rated current (amps), power rating (watts), volume of capacity, unit
Part 6: Home Appliance: Water Heater	Type of electrical water heater, number of units, number of years in use, manufacturer or brand, model, size for boiler, power rating (watts), hours of daily usage, average usage days per week
Part 7:	Type of washing machine and/or dryer, number of units,

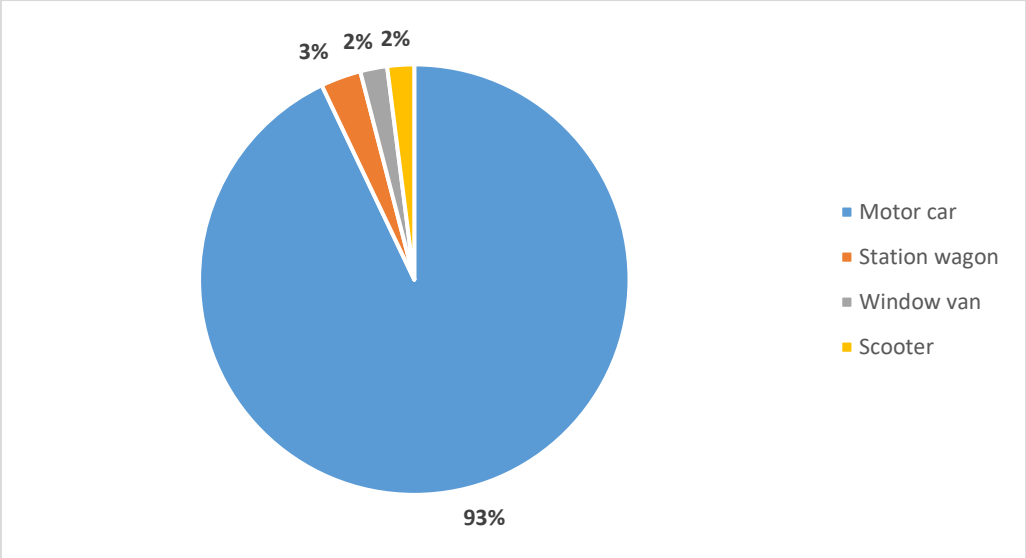
Home Appliance: Washing Machine	number of years in use, capacity (kg), manufacturer or brand, model, power rating (watts), frequency of usage per day, number of days per week the equipment is used for washing and/or drying
Part 8: Electronic: TV	Type of TV, number of years in use, manufacturer or brand, model, size, power rating (watts), hours of daily usage,
Part 9: Home Appliance: Rice Cooker	Type of rice cooker, number of years in use, manufacturer or brand, model, power rating (watts), frequency of cooking per day
Part 10: Other Fuels	Type of fuel, use of fuel, consumption of fuel per month
Part 11: Private Transportation	Number of motor vehicles owned, type of vehicle, year of registration, engine capacity, type of fuel, average distance travel per weekday, average distance travel per weekend, average distance travel per week (km), average fuel expenses per week (Brunei dollar [BND])

Source: Author (2019).

4.3. Basic Characteristics of Households

Households had an average of five people. About 34% of households had 1–5 members, 54% 6–10, and 12% more than 10. Most households lived in detached houses, most (93%) owned motor cars, and the rest owned station wagons (3%), window vans (2%), and scooters (2%) (Figure 6). On average, every household owned about three cars.

Figure 1.6: Share of Vehicle Type



Source: Author (2019).

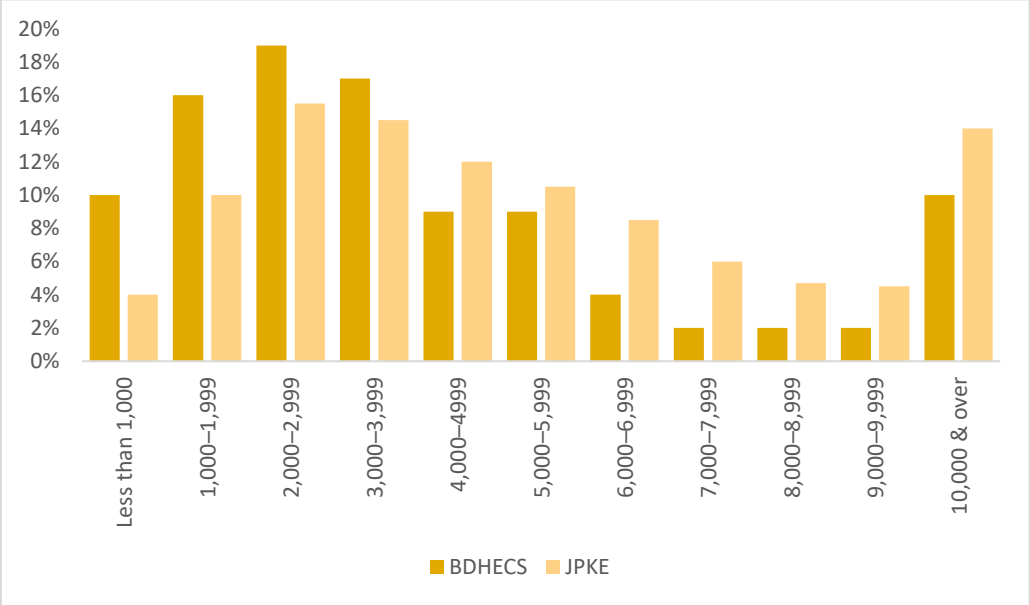
Dual wage-earning families were not uncommon and work from home was not unusual (some people ran their business from home whilst doing housework and rearing children).

The distribution of households by income varied, with about 80% earning BND1,000–BND10,000 (equivalent to US$742.75–US$7,427.52) monthly and the largest proportion (20%) earning BND2,000–BND2,999 (equivalent to US$1,485.60–US$2,227.51) monthly. Brunei Muara had the highest earning capacity.

Unlike the results of the Department of Economic Planning and Development (JPKE) Household Expenditure Survey, on the number of households by income level in 2015 (Figure 7), the BDHECS results include income bias, which shows that the proportion of lower-income households was higher by 6.7% and the proportion of higher-income households lower by 3.2%. Consequently, the BDHECS results on energy consumption were expected to be underestimated because the energy consumption survey greatly concentrated on households with low incomes.

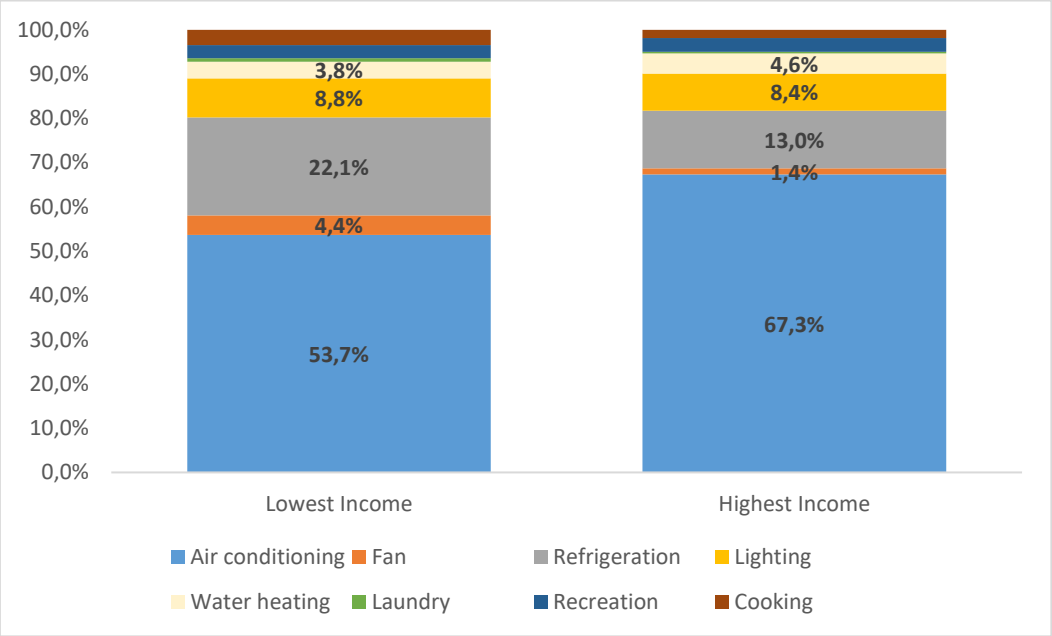
As shown in Figure 8, high-income households (BND10,000 and over) had higher shares of electricity demand for air conditioning and water heating than low-income households (less than BND1,000). In contrast, shares of electricity demand for refrigerators and fans were higher amongst low-income than in high-income households.

Figure 1.7: Comparison of Survey Results and National Statistics on Number of Households by Income Level



BDHECS = Brunei Darussalam Household Energy Consumption Survey, JPKE = Department of Economic Planning and Development.
Source: Author (2019).

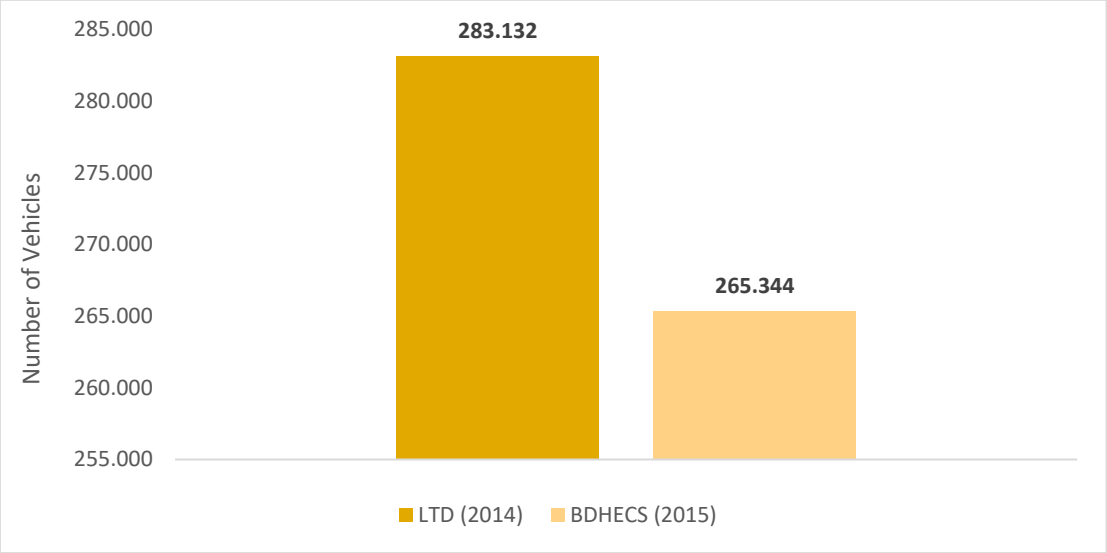
Figure 1.8: Comparison of Lowest-Income and Highest-Income Household Shares of Appliances



Source: Author (2019).

As for transportation (Figure 9), Land Transport Department statistics show that the number of vehicles (motor cars only, excluding government and commercial vehicles) was higher than that in BDHECS by 6.3%, which suggests the need for further investigation to verify this discrepancy.

Figure 1.9: Comparison of Survey Results and National Statistics on Number of Vehicles



BDHECS = Brunei Darussalam Household Energy Consumption Survey, LTD = Land Transport Department.
Source: Author (2019).

4.4. Energy Use by Households

The analysis of energy and fuel types consumed (by number of households) indicated that electricity represented about 76% of total residential sector demand. Total consumption of electricity per household was about 15,785 kWh per year (or 1,315 kWh per month per household), which made it the highest amongst Association of Southeast Asian Nations (ASEAN) members (Figure 11 and Figure 12). Brunei-Muara recorded the highest average consumption at about 18,019 kWh per year (or 1,502 kWh per month per household), followed by Tutong at 14,067 kWh per year (or 1,172 kWh per month per household), Temburong at 13,288 kWh per year (or 1,107 kWh per month per household), and Belait with 12,303 kWh per year (or 1,025 kWh per month per household).

APEC Energy Statistics shows that electricity consumption was 23% higher than the BDHECS results. Table 1.3 shows that projected national electricity consumption was about 21.8% higher than national energy statistics. Electricity consumption derived from this survey seems to have been underestimated. This validation check suggests that (i) the survey results might have been influenced by the sampling concentration on low-income households, and (ii) the sample size and spread of households in the survey might have been insufficient to establish greater accuracy of the survey data. Nevertheless, the survey's analyses and trending should be useful for formulating plans to improve energy efficiency.

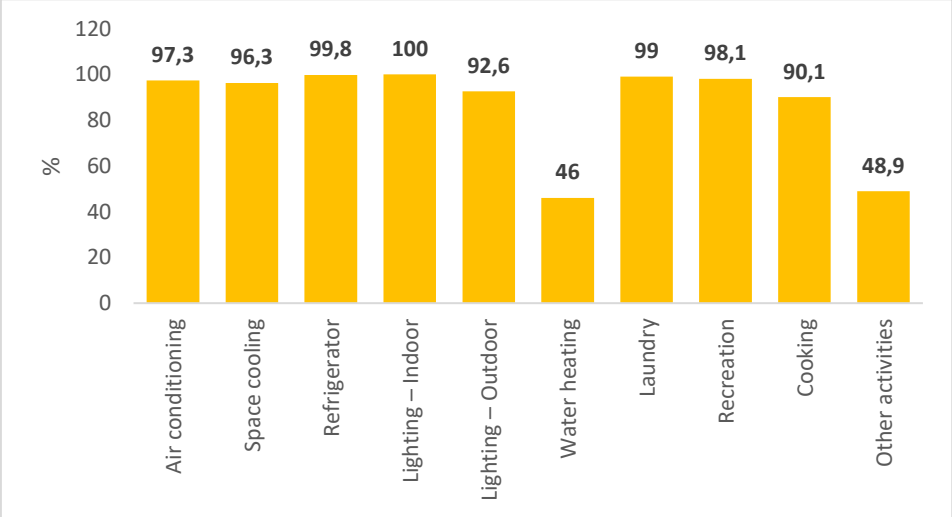
Table 1.3: Comparison Between Projected National Residential Electricity Consumption and National Energy Statistics

	Data Derived from BDHECS	National Energy Statistics	Remarks
No. of households in Brunei Darussalam	–	67,966	National statistics
Average electricity consumption per household from BDHECS	15,785 kWh/year	–	National average electricity consumption per household derived from the survey data.
National residential electricity consumption	1,073 GWh/year (92.25 ktoe/year)	118 ktoe/year	The difference between the projected electricity consumption based on BDHECS and the national energy statistics is 21.8%.

BDHECS = Brunei Darussalam Household Energy Consumption Survey.
Source: Author (2019).

As to the extent of electricity usage by appliance, Figure 10 shows the appliances commonly used, such as air conditioners, refrigerators, indoor lighting, laundry, and recreational appliances. Nearly all energy demand was met by electricity, except for cooking (90% from electricity and 10% from LPG) and water heating (50% from electricity and 50% from other energy sources).

Figure 1.10: Share of Appliances Utilising Electricity (%)



Source: Author (2019).

LPG provided 11% of residential demand for cooking and water heating. The national average consumption of LPG per household was 0.23 m^3. Belait recorded the highest average consumption of LPG per household at 0.3039 m^3, followed by Tutong at 0.2119 m^3, Brunei-Muara at 0.2109 m^3, and Temburong at 0.1867 m^3. The survey showed that total household LPG consumption in 2015 reached 121.30 m^3.

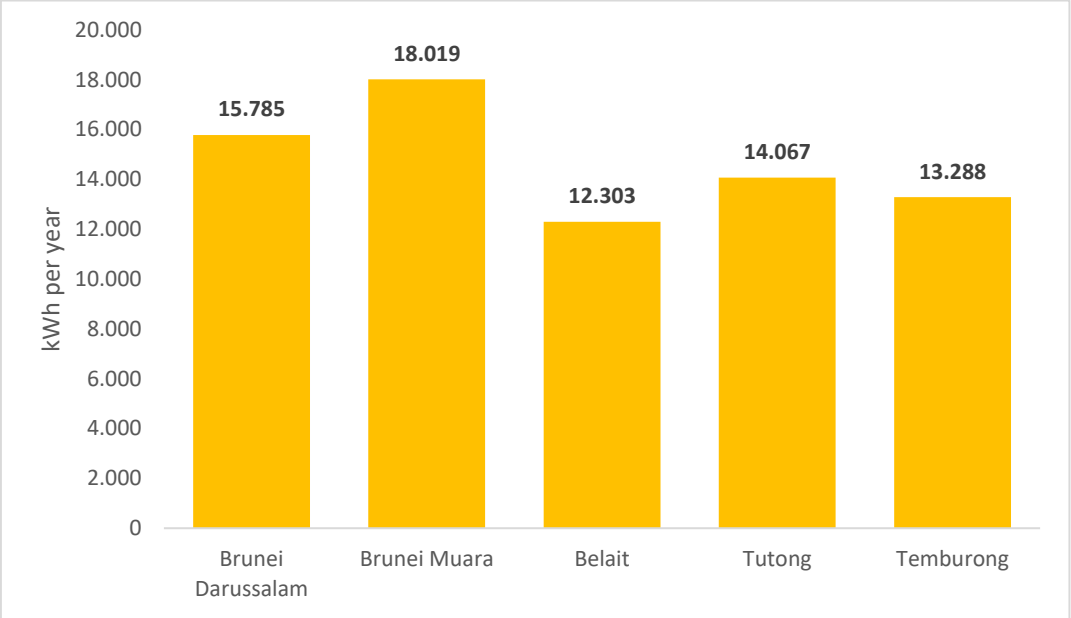
Of residential energy demand, 13% was met by natural gas, which was consumed only in Belait, for cooking, water heating, and electricity generation. Since natural gas consumption in Belait was fixed at BND5.00 per month per household, total natural gas consumption could not be calculated for the purpose of this survey. The households' data on consumption of fuels based on the survey results are in Table 1.4, covering energy consumption in all households, excluding energy utilised for domestic business activities.

Table 1.4: Number of Households Using Other Fuels, Percentage Share of Households Using Other Fuels, and Household Consumption by Type of Fuel by District

Other Fuels	No. of Households	Total Consumption (m^3)	Share (%)	Average Consumption per Household (m^3)
Brunei Darussalam	584	121.30		
Natural Gas	43	NA*		
Liquefied Petroleum Gas	540	121.30	100%	0.2246
Others	1		0%	
Brunei-Muara	317	66.86		
Natural Gas		NA		
Liquefied Petroleum Gas	317	66.86	55%	0.2109
Others			0%	
Belait	132	26.74		
Natural Gas	43	NA*		
Liquefied Petroleum Gas	88	26.74	22%	0.3039
Others	1		0%	
Tutong	99	20.98		
Natural Gas		NA		
Liquefied Petroleum Gas	99	20.98	17%	0.2119
Others			0%	
Temburong	37	6.72		
Natural Gas		NA		
Liquefied Petroleum Gas	36	6.72	6%	0.1867
Others	317	66.86		

Source: Author (2019).

Figure 1.11: Average Yearly Electricity Consumption per Household by District, and National Average

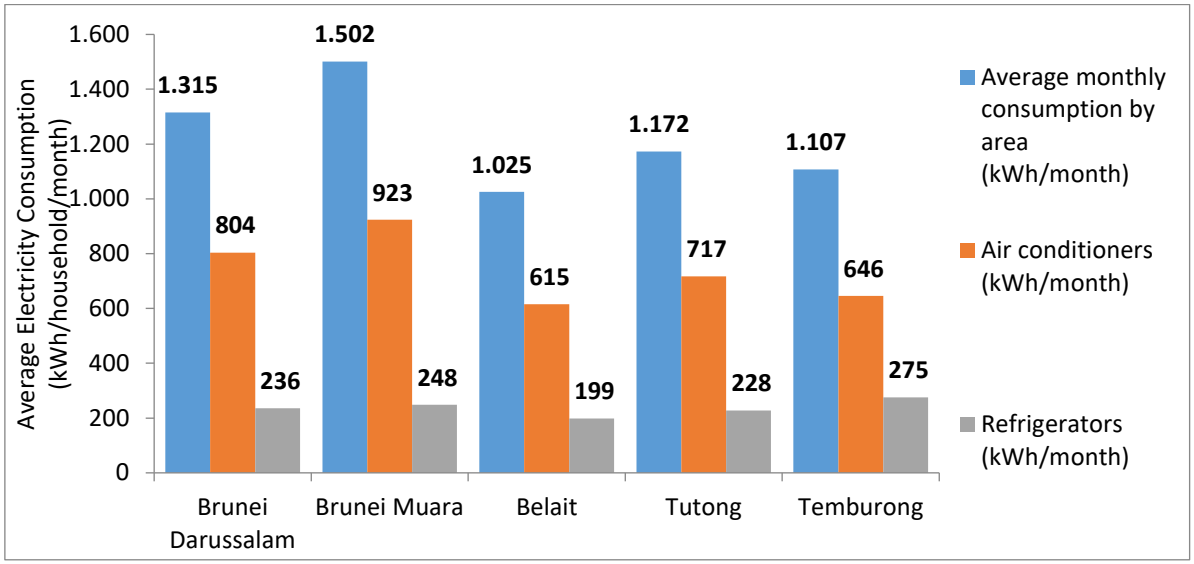


Source: Author (2019).

Figure 11 shows average yearly electricity consumption per household for the four districts; the national average was 15,785 kWh per year. Brunei Muara recorded the highest at 18,019 kWh per year. Surprisingly, sparsely populated and remote Temburong recorded fairly high electricity consumption at 13,288 kWh per year, which was almost as much as in urban districts.

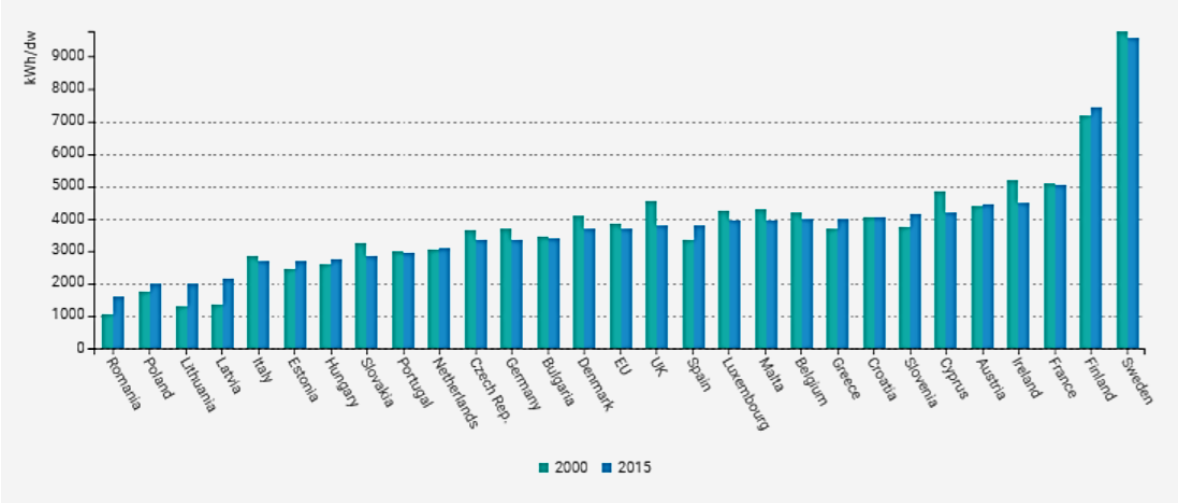
Figure 12 shows the average monthly electricity consumption per household for the four districts; the national average was 1,315 kWh per month. As expected, Brunei Muara recorded the highest at 1,502 kWh per month and, correspondingly, electricity consumption for air conditioning was the highest at 923 kWh per month or 61.45% of the average monthly consumption for the district. Interestingly, monthly electricity consumption of refrigerators was highest in Temburong at 275 kWh per month. The average monthly electricity consumption of air conditioners in Temburong was also fairly high at 646 kWh per month, which was almost as much as in Tutong at 717 kWh per month. This suggests that there was no distinct difference in electricity consumption between urban areas and remote areas such as Temburong.

Figure 1.12: Average Monthly Electricity Consumption per Household and Corresponding Electricity Consumption of Two Major Appliances



Source: Author (2019).

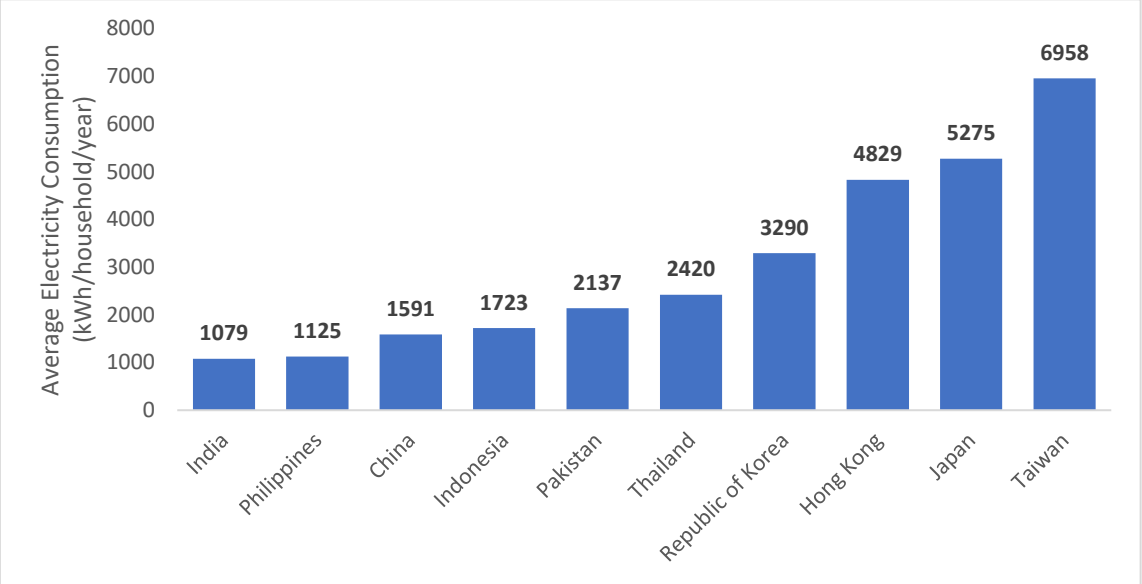
Figure 1.13: Electricity Consumption per Dwelling in European Union Countries



Source: Odysseemure (2015).

The average electricity consumption per household in the European Union (EU) was lower at around 4,000 kWh per year in 2015, although Finland and Sweden consumed 8,000–10,000 kWh per year (Figure 1.13). The publication on household energy consumption in the EU (2015) reported that Norway recorded the highest at 16,000 kWh per year. Based on the World Energy Council data for Asia in 2014 (Figure 1.14), average electricity consumption per household in Asia was lower at about 1,800 kWh per year, although Taiwan recorded the highest average consumption of 6,958 kWh/year. Therefore, the survey result for Brunei Darussalam of average electricity consumption per household of 15,785 kWh per year is considered high.

Figure 1.14: Average Electricity Consumption per Household in Asia



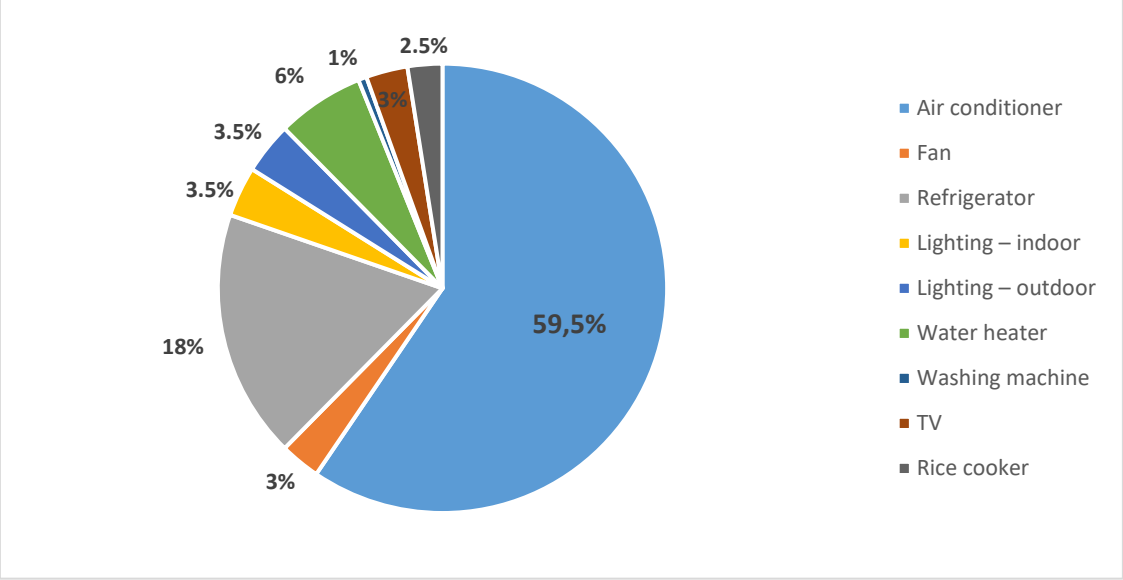
Source: World Energy Council (2014).

5. Key Findings

5.1. End-Use Energy Consumption Pattern

Electricity consumption has grown over recent years. The survey results show all households commonly used a large number of electrical appliances, accounting for significant residential electricity consumption.

Figure 1.15: Share of Electricity Consumption by Appliance



Source: Author (2019).

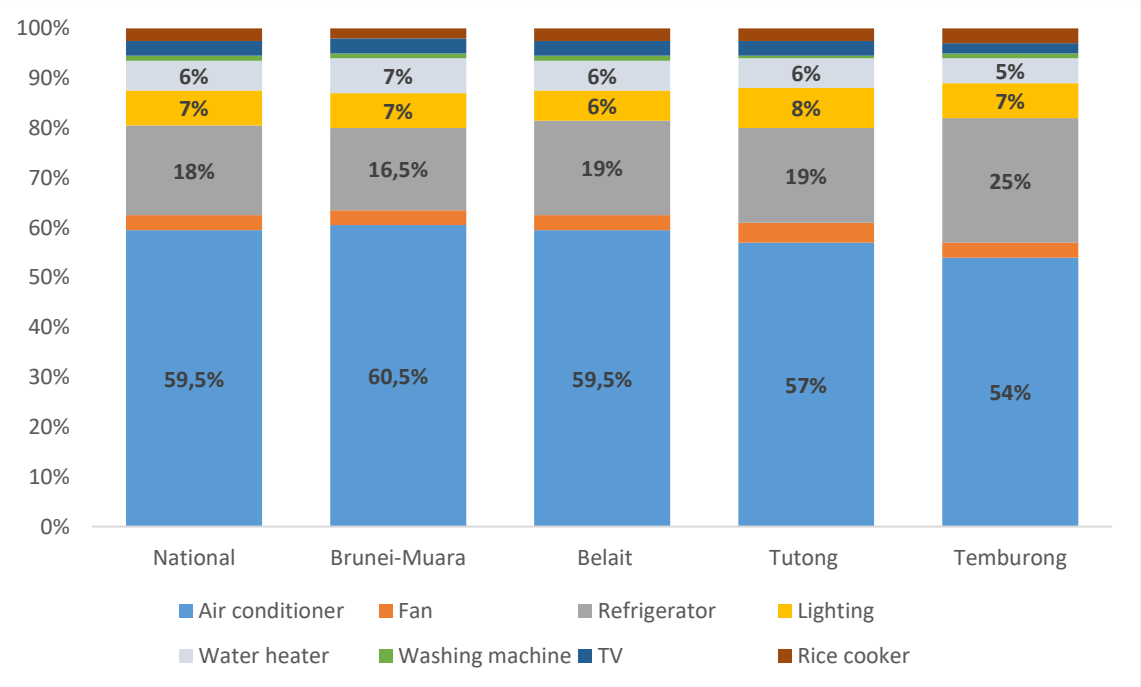
Figure 1.12 and Figure 1.15 show the results from the survey of electricity consumption by household appliance and by district. Generally, the electricity consumption trend by appliance for all four districts was consistent. In total, air conditioners consumed the largest proportion of energy, almost 60%. Combined fan and space cooling accounted for 62.5% of residential electricity consumption.

Refrigerators came in second at about 18%, and lighting (outdoor and indoor) third at 7%. Water heaters accounted for about 6%.

The combined share of these appliances accounted for almost 94% of end-use electricity consumption. Priority should be given to them in energy efficiency action plans to target energy saving. Other appliances that accounted for the rest of electricity consumption were washing machines, TVs, and rice cookers.

Figure 16 shows the share of electricity consumption of appliances by district compared with the national average values. The analysis of end-use household energy consumption patterns provides useful information on the use of energy by common household appliances. Considering the volume of these appliances in households, any plan to educate the public and change to more energy-efficient appliances will contribute significantly to energy savings. One such possible measure is to prioritize energy efficiency labelling of appliances that have larger shares of residential load demand, which will result in quick energy savings.

Figure 1.16: Share of Electricity Consumption by Appliance by District



Source: Author (2019).

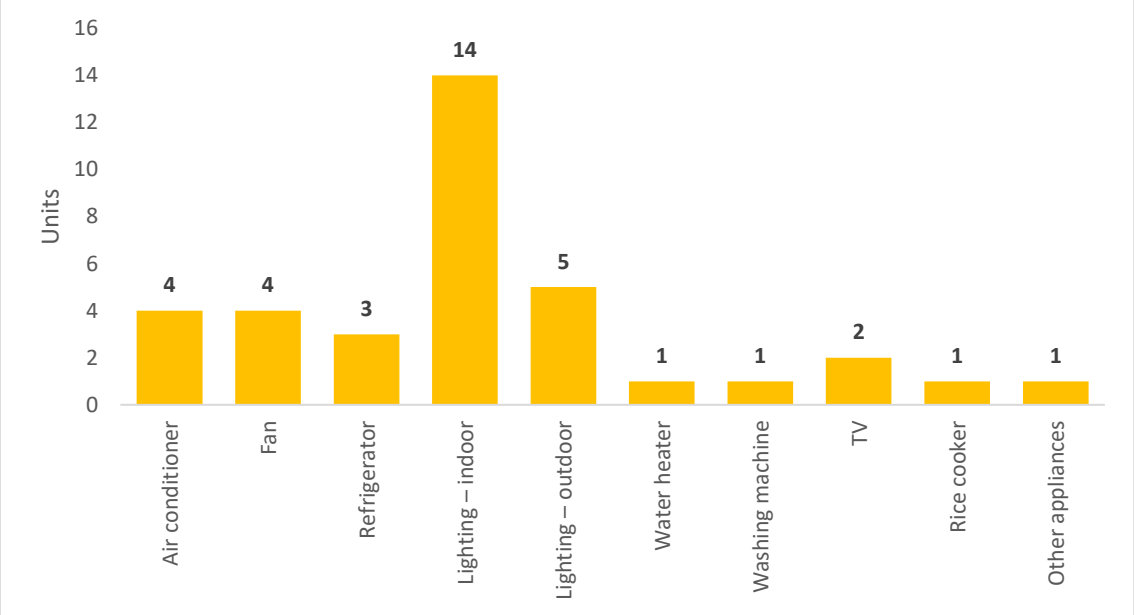
5.2. Average Number of Appliances per Household

The survey results show that electricity use was growing primarily because of the increase in number and usage of household appliances (Figure 17).

Indoor lighting has universal coverage and accounted for the highest number (14) of appliances per household. Air conditioning was the largest consumer of electricity in the survey. The findings show that every household had up to four air conditioners on average, demonstrating that each air conditioner contributed to the largest share of energy consumption.

Another widely used appliance was the refrigerator; 99.8% of households owned at least three on average. Each household had at least two TV sets. Since information technology is developing rapidly, the usage rate of recreational appliances such as TVs, desktop computers, laptops, amongst others, is growing rapidly. The number of appliances and electronics is expected to grow as the number of households increases.

Figure 1.17: Average Number of Appliances per Household



Source: Author (2019).

5.3. Age of Critical Household Appliances

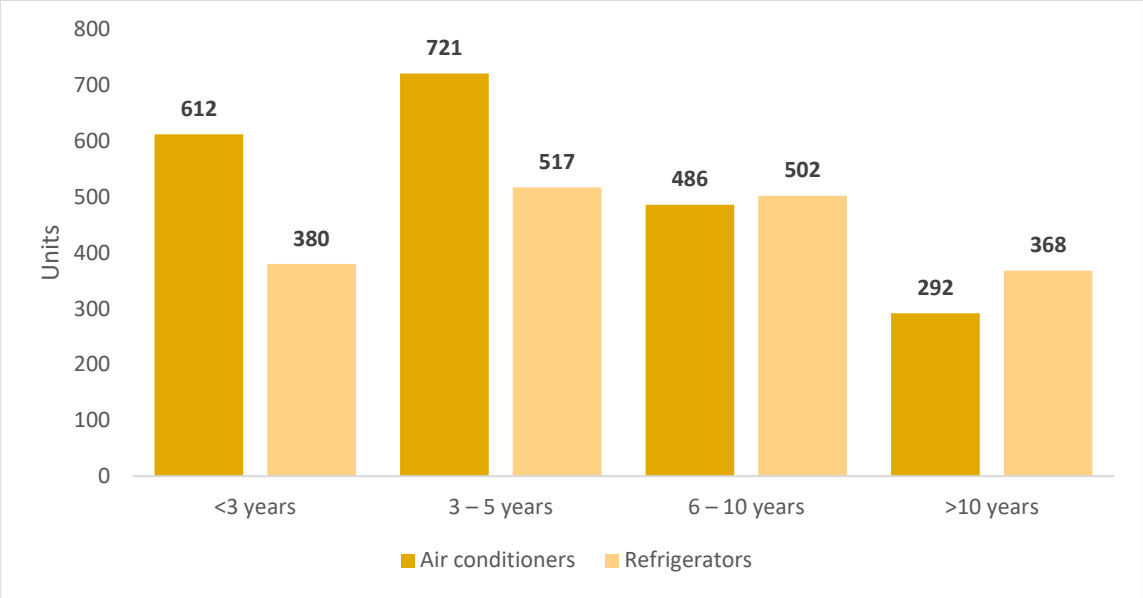
Based on appliances' end-use energy consumption patterns (section 1.5.1), air conditioners and refrigerators accounted for 77% electricity consumption. This section reviews their usage in less than 3 years, 3–5 years, 6–10 years, and more than 10 years. The age of a household appliance can affect its energy efficiency. The survey results show that a significant number of household appliances were 10 years old or more, which were likely to be less energy efficient than newer units. A significant number of air conditioners (292 units constituting almost 14% of the existing stock) and refrigerators (368, almost 21%) were more than 10 years old (Table 1.4). The number of air conditioners more than 6 years old

was about half the number of air conditioners 5 years old or under. Similarly, the number of refrigerators more than 6 years old was almost equal to the number of refrigerators that are 5 years old or under.

In other words, the proportion of older household refrigerators (the number of those 6 years old or more was almost the same as that of refrigerators 5 years old or less) seemed to be larger than the proportion of older air conditioners (6 years old or constitute about half as many as those 5 years old or less). Since the newer refrigerator models use inverter technology and are more efficient, it makes sense to promote them to replace old refrigerators, especially because they operate non-stop.

Survey respondents were asked about the frequency of air conditioner usage. Typically, an air conditioner was used mainly at night, for an average of 9.17 hours per day. On average, new models are more efficient than old models by 3%. Since air conditioners account for almost 60% of total household consumption, an energy efficiency campaign to increase awareness of substantial energy saving potential would benefit consumers.

Figure 1.18: Number of Units by Age Group



Source: Author (2019).

Table 1.5: Number of Units and Electricity Consumption per Unit by Number of Usage Years

Type of Equipment	Quantity (units)	Electricity Consumption (kWh)	Average Consumption per Unit (kWh/unit)
Air Conditioners			
< 3 years	612	1,546,945	2,528
3–5 years	721	2,008,826	2,786
6–10years	486	1,252,525	2,577
>10 years	292	757,521	2,594
Total	2,111	5,565,816	
Refrigerators			
<3 years	380	323,448	851
3–5 years	517	457,235	884
6–10 years	502	515,791	1,027
>10 years	368	376,547	1,023
Total	1,767	1,673,021	

Source: Author (2019).

5.4. Electricity Saving Potential of Appliances

The residential sector would have significant potential for energy saving if energy consumption habits changed. A sizeable portion of households were unaware of EEC and have not, therefore, done anything to use electricity more efficiently. Air conditioners, refrigerators, lighting, and water heaters consumed the most electricity in the residential sector (Figure 16). The proportion of refrigerators 6 years or older was significant at 49.3%. The proportion of air conditioners over 6 years old was only about 37% of all air conditioners. Newer refrigerators and inverter-type air conditioners are more energy efficient.

Households were asked about the use of energy-efficient lights such as compact fluorescent and other types of low-energy light bulbs instead of incandescent ones. About 95% of households said they had installed at least some low-energy light bulbs for indoor and outdoor lighting. Only 5% of households used LED.

As for water heating, most households (67.4%) had instantaneous water heating: 32.6% of households had a boiler and no households had solar water heating.

An estimated total of 73 GWh or 5.3% of residential electricity consumption (in 2015) could be saved if users of the four appliances were to engage in energy-saving practices.

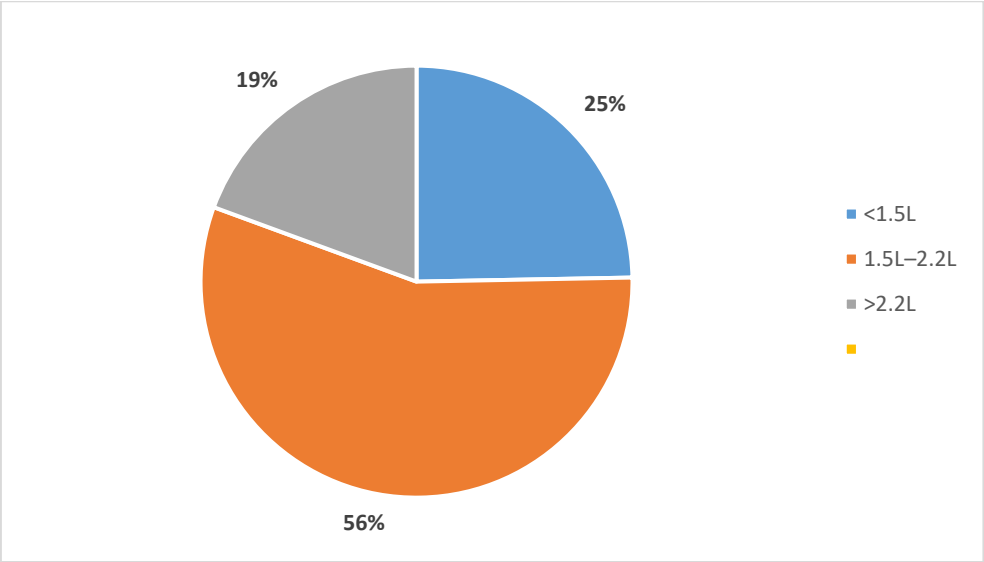
5.5. Analysis of Vehicle Ownership

The questionnaire included several questions about households' ownership of vehicles and use of motor fuels. Most households (92%) owned motorcars and the rest (8%) had some form of transportation such as station and dual-purpose wagons, window vans, scooters, microbuses, and motorcycles.

The indicator was higher for households living in Brunei-Muara and lowest in Temburong. Car-owning households owned an average of three. Households with incomes of BND3,000– BND10,000 and above had the highest rate of car ownership (16%).

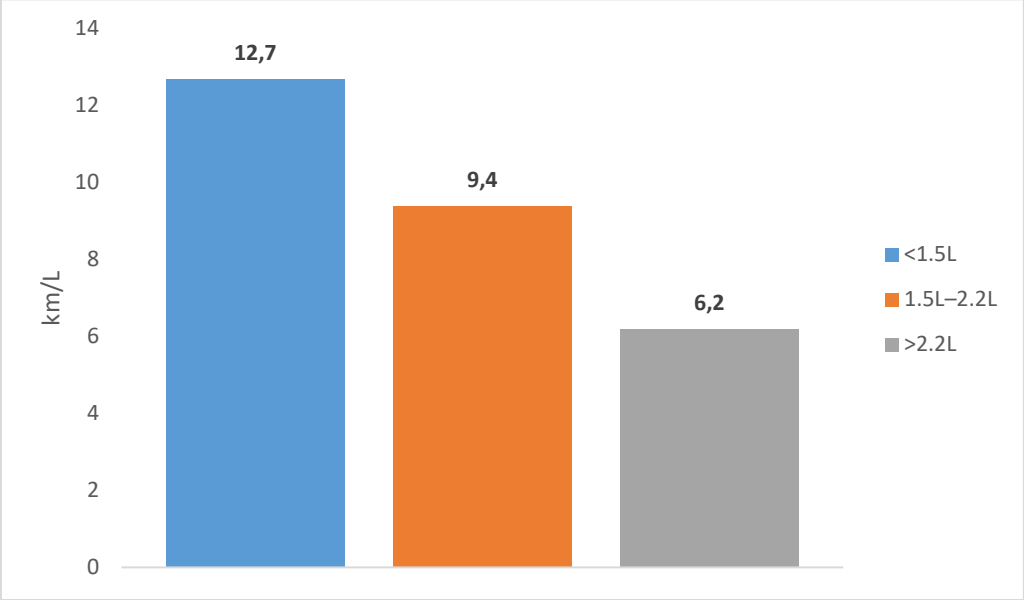
Half of households (56%) owned vehicles with an engine capacity of 1.5L–2.2L and about 19% of households owned vehicles with an engine capacity more than 2.2L (Figure 19). About 25% of households owned vehicles with an engine capacity of less than 1.5L. Vehicles with an engine capacity of less than 1.5L had the highest fuel economy of 12.7 km/L, followed by those with an engine capacity of 1.5L–2.2L at 9.4 km/L, and those with an engine capacity of more than 2.2L at 6.2 km/L (Figure 20). The overall average fuel economy was about 8.10 km/L.

Figure 1.19: Share of Vehicles by Engine Capacity



Source: Author (2019).

Figure 1.20: Share of Fuel Economy by Vehicle Engine Capacity

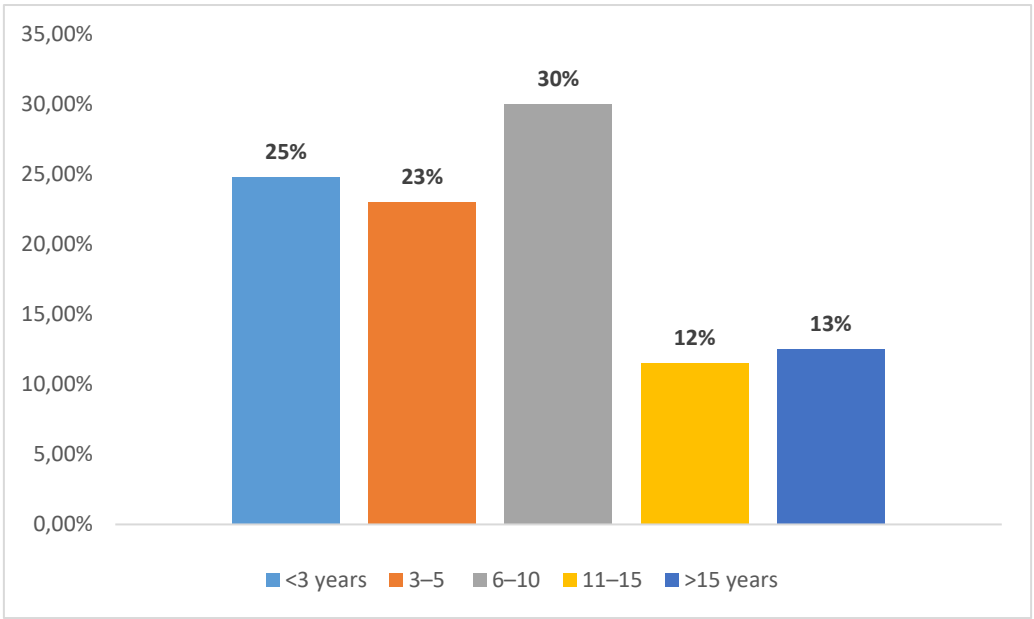


Source: Author (2019).

The analysis of the car stock (Figure 21) revealed that 30% of vehicles were 6–10 years old and 13% 15 years. The average age of cars was about 7.6 years.

Motorcars using petrol dominated with a share of 81%. Motorcars using diesel accounted for 18% and those using other fuels for 1%. Hybrid motorcars had no records. However, more detailed data is needed to establish a clear overview of energy consumption in transport.

Figure 1.21: Age of Vehicles (Years)



Source: Author (2019).

6. Summary of Key Findings on Household Energy Consumption

(i) Electricity was the main energy source, followed by LPG and, to a lesser extent, natural gas.

(ii) Average electricity consumption per household was 15,785 kWh/year (or 1,315 kWh per month), which was significantly higher than the average values of EU and Asian household electricity consumption. However, actual electricity consumption per household could be higher because the survey results were lower than national energy statistics (Table 1.3).

(iii) Average household electricity consumption in the four districts showed consistent trends:

  (a) Average electricity consumption per household was consistently high, exceeding 1,000 kWh per month in each district. The lowest monthly average was 1,025 kWh per month in Belait and the highest 1,502 kWh per month in Brunei-Muara (Figure 12).

  (b) All four districts showed substantial use of air conditioners and refrigerators.

(iv) Air conditioners, refrigerators, lighting, and water heaters used a significant amount of energy. Their combined share was about 91% of total household electricity consumption (94%, including fans). Air conditioners used the most electricity, with an average share of 59.5% (Figure 15).

(v) The influence of household income on electricity consumption is summarised in Figure 8. The highest-income group consumed more electricity for air conditioning (65.6%) whilst the lowest-income group consumed less (53.1%).

(vi) A significant proportion of refrigerators in use that were 6 years or older was almost 50% whilst that of air conditioners in use that were 6 years or older is 37%. Savings could be significant if old refrigerators were replaced with newer and energy-efficient models. (Appendix A compares refrigerators' unit electricity consumption by years used.) Because air conditioners are on for long hours, energy savings could be significant if old units were replaced with newer and energy-efficient models equipped with inverter technology.

(vii) Air conditioners were on for several hours (average 9.17 hours per day) because electricity tariff was low, which is why they accounted for about 60% total residential electricity demand. Electricity consumption data from the BDHECS were lower than national energy statistics. Air conditioners could be used longer than suggested by the survey, which means the share of electricity consumption by air-conditioners should be more than 60%.

7. Policy Recommendations

Analyses from the survey results show that appliances and electronics drive much of the household energy consumption in Brunei Darussalam. Most households had limited

understanding of appliance and equipment efficiency. To achieve significant residential energy savings, the following are recommended:

7.1. Implement mandatory standards and a labelling system

(i) Develop regulations and legislation for standards and labelling of lighting, appliances, and equipment and ensure that these measures are enforced and regularly updated. Standards and labelling should focus on products that will deliver the greatest energy savings as well as offer economic and environmental benefits by helping reduce energy intensity and the carbon footprint.

(ii) Establish minimum energy performance standards (MEPS) for building components and systems such as glazing, wall and roof materials, insulation, windows, water heating, and cooling systems.

(iii) Establish an energy labelling scheme to help consumers compare the energy efficiency of domestic appliances and make informed choices based on reliable and certified information.

(iv) Establish laboratories to test and evaluate the efficiency of household appliances and equipment, and to make sure that they comply with regulations and MEPS.

7.2. Develop information and awareness campaigns and educational programmes

Short term

(i) Develop and implement continuous and sustainable communication outreach programmes such as roadshows and exhibitions, as well as media information and education campaigns, to highlight energy efficiency opportunities of stakeholders in the energy business and of end-use consumers.

(ii) Publish energy efficiency guideline booklets and distribute them to households (applicable to all appliances). The booklets would be made available on the ME website to help consumers make informed decisions based on energy savings and quality of life rather than only on initial costs. Since space cooling accounted for the largest proportion of residential electricity use, the guidelines should promote optimising cooling through passive measures before considering energy saving through appliances.

(iii) Encourage replacement of appliances with efficient units, especially old units exceeding 10 years.

Long term

(i) Incorporate EEC in primary and secondary school curriculums, and train teachers so they can instil in students EEC as an integral part of living habits and decision making.

(ii) Introduce national energy awards to give public and professional recognition for excellent work in energy efficiency and to help encourage best practices.

(iii) Appoint an energy efficiency body or champion in government, business, and the public to save energy.

7.3. Implement incentives and tariff reform

(i) Encourage consumers to choose energy-efficient appliances and vehicles, including by reducing duties or sales tax on them.
(ii) Provide soft loans for efficient appliances and low-emission vehicles.
(iii) Restrict the importation of inefficient appliances based on MEPS and labelling.
(iv) Complement efforts to reform electricity tariffs and transport fuel assistance. Any increases in government expenses as a result of these measures could be balanced by a decrease in spending on energy subsidies.

7.4. Promote residential building energy efficiency technology

Adopt passive design strategies:

(i) Install insulation on roofs and/or walls to minimise solar thermal heat gain.
(ii) Install window shading devices to minimise solar thermal heat gain.
(iii) Improve building design and construction, e.g. doors, windows, and ceilings, to minimise air leakage.
(iv) Use roof turbine ventilators to vent out hot air.
(v) Use building materials suitable for a hot and humid climate.

Adopt active design strategies:

(i) Develop guidelines for selecting energy-efficient appliances.
    (a) Select suitable appliance capacity for household usage to avoid over-sizing.
    (b) Select appropriate technology, e.g. inverter type for air conditioning and refrigeration, CFL and LED lighting, solar water heating, outdoor photo sensors or timers and security lighting, amongst others.
(ii) Develop guidelines for the efficient use and maintenance of appliances.
    (a) Avoid ineffective usage (energy conservation).
    (b) Encourage regular servicing and maintenance.

8. Conclusion

The BDHECS was successful despite the small sampling size and some inaccuracies that resulted in electricity consumption results lower than national energy statistics. However, the discrepancy between the survey results and the national energy statistics is within a reasonable range.

The BDHECS analyses provide useful information for policy planning (section 1.6). The dominant consumer of household electricity was clearly air conditioners, contributing 59.5% of average residential electricity consumption. Air conditioners, refrigerators, lighting, and water heaters consumed about 91% of electricity. Therefore, by adopting the four key EEC policy measures recommended in section 1.7, Brunei Darussalam could potentially reduce its electricity consumption by up to 5.3% annually. Implementing these recommendations would require active participation of all stakeholders nationwide. If a residential EEC road map were to be established, the BDHECS would be a useful reference and guide.