ERIA Research Project Report FY2023 No. 15

Conducting Energy Consumption Survey and Establishing Energy Efficiency Indicators for the Industrial and Commercial Sectors of the Philippines

Edited by

Shigeru Kimura

Leong Siew Meng

Citra Endah Nur Setyawati

Conducting Energy Consumption Survey and Establishing Energy Efficiency Indicators for the Industrial and Commercial Sectors of the Philippines, 2023

Economic Research Institute for ASEAN and East Asia (ERIA)
Sentral Senayan II 6th Floor
Jalan Asia Afrika No. 8, Gelora Bung Karno
Senayan, Jakarta Pusat 10270
Indonesia

ERIA Research Project Report FY2023 No. 15

Published in November 2023

Preface

Energy efficiency and conservation (EEC) should be promoted by applying the PDCA cycle—Plan, Do, Check, and Act. “Plan” means to set EEC action plans to accomplish EEC targets across the final sectors. “Do” means implementing the EEC action plan. “Check” means assessing the implementation results, and “Act” means setting new EEC action plans referring to the implementation results. When we develop EEC action plans across the final sectors, such as the industrial and commercial sectors, energy efficiency indicators (EEIs) defined as energy consumption divided by activity variables, such as the Index of Industrial Production of sub-industrial sectors and floor area of commercial buildings, referred to as energy use intensity (EUI), will be useful to provide important information for understanding past trends, assessing the potential for energy savings, and reviewing energy efficiency policies. Full benefits in establishing EUIs can be realised once sufficient and quality EUI data are compiled and computed to establish benchmarks for various end-use sectors and sub-sectors.

The Philippines enacted the Energy Efficiency and Conservation Act, signed on 12 April 2019, to institutionalise EEC as a way of life for Filipinos. However, there are no official EEIs so far in the Philippines. Thus, the Philippine Department of Energy (PDOE) requested the Economic Research Institute for ASEAN and East Asia to support the Energy Utilization and Management Bureau (EUMB) of the PDOE in preparing the EEIs of commercial buildings and industrial factories.

This project conducted energy consumption surveys in industrial factories and commercial buildings using local consultants in the Philippines. Although the local consultants are inexperienced in conducting this kind of survey, especially validation capacity on collected data from the surveys, this project succeeded in preparing some meaningful EEIs due to the strong support from ERIA regarding its knowledge and expertise on EEIs. Thus, ERIA would like to strongly suggest to the EUMB/PDOE to update the EEIs periodically by conducting the energy consumption survey and applying the knowledge and experiences obtained from this project. This publication serves as a valuable guide for the EUMB/PDOE to continue pursuing the establishment of EUI benchmarking and other EEC programs.

Shigeru Kimura

Special Advisor to the President on Energy Affairs
Economic Research Institute for ASEAN and East Asia

Acknowledgements

This report was developed by the Philippines' Department of Energy, the Economic Research Institute for ASEAN and East Asia (ERIA), Malaysian energy efficiency experts, and local consultants who conducted the energy consumption survey in the industry and commercial sectors under knowledgeable consultation of ERIA and the EEC expert.

I would like to acknowledge the following persons who contributed to the success of this project:

- Art P. Habitan, OIC Assistant Director, Energy Utilization Management Bureau, Department of Energy, Philippines
- Leong Siew Meng, Energy Efficiency and Conservation expert, Malaysia
- Philippine Institute of Energy Management Professionals Inc.
- MELARCO Power Academy

Special thanks go to Shigeru Kimura, Special Advisor to the President on Energy Affairs, ERIA.

Patrick T. Aquino, CESO III
OIC Director of Energy Utilization and Management Bureau
Department of Energy, Philippines

List of Project Members

Economic Research Institute for ASEAN and East Asia (ERIA) Team

Shigeru Kimura, Special Advisor to the President on Energy Affairs

Alloysius Joko Purwanto, Energy Economist

Citra Endah Nur Setyawati, Research Associate

Leong Siew Meng, Energy Efficiency and Conservation expert, Malaysia

Philippines' Department of Energy (PDOE) Team

Patrick T. Aquino, Officer In Charge (OIC) Director of Energy Utilization and Management Bureau (EUMB), PDOE

Art P. Habitan, OIC Assistant Director, EUMB, PDOE

Jimwel B. Balunday, OIC Division Chief, EE&C Program Management and Technology Promotion Division (EPMPD), EUMB, PDOE

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BCA	Building and Construction Authority (Singapore)
BEI	building energy intensity
EEC	energy efficiency and conservation
EEI	energy efficiency indicator
EUI	energy use intensity
EUMB	Energy Utilization and Management Bureau
GFA	gross floor area
IEA	International Energy Agency
MJ	megajoule
MPA	Meralco Power Academy
NDA	non-disclosure agreement
OIC	officer in charge
PDOE	Philippines' Department of Energy Philippines
PIEMI	Philippine Innovation Entrepreneurship Mission, Inc.
PIEMPI	Philippine Institute of Energy Management Professionals Inc.
TOR	terms of reference

Executive Summary

Energy efficiency indicators (EEIs) are indispensable to promoting a country's energy efficiency and conservation (EEC) programs. The EEIs can bring about many benefits, such as monitoring and measuring the effectiveness of EEC strategies and programs. If the EEIs decline year by year, it will be evidence of the effectiveness of promoting EEC in a country. EEIs can also be used to quantify energy savings achieved in end-use sectors and sub-sectors, providing that sufficient and quality data could be collected to establish the respective benchmarking. Thus, it is recognised that this survey which collected 2 years of data from 2018 to 2019 has limitations. Furthermore, meaningful data is limited due to insufficient sample numbers (less than 100 as targeted) and the low capacity of local consultants on energy consumption surveys. However, this report made clear that indicative (2018 and 2019) energy efficiency levels in the Philippines could be derived as follows, albeit with limitations and constraints:

- Commercial sector
  - Office building sector
    - Range of average energy utilization intensity (EUI): 213–336 kWh/m2/y
    - Median EUI: 275 kWh/m2/y
  - Retail building sector
    - Range of average EUI: 324–458 kWh/m2/y
    - Median EUI: 391 kWh/m2/y
- Industrial sector
  - Cement sector average EUI: 3,097 MJ/MT/y
  - Sugar sector average EUI: 42,058 MJ/MT/y
  - Food sector average EUI: 3.14 MJ/kg
  - Beverage sector average EUI: 0.61 MJ/litre

The EUIs mentioned above suggest that the Philippines' industry and commercial sectors might have energy-saving potential compared with neighboring countries such as Singapore and Malaysia. Thus, the Energy Utilization and Management Bureau (EUMB) should set up feasible and effective EEC action plans for both sectors and continuously monitor the EUI produced from the energy consumption data submitted by designated factories and buildings periodically under the Energy Efficiency and Conservation Act.

This project also provides many lessons learned to all the stakeholders who participated in the study, such as (i) the methodology of energy consumption survey and validation of sampled data, and computation and analysis on average EUIs; (ii) the usefulness and

benefits of EEIs, and challenging tasks in building respondents' trust and confidence in energy consumption surveys; (iii) hands-on experiences in data collection, and methodology on analysis and validation of the sampled data.

This project is an initial step for the EUMB/Department of Energy Philippines (PDOE) to start preparing EEIs in the industry and commercial sectors, referring to the lessons learned mentioned above, The EUMB/PDOE should continue to prepare more quality EEI data and continuously monitor them to assess how EEC action plans have contributed to EEC programs.

Chapter 1
Introduction

1. Background

The Philippines has achieved high economic growth in the past 10 years, and its energy demand also increased according to its gross domestic product (GDP) growth (5.7% p.a. in 2021). The growth rate with biomass in 2010–2017 was 3.6% in terms of the total final energy consumption (TFEC), but the growth rate without biomass registered 4.5% from 2010 to 2017. If there were no plan to control the increase in energy demand, the TFEC without biomass in 2050 would be 3.2 times that of 2017, according to the country's energy outlook reported in the *East Asia Summit Energy Outlook* published by the Economic Research Institute for ASEAN and East Asia (ERIA). Thus, the Philippines' Department of Energy (PDOE) implements EEC programs and activities according to the Energy Efficiency and Conservation Act enacted by the legislature in April 2019. Consequently, the PDOE requested ERIA to promote EEC in the Philippines.

As part of the plans for PDOE to promote EEC per the Energy Efficiency and Conservation Act, signed on 12 April 2019 to institutionalise EEC as a way of life for Filipinos, the PDOE should prepare energy efficiency indicators (EEIs) to determine the current level of energy consumption. Thus, this project will support the Energy Utilization and Management Bureau (EUMB) of the PDOE to prepare EEs) to focus on commercial buildings and industrial factories, providing the EUMB staff with capacity building on the methodology in EEI preparation.

In addition to the aggregate data, such as total energy consumption per GDP per capita contained in national energy balances, the establishment of EEIs will support policy development, implementation, and monitoring for each final energy-use sector, such as the industrial and commercial sectors. EEIs can show policy-makers where energy savings can be made. In addition to providing useful information on trends in the energy performance of sectors and sub-sectors, EEIs can also help model and forecast future energy demand. Another significant outcome is establishing benchmarking EEI values once enough years of data are compiled. Benchmarking EEI values can drive the energy efficiency agenda for each sector and sub-sector.

2. Preparation of Energy Consumption Survey

Before the preparation and commencement of the energy consumption survey, ERIA and the EUMB had two online meetings—the first on 17 December 2021 and the second on 4 February 2022.

The 17 December 2022 meeting discussed the following agenda:

1) The scope of work – by Shigeru Kimura of ERIA
2) The Terms of Reference (TOR) of the local consultants – by Shigeru Kimura of ERIA
3) Briefing on the survey sample questionnaires – by Leong Siew Meng, Malaysian energy efficiency expert

4) Discussion on the selection of local consultants
5) Way forward by Shigeru Kimura of ERIA

This project aimed to conduct an energy consumption survey and prepare the EEIs for the industry and commercial sectors. Although this project was planned to collect energy consumption data for 2 years, the methodology, analyses, and development of EEIs would benefit the PDOE in future data collection, establishment of EEIs, and benchmarking values when sufficient data and in-depth indicators could be obtained. According to the International Energy Agency (IEA) (2014a), it is important to develop and maintain well-founded energy efficiency indicators to understand better the drivers and potential for energy efficiency, inform the policy process, and help decision-makers develop policies best suited to meet domestic and/or international policy objectives.

At the meeting on 17 December 2021, Leong Siew Meng conducted a briefing on the survey sample questionnaire. Subsequently, the EUMB raised some queries regarding Mr Leong's briefing. Mr Kimura replied to these queries on 30 December 2021, and Mr. Leong on 2 January 2022.

Requests for proposals were sent out to local consultants upon PDOE's recommendations after the approach, methodology, and the TOR for the energy consumption survey in the industry and commercial sectors were finalised. Two consultants—the Philippine Institute of Energy Management Professionals Inc. (PIEMPI) and Meralco Power Academy (MPA)—were shortlisted and asked to attend meetings on 4 February 2022 with ERIA and the EUMB to discuss the following agenda separately (10:00 a.m. session with PIEMPI, and 2:00 p.m. session with the MPA):

1) Briefing on the Philippines' EEC ACT and the need for EEIs – by the EUMB and PDOE
2) Briefing on overall ERIA support to the PDOE on the EEIs and the contents of the TOR to PIEMPI and the MPA
3) Presentation of the proposal by PIEMPI (10:00 a.m. session)/MPA (2:00 p.m. session).
4) Comments on the proposal by Mr Leong, Malaysian EE expert
5) Overall discussion (including questions and answers)

After the discussions and clarifications during the 4 February 2022 meetings, the MPA and PIEMPI submitted revised proposals to ERIA. As a result, the TOR and contracts to engage the MPA and PIEMPI to conduct energy consumption surveys in the commercial and industry sectors were finalised and awarded in March 2022.

PIEMPI would conduct the energy consumption survey with a total of 100 samples in the following sectors of the industry sector:

- Cement factories
- Sugar factories
- Food factories
- Beverage factories

The MPA would conduct the energy consumption survey with a total of 100 samples in the following building categories of the commercial sector:

- Office buildings
- Retail buildings

However, the MPA collected data for some hotels and condominiums, which was insufficient as the survey questionnaire did not cover sufficient parameters to allow the analysis and preparation of EEIs to be carried out. It was decided that the MPA would focus on analysing the data collected for office and retail buildings, and preparing their respective EEIs.

3. Training of Enumerators to Conduct the Energy Consumption Survey

ERIA conducted two training sessions, one on the industry sector with PIEMPI on 6 April 2022, and another on the commercial sector with the MPA on 7 April 2022.

3.1. Industry Sector

The training covered the following topics:

- Objectives of the energy consumption survey
- Understanding of EEIs
- Significance of EEIs
- Energy consumption and production output
- The outcome of survey and potential sources of errors
- Survey questionnaire and analysis format

1) Objectives

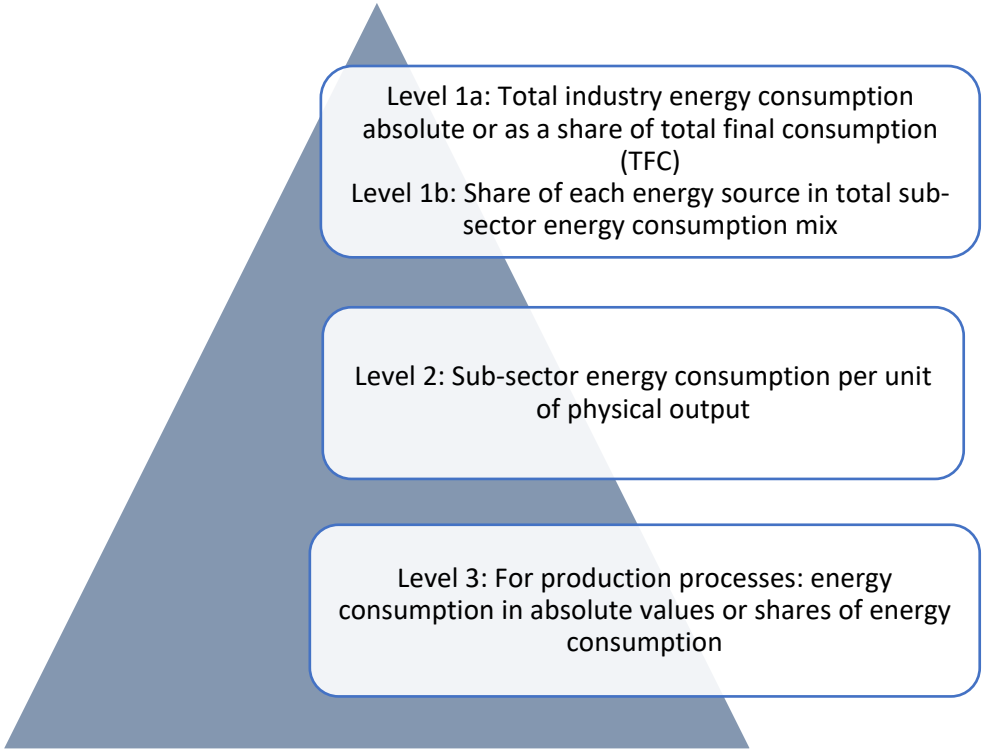
a) To conduct an energy consumption survey of the industry sector covering:
   (1) Cement factories
   (2) Sugar factories
   (3) Food factories
   (4) Beverage factories

b) The data to be collected shall be sufficient to prepare EEIs, which are representative of the respective sectors and shares of energy consumption by industrial processes.

2) Understanding energy efficiency indicators (EEIs)

The explanation of EEIs was based on the *Energy Efficiency Indicators: Fundamentals on Statistics* published by the IEA (2014a). The IEA indicators approach is based on a conceptual structure of an indicator pyramid, which portrays a hierarchy of energy indicators from the most detailed at the bottom of the pyramid to the least detailed at the top. The generic pyramid of manufacturing sector indicators (as illustrated in Figure 1.1) was explained to the enumerators. For this survey for the industry sector, the enumerators were asked to focus on getting sufficient data to compute EEIs under Level 2 in Figure 1.1, a measurement of energy use intensity (EUI), which is the same as the EEIs referred to by the IEA.

Figure 1.1. Generic Pyramid of Manufacturing Sector Indicators



Source: IEA (2014a).

Energy use intensity (EUI) would be an appropriate term to refer to the EEIs for the industry sector. EUI is the energy intensity that measures how much energy is needed to produce one unit of physical output from a sector factory. EUI is defined as follows:

$$EUI = \frac{(Total\ yearly\ energy\ consumption)}{(Total\ yearly\ production\ output)}$$

EUI is a ratio of total energy consumption within a year to total production output for the corresponding period. The total energy consumption covers all energy-consuming activities required in a factory's production processes, including the energy needed to operate facilities within the factory or plant. However, the energy needed to transport goods and services, which are not part of the production processes, is excluded. The collection of energy and production data for computing EUIs should be confined to the same industry sectors following the general International Standard Industrial Classification of all Economic Activities within the same year. The EUI computation corresponds with the Level 2 activity in IEA's generic pyramid manufacturing sector indicators.

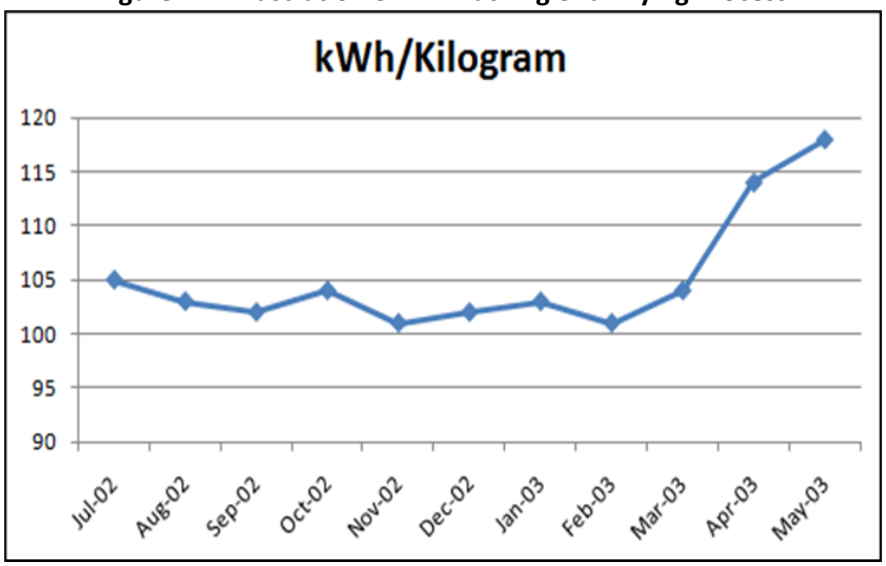
3) Significance of EEIs

Energy efficiency is "using less energy to provide the same service" (IEA, 2014a). An indicator is often taken as something that provides an indication; however, an indicator could be any statistical values that, once gathered and analysed, give a clue . With sufficient data, EEI trending can be charted to provide valid comparisons within a factory and other factories, providing they are of the same classification of industry sectors, as illustrated in Figure 1.2.

Establishing EEI benchmarking value for each industry sector is useful. However, this energy consumption survey does not intend to establish EEI benchmarking values because this exercise has its limitation. Only 2 years of data were collected during the survey period.

Figure 1.2 shows the energy required to dry a unit weight of a product. The energy requirement varies depending on the extent of drying, which in turn depends on the extent of moisture content present in the raw materials. Figure 1.2 shows that the unusually high energy consumption rate could be due to scenarios, namely, lack of maintenance in the production equipment and/or increased moisture content in a particular batch of raw materials. Figure 1.2 illustrates the significance and usefulness of EEI charting and tracking.

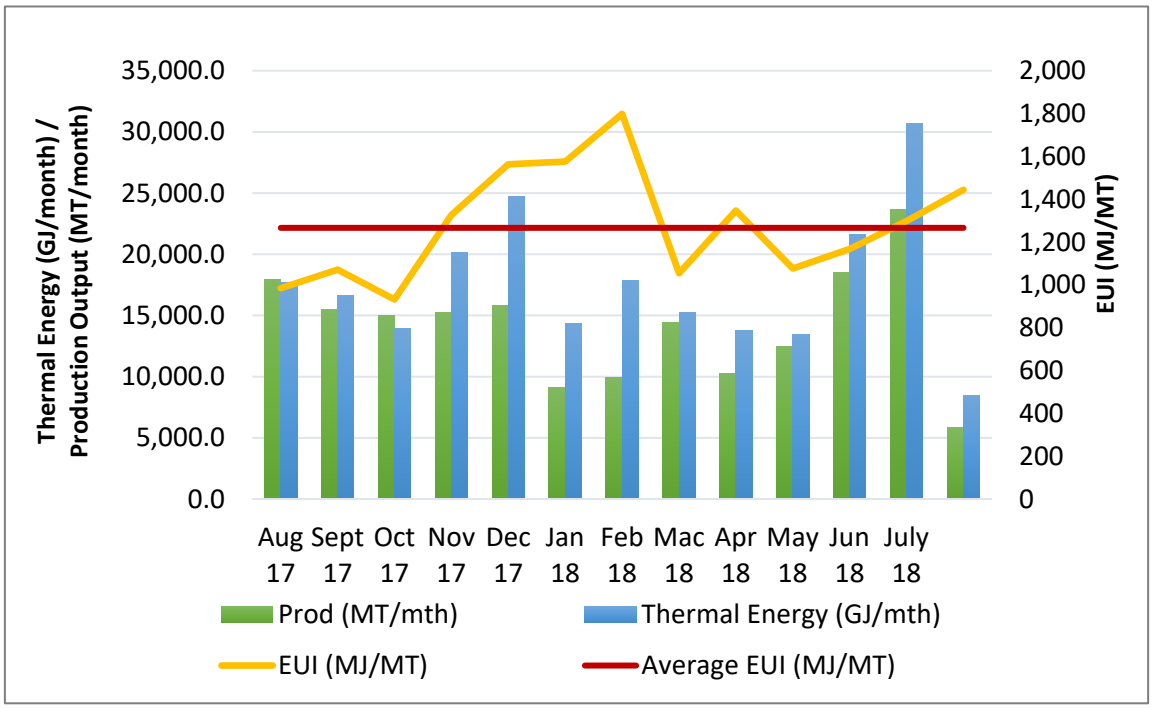
Figure 1.2. Illustration of EEI Tracking of a Drying Process



Source: UNIDO (2012).

The training conducted on 6 April 2022 also shows another application of EUI analysis and tracking method deployed in an oleochemical plant (Figure 1.3). Monthly energy consumption and production data were collected and computed as monthly EUIs. In addition, the monthly EUI and average yearly EUI were computed. The graphs of monthly data and EUIs were plotted in Figure 1.3. Figure 1.3 shows that the values of EUI fluctuate, and the EUIs in certain months are not as good and are above the average yearly EUI value. Such indication may prompt further data collection and investigation into the reasons for poorer energy performance. Nevertheless, Figure 1.3 shows that tracking of EUI can be a valuable tool for indicating energy performance and overall energy management of a factory.

Figure 1.3. Example of EUI Tracking in an Oleochemical Plant



Source: Authors.

4) Energy consumption and production output

The training highlighted that energy sources include electricity and fuel energy consumption. Table 1.1 was used in the training to explain the various forms of energy usage with respective calorific values. However, the exact values of fuel used would depend on the data from fuel suppliers in the Philippines. The training also highlighted the importance of applying consistent energy units in computing energy consumption from energy data (e.g., in kg or litre) that would be obtained in the survey. It was suggested that a common energy unit for different energy sources should be megajoules (MJ). Table 1.1 shows the typical calorific values obtained from APERC 2020 (APEC Energy Statistics 2018).

The training also explained the importance of applying consistent measurement units for production outputs, for example, tonne, cubic metre, litre, etc. as illustrated in Table 1.2. This will allow the computation of EUIs in consistent units to compare the EUIs of various plants in the same sub-sector.

Table 1.1. Example of Energy Consumption Data and Computation of Energy Consumption

Diesel for standby genset power	• Data in kg or litre (density: 860 kg/m³) • x CV = thermal energy in MJ
Fuel oil	• Data in kg • x CV = thermal energy in MJ
Natural gas	• Data in kg or m³ • x CV = thermal energy in MJ
Fuelwood	• Data in kg • x CV = thermal energy in MJ
Electricity	• Data in kWh • x 3.6 MJ/kWh = thermal energy in MJ

Fuel	Calorific Value (CV)
Bituminous coal	24,618 kJ/kg
Diesel	42,600 kJ/kg
Fuel oil	42,600 kJ/kg
LPG	47,700 kJ/kg
Natural gas	36,031 kJ/kg
Fuel wood & wood waste	15,500 kJ/kg

Note: Actual CV values to be obtained from fuel supply companies.
Source: APEC (2019).

Table 1.2. Example of Measurement Units for Production Outputs

	Products with Different Measurement Units	Energy Consumption in MJ	Production Output (should be in consistent units & corresponding period w.r.t. energy consumption data)	EUI per Product Type Basis
1	Product #1 (tonne)			
2	Product #2 (m3)			
3	Product #3 (litre)			
4	Product #4 (carton)			

Source: Authors.

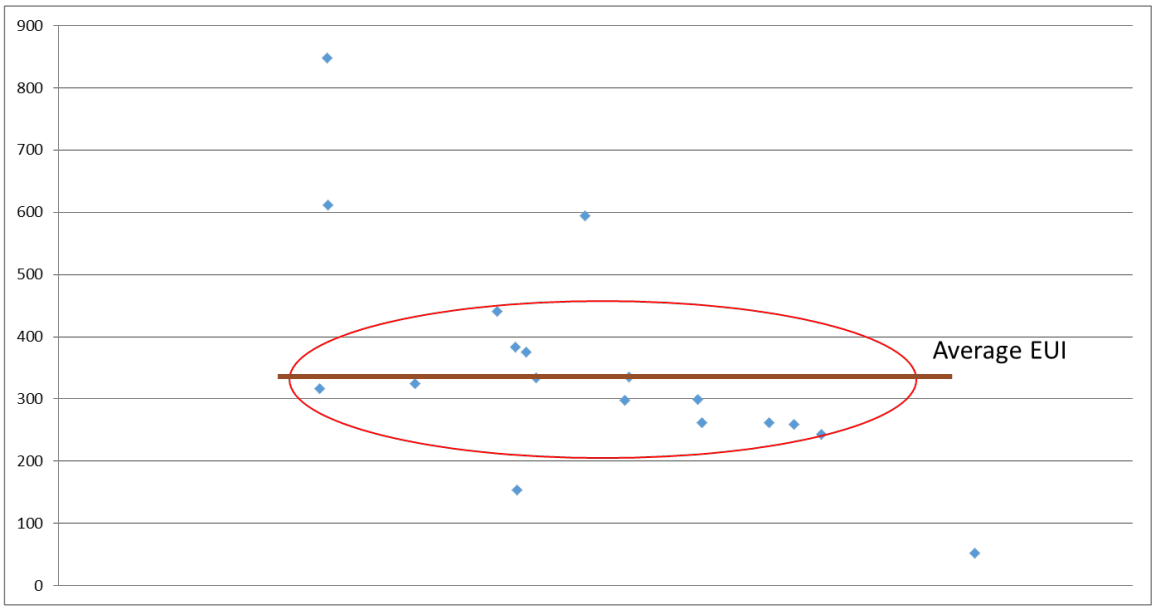
5) Outcome of the survey and potential sources of errors

The training discussed the outcome of the survey, which should provide the following:

1) Average yearly EUIs for cement, sugar, and food and beverage factories
2) Percentage shares of energy consumption for various production processes, such as heating, drying, production cooling, and production automation.

The training explained that the survey data would likely contain invalid and outlier data (Figure 1.4). Therefore, it is necessary to conduct data validation exercises after data collection. Various potential sources of errors, as illustrated in Table 1.3, were also explained during the training.

Figure 1.4. Illustration of Scattered EUI Data



Source: Authors.

Table 1.3. Example of Potential Sources of Errors

Energy Consumption Data	Production Output Data
Under-disclosure of data	Under-disclose
Over-disclose	Over-disclose
Inaccurate & inconsistent calorific values	Errors in measurement units
Inconsistency in energy units	Inaccuracy in production records
Errors in energy conversion	Mix-up between production input & output
Incomplete records, missing data, etc.	Incomplete records, missing data, not corresponding with the same period as the energy data.

Source: Authors.

3.2. Commercial Sector

The training covered the following topics:

- Objectives of the energy consumption survey
- Understanding of EEIs
- Significance of EEIs
- Energy consumption and gross floor area (GFA)

- Outcome of the survey and potential sources of errors
- Survey questionnaire and analysis format

1) Objective

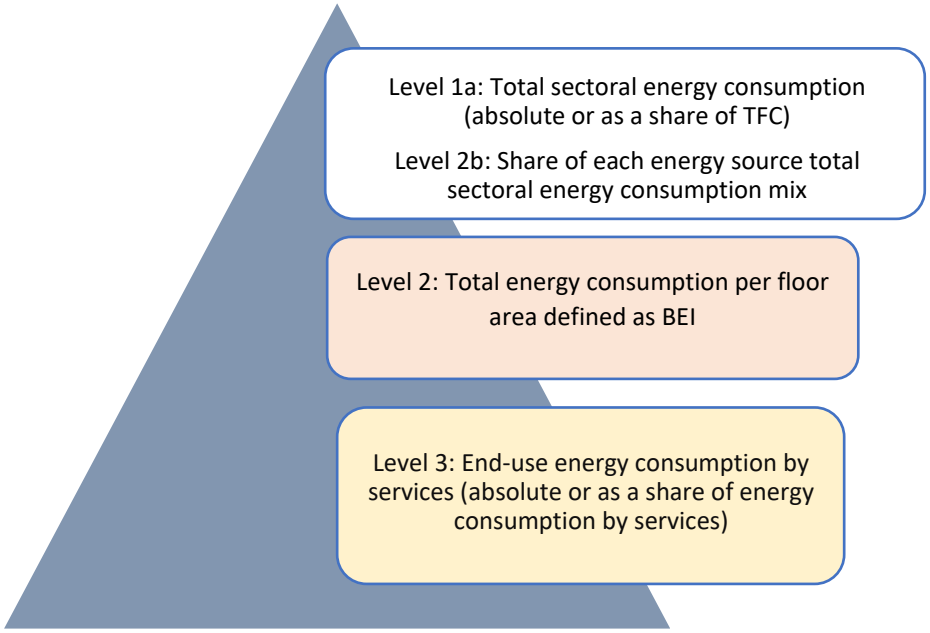
a) To conduct am energy consumption survey of the commercial sector covering office and retail buildings

b) The data to be collected shall be sufficient for establishing EEIs and shares of energy consumption by services.

2) Understanding of EEIs

The explanation of EEI was based on IEA's Energy Efficiency Indicators: Fundamental Statistics (IEA, 2014a). The generic pyramid of commercial sector indicators, as illustrated in Figure 1.5, was explained to the enumerators. For this survey, the enumerators were asked to focus on getting sufficient data to compute the EEIs under Level 2 in Figure 1.5, a measurement of building energy intensity (BEI) expressed as the ratio of total yearly energy consumption to the GFA of a building.

Figure 1.5. Generic Pyramid of Commercial Sector Indicators



BEI = building energy intensity, TFC = total final consumption.
Source: IEA (2014a).

Usually, commercial buildings are air-conditioned. For air-conditioned buildings, it was suggested to refer to BEI as the EEI for the commercial sector. Alternatively, the EUI may be used to describe building EEI in lieu of BEI. BEI is the energy intensity that measures how much distributed energy is needed per occupied floor area for buildings of the same category. The definition of BEI is given as follows:

$$BEI = \frac{(TBEC - CPEC)}{(GFA - CPA) - (GLA\ x\ FVR)}\ x \frac{AWH}{WOH}$$

Where: TBEC = total yearly building energy consumption (kWh/y)

CPEC = yearly car park energy consumption (kWh/y)

GFA = gross floor area (m^2)

CPA = car park area (m^2)

GLA = gross lettable area (m^2)

FVR = floor vacancy rate (%)

AWH = average weekly operating hours (hours/week)

WHO = weighted operating hours of building under BEI computation

The following factors should be considered in comparing BEIs between buildings:

a) BEIs of different buildings should be compared for buildings of the same categories, e.g., office buildings, retail buildings, hospitals, hotels, etc.

b) The average operating hours should reflect the actual average operating hours amongst the surveyed buildings of the same category.

c) Indoor car park areas are usually large and are not air-conditioned. Therefore, car park areas are excluded in the BEI computation to avoid distortion of BEI.

d) Similarly, the GFA should not include unoccupied floor areas, as some buildings may be partially occupied. Otherwise, BEI values will be distorted.

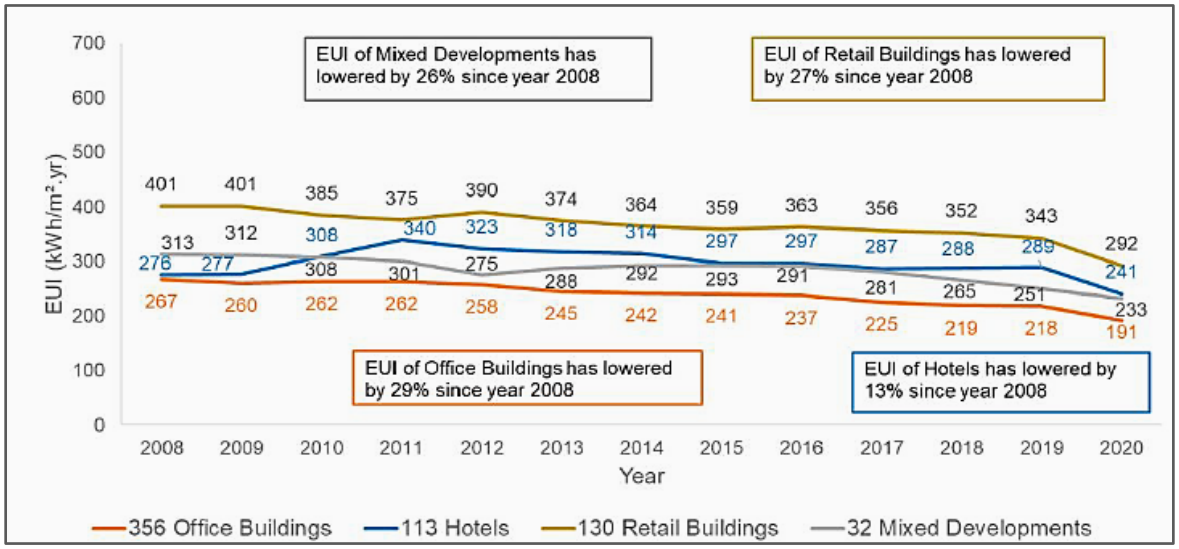
3) Significance of EEI

Space cooling is a major driver of building energy demand for hot and humid climates. Therefore, BEI reflects the distributed energy demand within the GFA of a commercial building, and will indicate total energy demand that includes air-conditioning. lighting, and other equipment loads.

With sufficient BEI data, building management can use BEI charting to monitor and evaluate the energy performance of a building. The tracking of BEIs can be used as a basis for diagnosing any issues on energy use in a building over a period.

BEI data and charting can provide valuable tools for policy-making to assess the effectiveness of energy efficiency strategies and policies. The information gained from establishing and tracking EEIs will help policy-makers set energy efficiency targets and track progress towards these targets, as well as quantify energy savings (Figure 1.6). Singapore commenced its green building programs in 2005. Figure 1.6 shows Singapore's average yearly EUI (or BEI as referred to by the author) trend by commercial building types. To compare the EUI/BEI on similar situation (initial stage of energy efficiency drive), reference should be made to the 2008 average EUI values in Singapore, i.e., 276 kWh/m^2/y for office buildings and 401 kWh/m^2/y for retail buildings.

Figure 1.6. Singapore's Average EUI Trend by Commercial Building Types



Source: Building and Construction Authority (BCA) (2021).

4) Energy Consumption and GFA

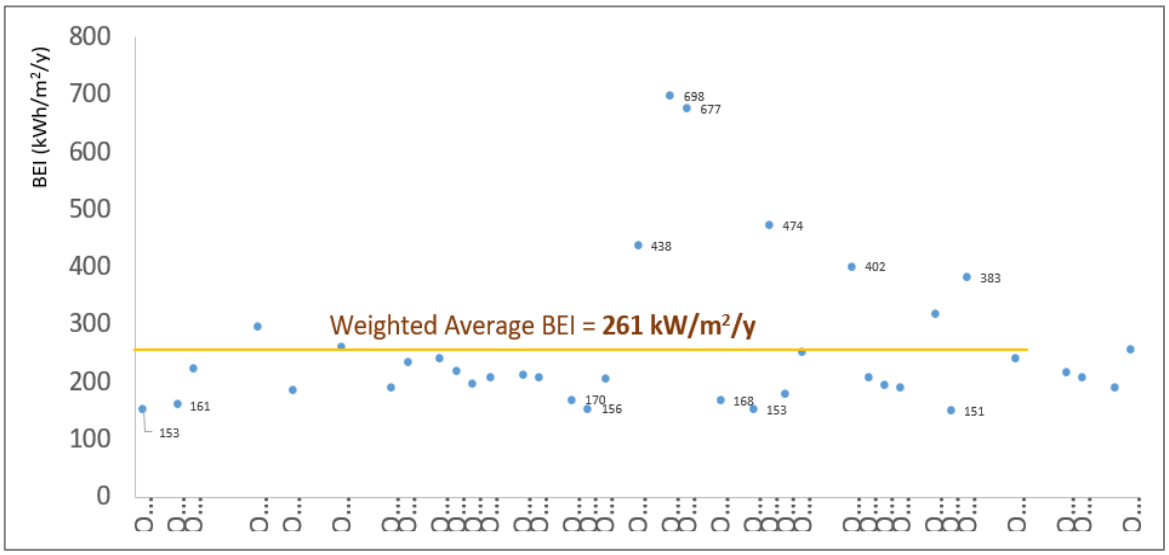
Like the industry sector, energy consumption and GFA should be consistent units. Energy consumption data include electricity and other fuels consumed in buildings. Other fuels will likely come from standby power generation, water heating, and food preparation.

As explained above, the GFA will exclude the indoor car park area. Therefore, the survey should determine the extent of floor vacancy rate by percentage for the computation of actual occupied area for a more accurate determination of BEI. In addition, information on the building footprint should be obtained to gauge the accuracy of any given GFA.

5) Outcome of the Survey and Potential Sources of Errors

The survey will produce indicators for office and retail building buildings. However, it was highlighted that data collection must undergo a data validation process to identify invalid and outlier data. Otherwise, unrealistic BEI values will be derived. Figure 1.7 shows examples of outlier data.

Figure 1.7. Example of Outlier BEI Data



Source: Authors.

Table 1.4. Example of Potential Sources of Errors

Energy Consumption Data	GFA and Other Factors
Under-disclosed data	Under-disclosed GFA
Over-disclosed data	Over-disclosed GFA
Inaccurate and inconsistent calorific values	Carpark area is included
Inconsistent energy units	Inaccuracy in operating hours
Errors in energy conversion	Floor vacancy rate not available
Incomplete records, missing data, etc.	Lack of as-built drawings/ building records

GFA = gross floor area.
Source: Authors.

Chapter 2

Energy Consumption Survey and Energy Efficiency Indicators

1. Introduction

The Philippine Institute of Energy Management Professionals Inc. (PIEMPI) conducted the energy consumption survey for the industry sector. The Meralco Power Academy (MPA) conducted that for the commercial sector. The enumerators of both consulting companies were given training by ERIA on 6 and 7 April 2022, respectively.

The methodology was explained during the training with survey questionnaire guides prepared by ERIA. The survey questionnaire guides aimed to provide an example of the types of data to be collected in Excel files, formatted to compute the EUI for the industry sector and BEI for the commercial sector. However, during the survey and subsequent reporting, the MPA referred to BEI as EUI. Therefore, tor consistency, the EUI will also be referred to as the EEI for the commercial sector. However, the units will be different as the definitions of EUI for the industry and commercial sectors are different.

Because of the expected production interruptions due to the COVID-19 pandemic during 2020 and 2021, the PDOE and ERIA agreed that the data collection was to base on 2018 and 2019 data. The energy consumption and production output values for the industrial and commercial sectors must be consistent.

2. Survey Questionnaire for the Industry Sector

As shown in Appendix C, the survey questionnaire comprised the following tables:

1) Table C1: General information
   - General company information, industry category, etc.
   - Description of products and production processes, type of fuels used, and respective calorific values
2) Table C2: Energy consumption data, including fuels and electricity from the utility and onsite power generation, other fuel usage, and production output data.
   - Energy consumption from various sources, including utility, generator sets, and other fuel usage
   - Production outputs complete with measurement units
3) Table C3: Energy consumption breakdowns for production processes, for example:
   - Steam
   - Heating
   - Drying
   - Process heating
   - Production automated processes
4) Table C4: Energy consumption breakdowns for products with different measurement units.

3. Survey Questionnaire for the Commercial Sector

As shown in Appendix D, the survey questionnaire comprised the following tables:

1) Table D1: General information
   - General company information, building category (office or retail buildings).
   - Description of building functions, type of fuels used, and respective calorific values.
2) Table D2: Energy consumption data, including fuels and electricity from the utility and onsite power generation, other fuel usage, and the GFA.
3) Table D3: Details of air-conditioned spaces for estimating energy consumption by air-conditioning system.
4) Table D4: Lighting installations in retail buildings for estimating electricity consumption by lighting
5) Table D5: Lighting installations in office buildings for estimation of electricity consumption by lighting

4. Outcome of the Survey

The industry sector survey undertaken by PIEMPI and the commercial sector undertaken by the MPA encountered numerous challenges, such as indifferent responses, lack of cooperation, and incomplete and erroneous submissions, which were probably due to the voluntary and unfamiliar nature of the survey and the likely absence of readily available data required by the survey questionnaire. The challenges were further compounded by the COVID-19 pandemic situation, which imposed restrictions on physical or onsite surveys to be carried out. As a result, the survey reached out to the companies or respondents in the four industry sub-sectors: sugar, cement, food and beverage factories, and commercial sectors, namely office and retail buildings mainly relied on emails and telephone calls. The companies to be surveyed were primarily based on PDOE's predetermined list of companies. The scope of the survey was based on 100 samples for each of the industry and commercial sectors. The number of samples per sector was to be determined by the PDOE.

5. Industry Sector Outcome

5.1. Industry Sector Preliminary Outcome

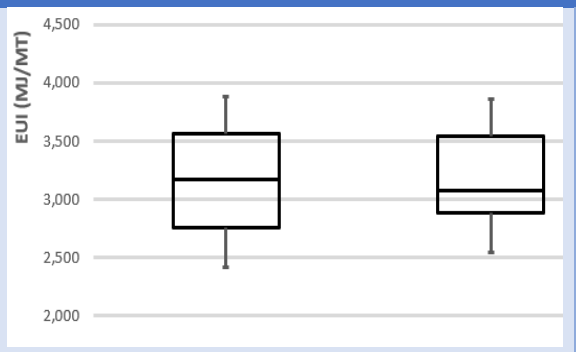
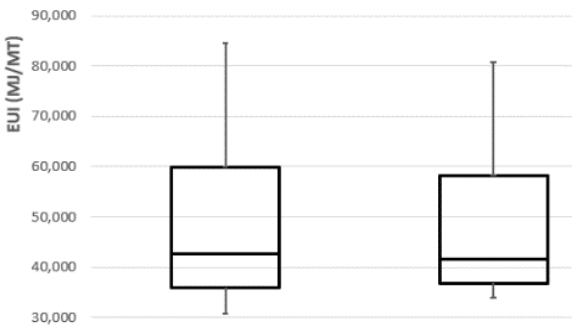
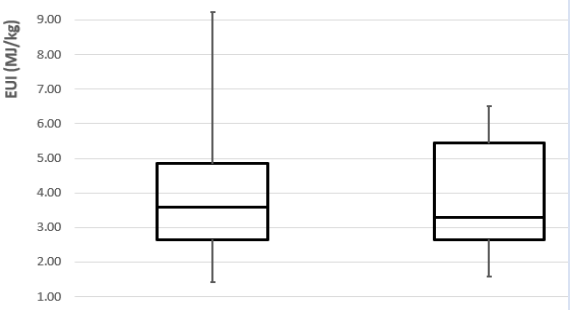
PIEMPI reported the following when they commenced the survey in May 2022:

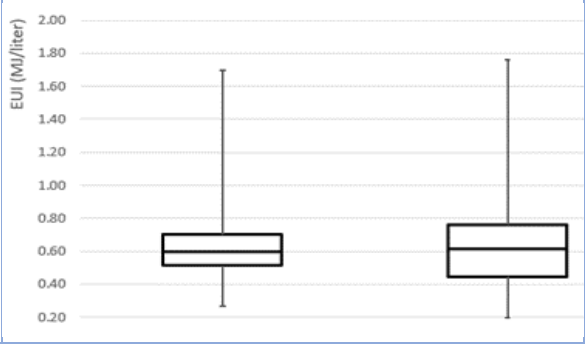
1) Five enumerators handled about 20 companies each.
2) Out of the 99 survey questionnaire emailed to companies, 18% of emails bounced, 36% without response, 27% responded but had yet to receive the completed questionnaire, and 18% responded with submissions.
3) Because of the bounced emails, PIEMPI requested 20 companies to be replaced in their original list.
4) Encountered administrative issues such as:
   - No contact telephone number in the list

- Invalid contact numbers provided
- Change of contact personnel
- Request for more time
- Approval needed from top management
- Signing of non-disclosure agreement

Following PIEMPI's submission of the first set of consolidated and validated Excel files on the survey data for the four sectors on 27 August 2022, ERIA reviewed and analysed the survey data. The following preliminary findings were shared with PIEMPI using the Box and Whisker method.

Table 2.1. Preliminary Analysis and Computation of EUI Based on PIEMPI Data Submitted on 27 August 2022

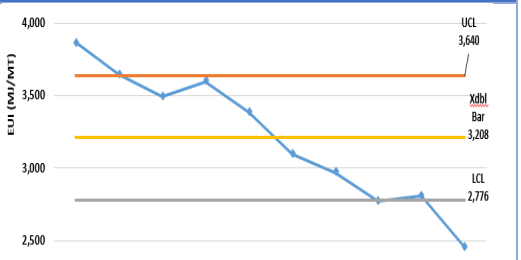
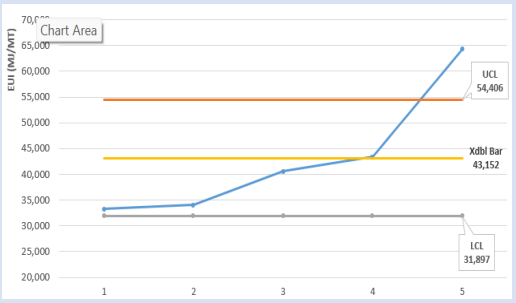
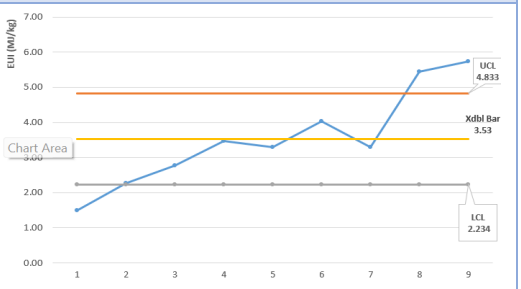
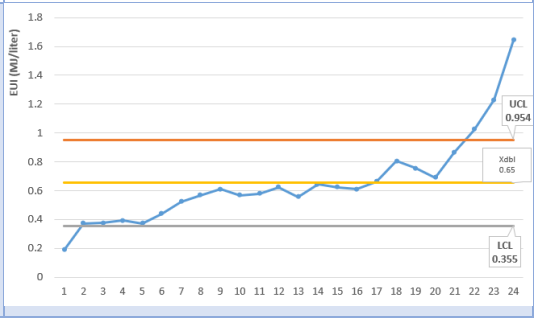
Sector	No. of Samples	Preliminary EUI		Results of Box and Whisker Analysis
		2018	2019	
Cement sector	10	3,174 MJ/MT/y	3,075 MJ/MT/y	
Sugar sector	6	42,565 MJ/MT/y	41,551 MJ/MT/y	
Food sector	9	3.59 MJ/kg/y	3.29 MJ/kg/y	

Sector	No. of Samples	Preliminary EUI		Results of Box and Whisker Analysis
		2018	2019	
Beverage sector	24	0.60 MJ/liter/y	0.62 MJ/liter/y	

Source: Authors, based on PIEMPI's survey data submitted on 27 August 2022.

PIEMPI submitted subsequently updated survey data files on 1 and 2 October 2022. ERIA made another review and analysis, but the X-bar and R-chart analytical tool was used. The results were shared and discussed with PIEMPI in a meeting held on 26 October 2022, as summarised in Table 2.2. The analysis, methodology, and various potential outliers were discussed in this meeting.

Table 2.2. Preliminary Analysis and Computation of EUI based on PIEMPI Data Submitted on 1 and 2 October 2022

	No. of Samples	Preliminary EUI			Results of X-Bar & R-Chart Analysis
		Upper EUI	Average EUI	Lower EUI	
Cement sector	14	3,640 MJ/MT/y	3,208 MJ/MT/y	2,776 MJ/MT/y	
Sugar sector	6	54,406 MJ/MT/y	43,152 MJ/MT/y	31,897 MJ/MT/y	
Food sector	9	4.833 MJ/kg/y	3.53 MJ/kg/y	2.234 MJ/kg/y	
Beverage sector	25	0.954 MJ/litre/y	0.65 MJ/litre/y	0.355 MJ/litre/y	

Source: Authors, based on PIEMPI's survey data submitted on 1 and 2 October 2022.

5.2. Industry Sector Final Outcome Reported by PIEMPI

Based on feedback given by ERIA following their reviews, , PIEMPI made further data validation and analyses. PIEMPI identified some outlier data and reported possible reasons for deviation, as follows:

- Some factories have incomplete processes (e.g. bagging only).
- Some factories have ongoing construction or facility upgrade work.
- The food and beverage sectors revealed a wide range of EUI due to differences in products and processes.

PIEMPI, which did the analyses based on the respective excel sheets, reported the following findings.

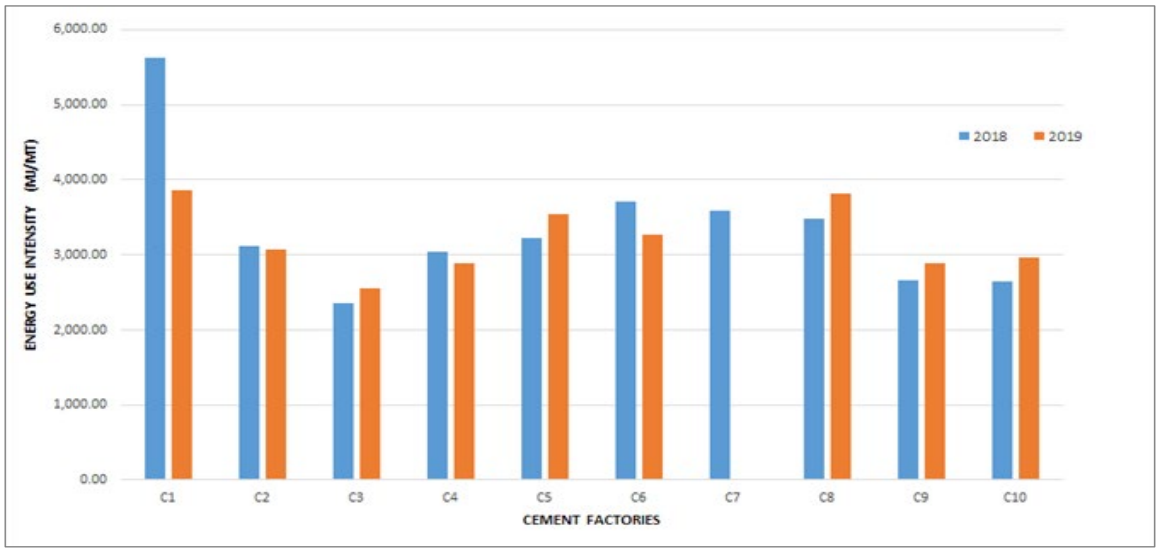
Table 2.3. Number of Survey Samples Collected and Used in the Analyses

	Target Number of Samples	Number of Samples Collected	Number of Samples Used in Analysis & Computation of EUIs
Cement Sector	15	14	10
Sugar Sector	10	7	6
Food Sector	35	16	9
Beverage Sector	40	30	24
Total	**100**	**67**	**49**

Source: PIEMPI (2023).

Cement Sector

Figure 2.1. Cement Factory EUIs Computed from Survey Data



Source: PIEMPI (2023).

Table 2.4. Range of Cement Sector EUI Computed from the Survey Data

	2018	2019	Remarks
Average EUI (MJ/MT)	3,095	3,206	Average value
Median EUI (MJ/MT)	3,118	3,075	Box and Whisker method
Lowest computed EUI (MJ/MT)	2,364	2,548	Box and Whisker method
Highest computed EUI (MJ/MT)	3,706	3,864	Box and Whisker method

Source: PIEMPI (2023).

Table 2.5. Distribution of Energy Usage in the Cement Sector

Energy Source	Percentage of Energy Usage (%)	Remarks
Coal	89	Coal is the most commonly used fuel in all cement factories.
Pet coke	53	Pet coke is the second-most commonly used fuel.
Solid fuel	42	Solid fuel is also commonly used.
Fuel oil	14	Fuel oil is relatively less commonly used.
Electricity	14	Electricity accounts for about 14% of energy usage.
Others	4-11	

Source: PIEMPI (2023).

Table 2.6. Distribution of Energy Used in Cement Production Processes

Production Process	Percentage of Energy Used	Remarks
Heating	82%–97%	Most energy is used for heating in the clinkering process, which converts the raw material into cement.
Mechanical process	3%–18%	Electricity is primarily used in mechanical processes, which account for about 3%–18% of the total energy used.

Source: PIEMPI (2023).

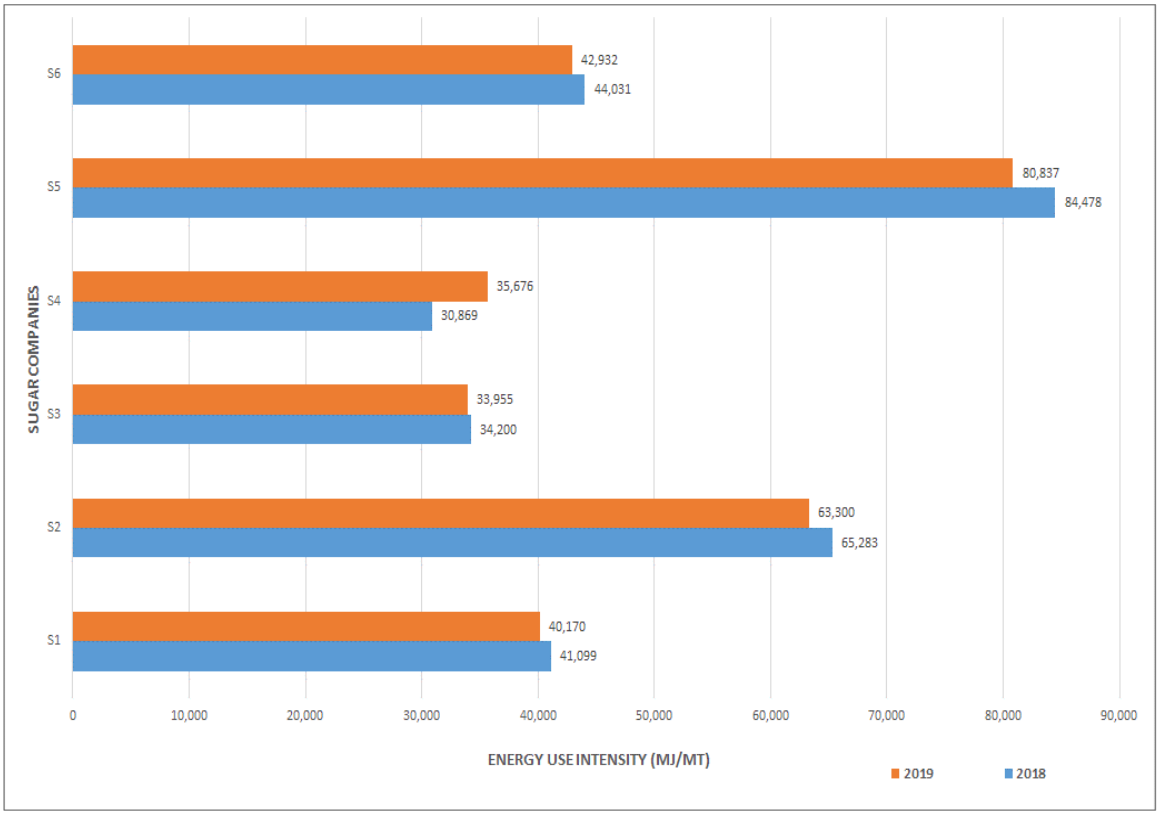
Sugar Sector

Table 2.7. Range of Sugar Sector EUI Computed from Survey Data

	2018	2019	Remarks
Average EUI (MJ/MT)	49,993	49,478	Average value
Median EUI (MJ/MT)	42,565	41,551	Box and Whisker method
Lowest computed EUI (MJ/MT)	30,869	35,676	Box and Whisker method
Highest computed EUI (MJ/MT)	84,478	80,837	Box and Whisker method

Source: PIEMPI (2023).

Figure 2.2. Sugar Factory EUIs Computed from Survey Data



Source: PIEMPI (2023).

Two sugar factories show consistently high EUIs, possibly due to the age of the factory plant equipment. In terms of fuel use, all factories use bagasse as fuel to produce electricity and steam for heating. Diesel and bunker fuel oil usage is minimal compared with other fuels consumed. The distribution of energy used in heating and mechanical processes in the sugar sub-sector is about equal (Table 2.8).

Table 2.8. Distribution of Energy Used in Sugar Production Processes

Production Process	Percentage of Energy Used
Heating	40%–56%
Mechanical	60%–44%

Source: PIEMPI (2023).

Food Sector

Table 2.9. Range of Food Sector EUI Computed from Survey Data

	2018	2019	Remarks
Average EUI (MJ/kg)	2.94	3.5	Average value
Median EUI (MJ/kg)	3.18	3.10	Box and Whisker method
Lowest computed EUI (MJ/kg)	1.42	1.58	Box and Whisker method
Highest computed EUI (MJ/kg)	4.25	5.74	Box and Whisker method

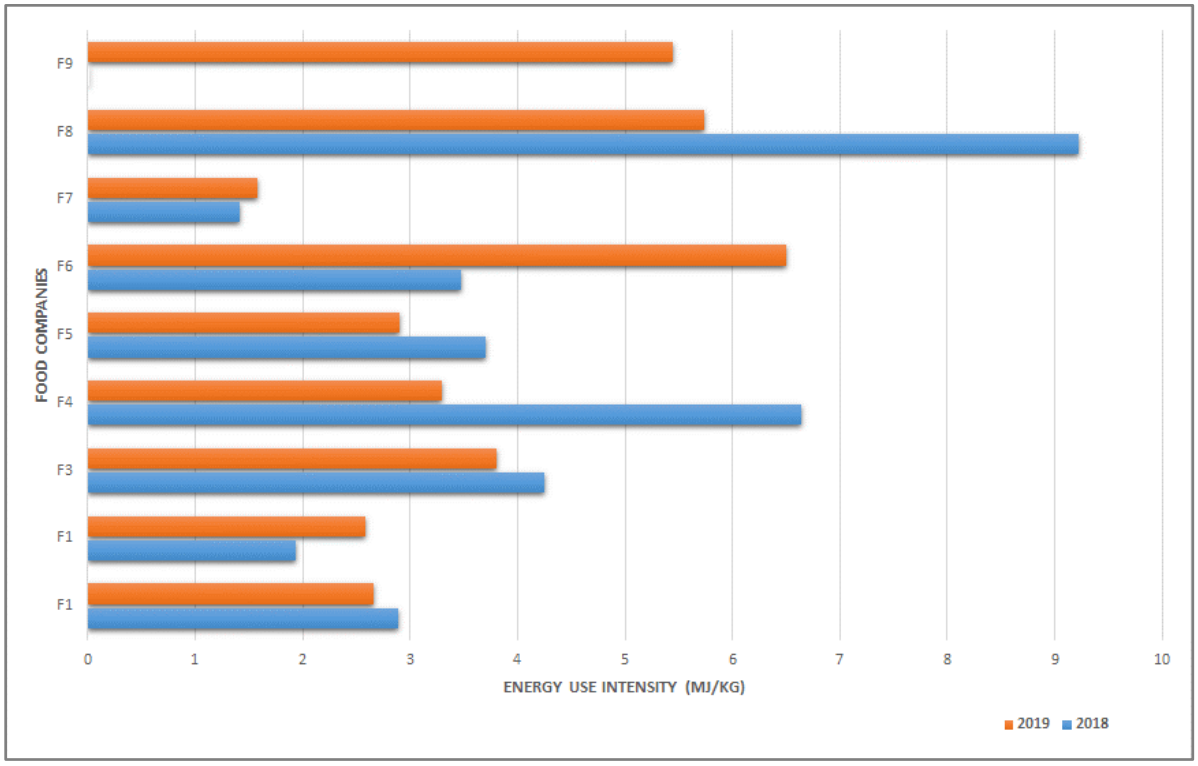
Source: PIEMPI (2023).

Table 2.10. Variations in Food Sector EUIs Due to Product Variations

Product Type	EUI (MJ/kg)	Remarks
Food snack (chips, etc.)	1.42–1.58	Consistent range
Bakery products	1.94–4.25	Wide range due to different bakery products
Varied products	5.44–5.74	Plants produce a variety of products

Source: PIEMPI (2023).

Figure 2.3. Food Sector EUIs Computed from Survey Data



Source: PIEMPI (2023).

Table 2.11. Share of Energy Usage by Percentages in Food Sector

Type of Energy Source	Range of Energy Use by Percentage (%)	Remarks
Electricity	20–72	
Fuel	80-28	Most plants used diesel, coal, and liquified petroleum gas

Source: PIEMPI (2023).

Table 2.12. Distribution of Energy Used in Production Processes of the Food Sector

Production Process	Range of Energy Use (%)	Remarks
Heating	27–81	Varied range due to products. Energy is mainly used for heating and mechanical processes.
Mechanical	73–19	Varied range due to products. Energy is mainly used for heating and mechanical processes.

Source: PIEMPI (2023).

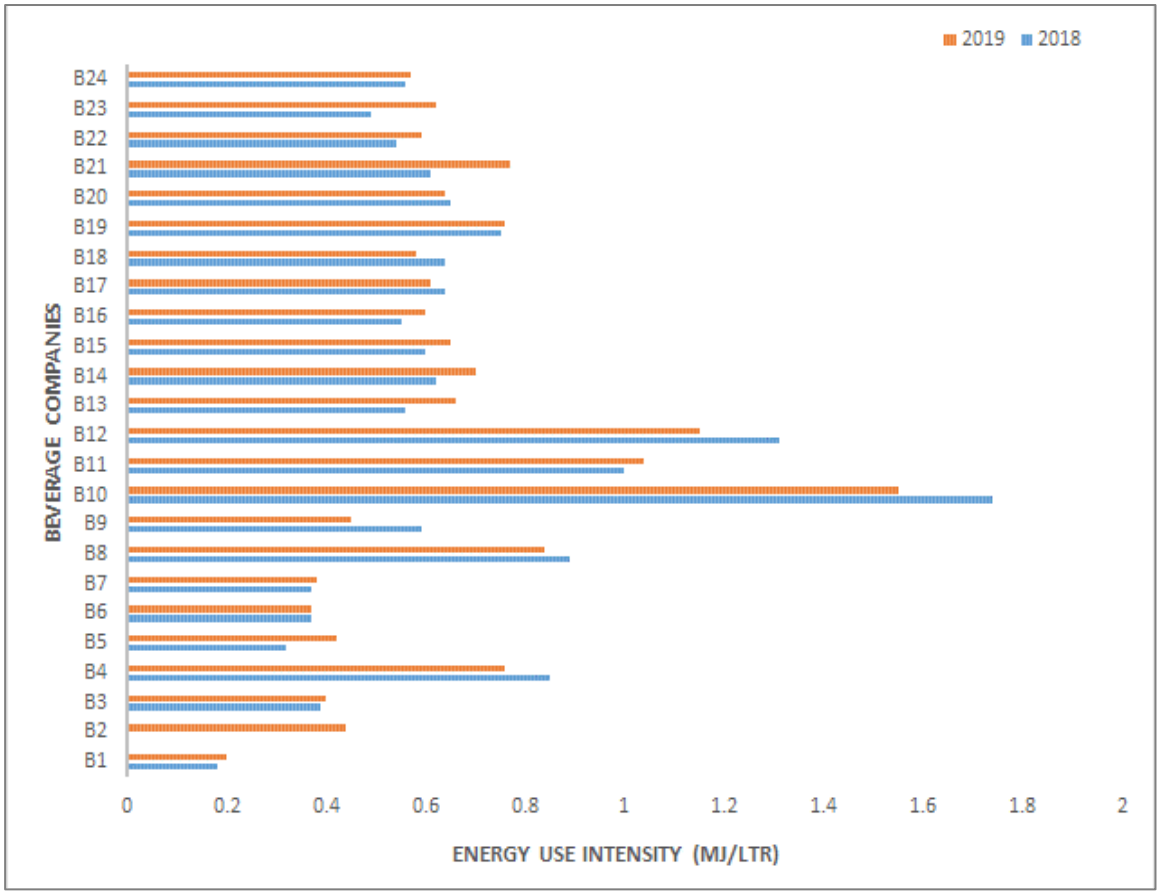
Beverage Sector

Table 2.13. Range of Beverage Sector EUIs Computed from Survey Data

	2018	2019	Remarks
Average EUI (MJ/litre)	0.66	0.66	Average value
Median EUI (MJ/litre)	0.60	0.62	Box and Whisker method
Lowest computed EUI (MJ/litre)	0.18	0.2	Box and Whisker method
Highest computed EUI (MJ/litre)	1.74	1.55	Box and Whisker method

Source: PIEMPI (2023).

Figure 2.4. Beverage Sector EUIs Computed from Survey Data



Source: PIEMPI (2023).

Table 2.14. Variations in Food Sector EUIs Due to the Nature of Products

Product Type	EUI (MJ/litre)	Remarks
Bottled water	0.18–0.44	
Soft drinks	0.49–0.77	
Beer	1.0–1.04	
Energy drinks	0.84–1.74	
Mixed beverage & food	1.15–1.31	Some plants produce mixed beverage and food, resulting in a higher EUI range.
Soya-based drinks	8.4 – 8.42	This type of product entails cooking soya beans that consume more energy than other beverage production.

Source: PIEMPI (2023).

Table 2.15. Share of Energy Usage by Percentages in Beverage Sector

Type of Energy Source	Range of Energy Use by Percentage (%)	Remarks
Electricity	25–85	Range of energy use due to process variations
Fuel	75–15	Most plants used diesel, coal, and blended fuel (diesel and bunker oil) for process heating. Companies B3 to B7 mainly use diesel, while B13 to B24 use blended fuel.

Source: PIEMPI (2023).

Table 2.16. Distribution of Energy Used in the Production Processes of the Beverage Sector

Production Process	Range of Energy Use (%)	Remarks
Heating	15–74	- Range of heating energy use due to process variations - Energy is mainly used for heating, cooling, and mechanical processes.
Cooling/Mechanical	85–26	

Source: PIEMPI (2023).

5.3. Summary of Industry Sector Final Outcome

Based on the average median values of 2018 and 2019 EUIs computed as the representative EUIs for the cement, sugar, food, and beverage sectors, Table 2.17 summarises the EUIs compared with the available target or benchmark values from other countries.

Table 2.17. Summary and Comparison of EUIs

	EUI Computed from the Survey Data	EUI Target Values of Other Countries	Source
Cement	3,097 MJ/MT/y	3,220 MJ/MT/y	ECCJ, Japan
Sugar	42,058 MJ/MT/y	37,867 MJ/MT/y	Indonesia Thinzar and Haryanto (2021)
Food	3.14 MJ/kg	N/A	—
Beverage	0.61 MJ/litre	N/A	—

Source: Compiled by the authors, based on PIEMPI and sources as quoted.

Table 2.17 shows that the EUI values computed from the survey data of the Philippines' cement and sugar sectors are within a reasonable range of values compared with the target values of Japan in the cement and sugar sectors for Indonesia. Based on the findings of the Philippine Innovation Entrepreneurship Mission, Inc. (PIEMI), it is more realistic to establish EUI values under further breakdowns in classification for the food and beverage sectors due to the wide range of products involving many variations in production processes. Therefore, PIEMI's findings show that subdividing the broad range of products in the food and beverage sectors is more meaningful, as suggested in Tables 2.10 and 2.14.

PIEMI's findings also showed that the primary energy sources are electricity and fuel, comprising mainly diesel, coal, and blended fuels. The energy sources are used primarily for heating and mechanical production processes, except for the beverage sector, where cooling is required.

PIEMI encountered the following challenges:

1) PIEMPI encountered Indifference from targeted respondent companies. Complete with a formal letter from the PDOE, many respondent companies ignored PIEMPI's efforts to establish a connection by not replying to emails or answering calls, or blocking off emails. This created so much delay in completing the survey project.

   Some company data were unclear and could not be reconciled. PIEMPI's efforts to further clarify the data submitted encountered no response.

   PIEMPI surveyed more than 200 companies in three batches to be able to complete the survey project. This project was finalised, thanks to the PDOE's assistance and the openness of ERIA to the encountered problems.

2) Some survey data submitted were unreliable because they could not be used for computation and analysis of their energy use performance. Some data or information are erroneous, incomplete, or inconsistent with what is expected of the respondents' nature of operation.

3) Not all companies in the cement sector have the complete process of producing cement, from clinkering to finished cement. A few companies undertake only one or more stage/s of the process, which hinders PIEMPI's effort to reconcile the data or information obtained.

6. Commercial Sector Outcome

6.1. Commercial Sector Preliminary Outcome

The MPA reported the following in their preliminary report dated 10 May 2022:

1) Based on a list of 100 companies received from the PDOE on 19 April 2022, an additional list of 100 companies on 22 April 2022, and an additional list of 32 companies to replace erroneous entries, the MPA reported the survey response situation as follows:

   a) Companies responded: 79 (However, out of the 79 companies responded, only 23% fully completed the survey questionnaire; 13% completed 50%; 64% completed less than 50%).
   b) Companies without response: 22
   c) Number of calls via telephone and/or mobile phone: 32

d) Additional emails after the first emails: 16

2) Issues encountered by the MPA at the initial stage of the survey:

   a) Preparation of master list and communication

      – Preparation and updating of the master list could be improved to expedite the survey implementation. On week 2 of the rollout, enumerators were still catching up on getting the correct contacts.
        - Contact details were not updated.
        - Duplication of records

   b) Several companies claimed that they did not receive emails from the PDOE.

   c) Enumerators needed to follow up with respondents on data validation due to erroneous data entries such as:
      - GFA discrepancies not matching the building footprint.
      - Operating days are given as 1 or 1.5 days/week.
      - Data for electricity and water consumption provided were incomplete.

3) Most companies selected for the survey knew about the EEC Law and practices and had submitted annual reports. Most companies were willing to contribute and participate in the survey. However, due to a lack of knowledge about the energy consumption survey, the enumerators must get buy-in or cooperation from the respondents, especially in the initial interviews. The enumerators needed to explain the objectives, scope, contents, and methods of filling in survey forms. Some companies had restrictions on accessing external websites. The MPA provided Excel format directly to these companies.

The MPA reported the following in a subsequent progress report submitted in August 2022:

1) The MPA developed a survey tool form based on the initial Excel file provided by ERIA. The survey tool form was complete with a link sent directly to the selected companies. The first draft was shown to energy practitioners for feedback before the deployment. Due to the COVID-19 restrictions, the survey was conducted through digital or online platforms.

2) The survey tool form comprised four parts for better information organisation. The form allowed respondents to review, save, exit after each part, and return to their saved work at their convenience. Additional versions of the survey tool were developed to accommodate respondents who had difficulty in accessing the form online due to company policies and security firewalls.

   Part 1 – Introduction and General Information
   Part 2 – Types of Fuels Used
   Part 3 – Air-Conditioning Section
   Part 4 – Lighting Section

3) Eight enumerators were trained and deployed to conduct the survey, including engagement with the respondents and providing technical support during the data-gathering activities.

Some strategies used in the engagement with respondents were:

- Group orientation sessions were conducted for engineers, energy managers, and building management focal persons who helped convey instructions and gather data from their subordinates.
- Enumerators guided respondents in filling out the survey tool forms.

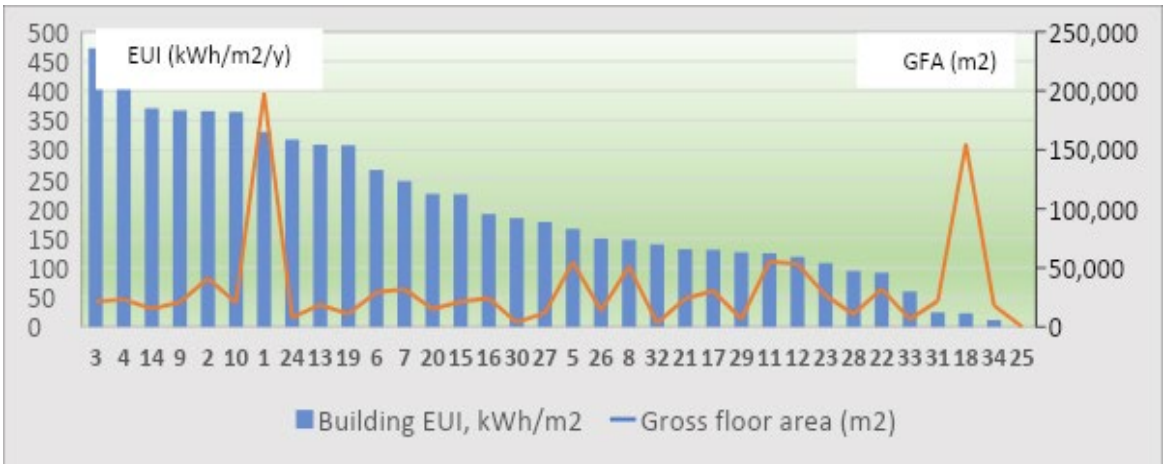
4) The MPA intended to achieve a sample size of 30 companies in retail and 30 in office buildings, and the balance in hotels and condominiums. However, the survey questionnaires were not formulated to conduct such surveys. As a result, data was insufficient to complete the survey and analyse hotels and condominiums. Hence, this part of the survey not originally planned for was aborted.

5) Out of the 200 companies in the PDOE lists, the MPA reached out to 185 companies, 92 of which were successfully contacted and responded (5 additional companies were later added to make up a total of 97 respondents). However, 93 companies (or 46.5%) were removed or excluded from the list due to the following reasons:

- Did not respond: 51 companies
- Decline to participate: 13 companies
- Double entries: 22 companies
- Disqualified: 7 companies

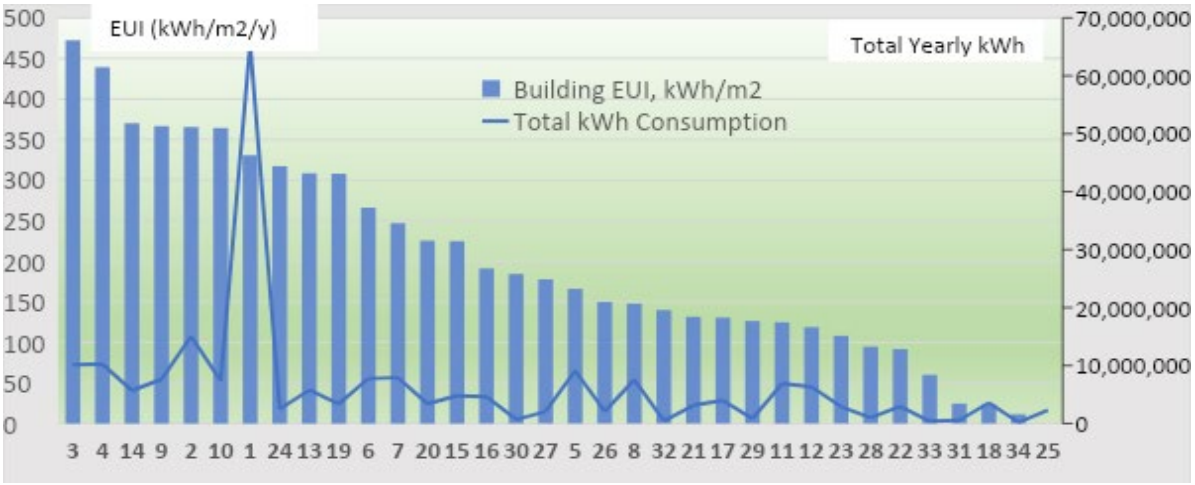
The MPA presented its survey results on office and retail buildings based on 2018 and 2019 data in a meeting held on 15 July 2022.

Figure 2.5. Computed Office Building EUI vs GFA Based on 2018 Data



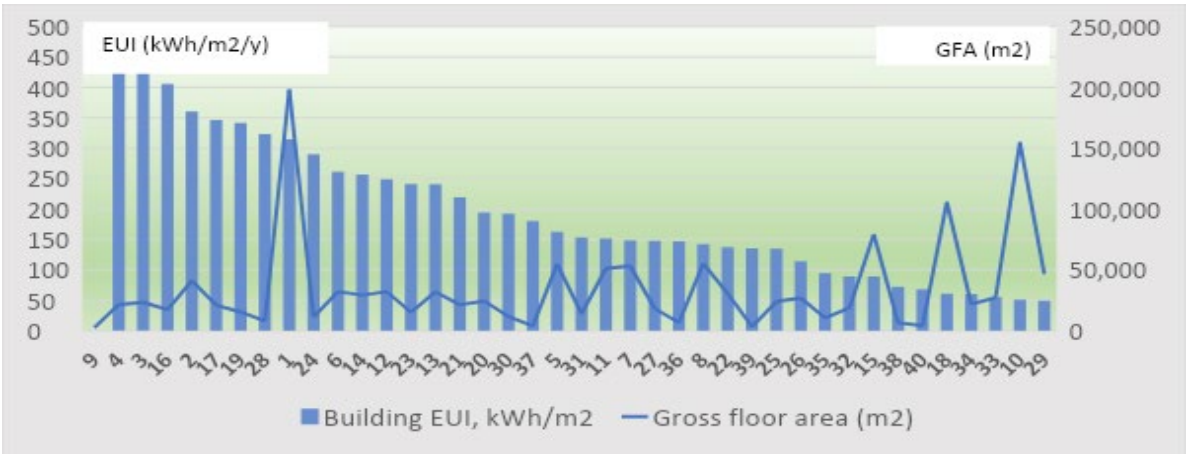
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.6. Computed Office Building EUI vs Total Yearly kWh Based on 2018 Data



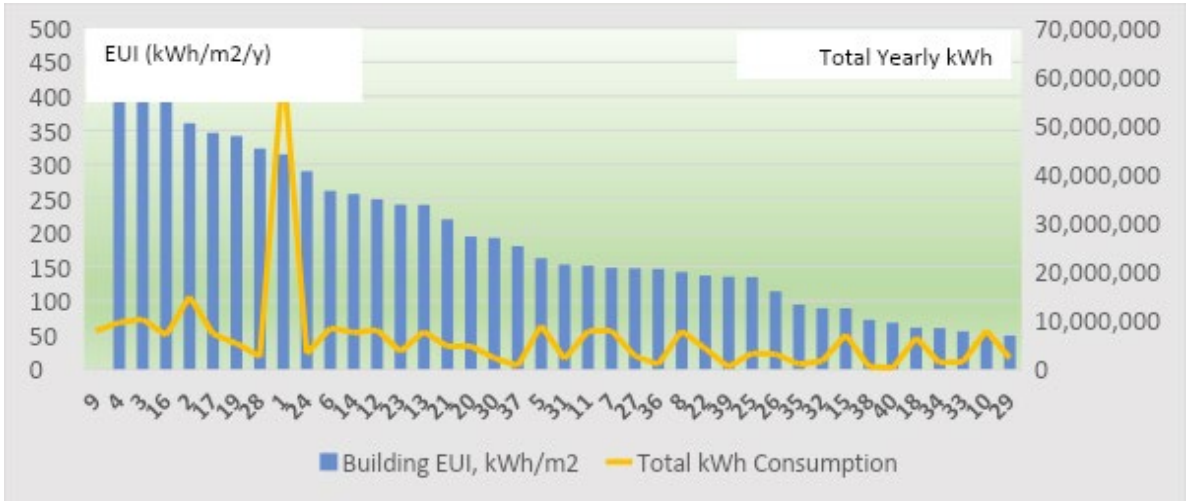
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.7. Computed Office Building EUI vs GFA Based on 2019 Data



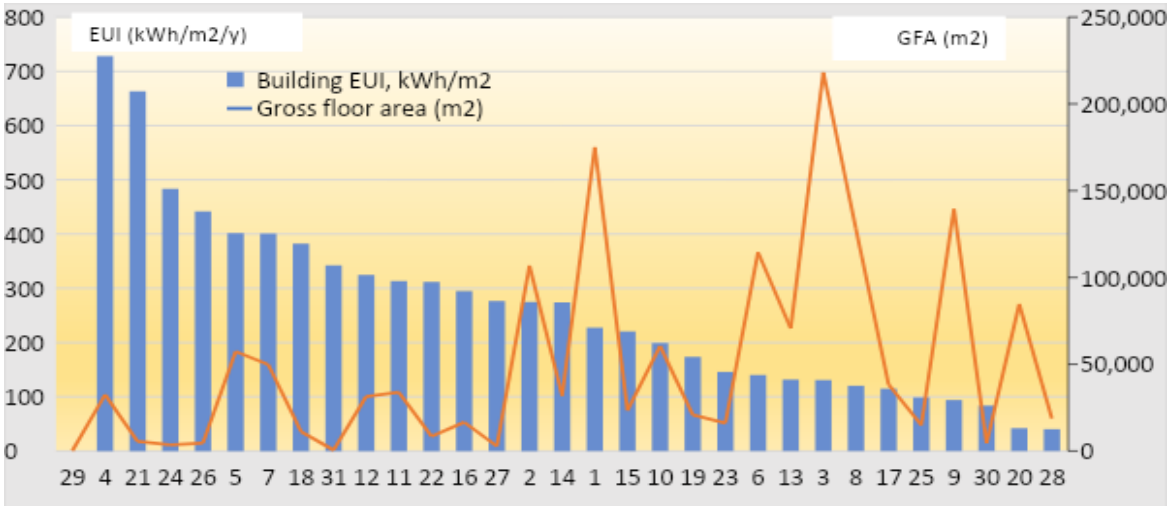
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.8. Computed Office Building EUI vs Total Yearly kWh Based on 2019 Data



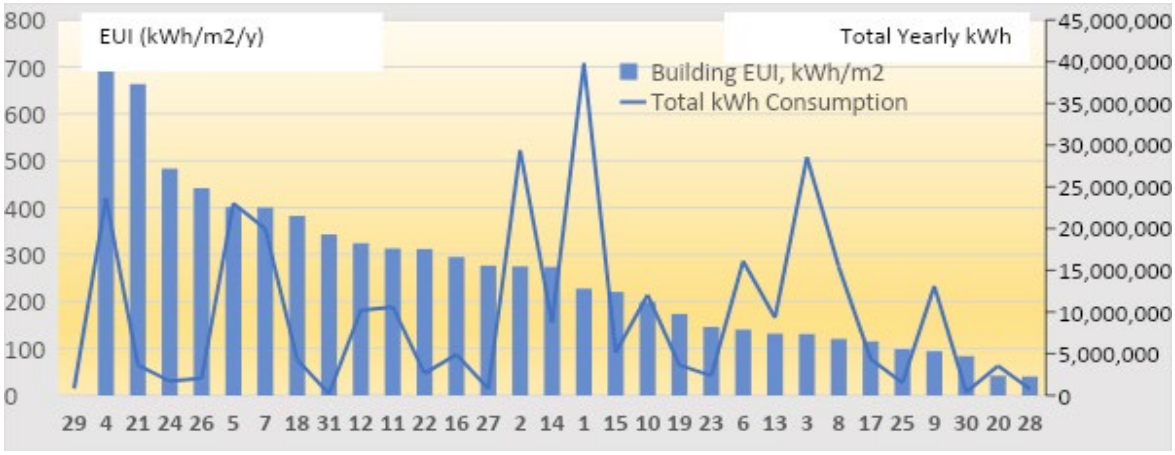
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.9. Computed Retail Building EUI vs GFA Based on 2018 Data



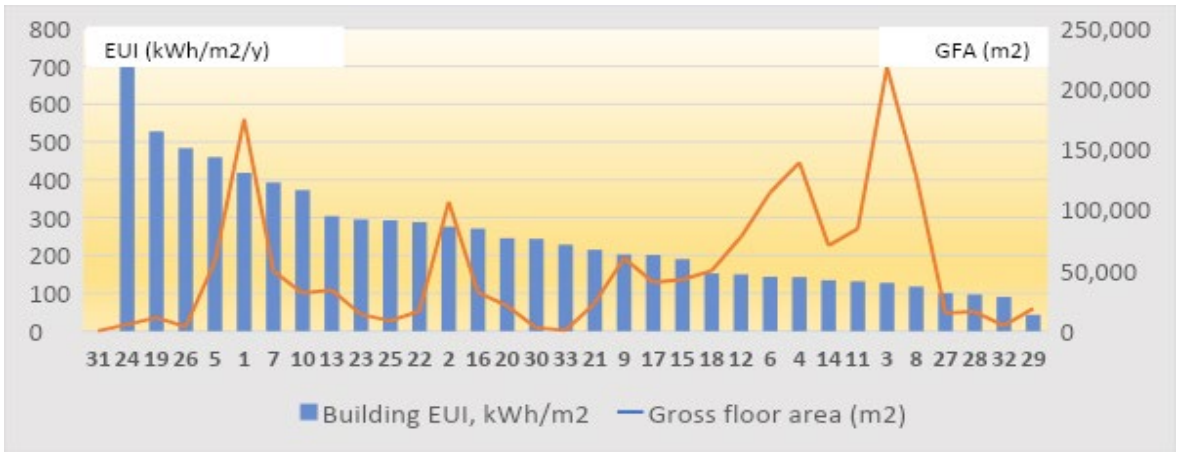
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.10. Computed Retail Building EUI vs Total Yearly kWh Based on 2018 Data



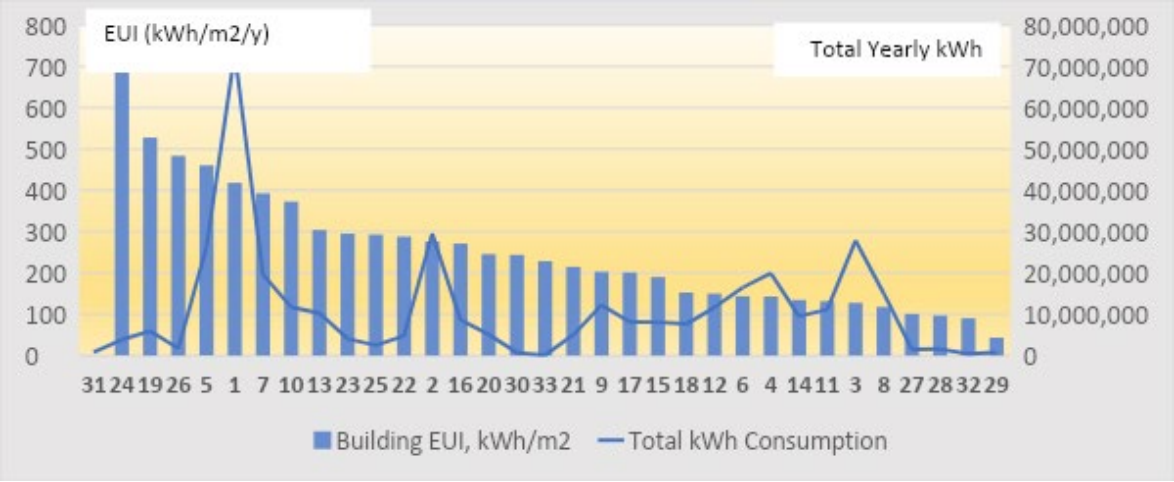
Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.11. Computed Retail Building EUI vs GFA Based on 2019 Data



Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

Figure 2.12. Computed Retail Building EUI vs Total Yearly kWh Based on 2019 Data



Source: MPA's PowerPoint report presented in the 15 July 2022 meeting.

The initially computed EUIs in Figures 2.5 to 2.12 show a wide range of EUI variation for both office and retail buildings. The GFA and total yearly energy consumption data were also inconsistent. The extreme values of GFA and total yearly consumption were highlighted in the meeting as potential sources of erroneous data. The MPA was advised that such extreme GFA values and total annual energy consumption would warrant further effort in reviewing and validating the data. In addition, these initially computed EUIs were not normalised to reflect the average building operating hours. For example, the range of office and retail business operating hours recorded was 40–168 hours/week was the same, but with differences in the skewed distribution of data. The average office operating hours recorded in the survey was 124 hours/week, while retail business operating hours was 94 hours/week. The standard 2,000 hours/year for office buildings aligned with the ASEAN Energy Award was also considered. The normalised EUI values could then be compared with other buildings of the same category.

The MPA explained its findings during the initial stage of the survey, as follows:

1) Some contact persons or appointed energy managers and staff appeared to need to strengthen data collection and quality control because some data on buildings, building facilities, and energy parameters were lacking or undocumented.

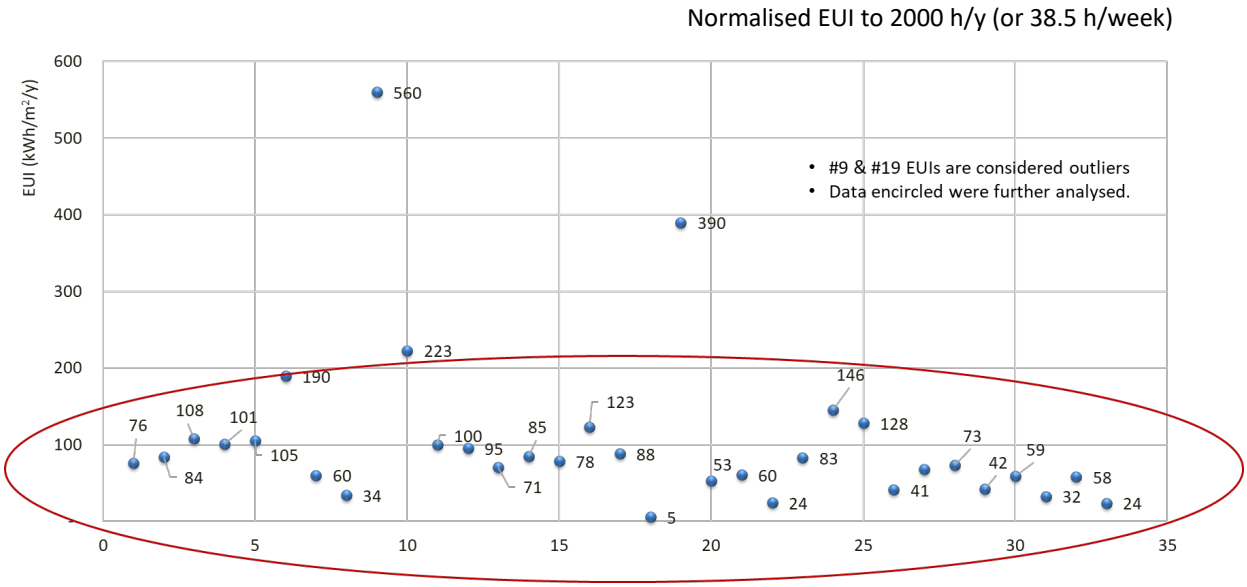
2) Most respondents needed to improve their awareness of building energy performance on energy baselining, use of energy performance indicators, and establishing benchmarking, which explained the low quality and inconsistent data provided in the survey.

3) There was a need to improve data reliability on significant energy users, energy balance, and the capability of showing or presenting energy information, including energy performance data. This showed opportunities to improve energy management processes and systems in companies.

4) The functions of some designated establishments in the Philippines' commercial sector are multi-use, multipurpose, and flexible, as they might coexist in the same building and even on the same floors. This makes the sectoral industry energy consumption survey challenging and complex.

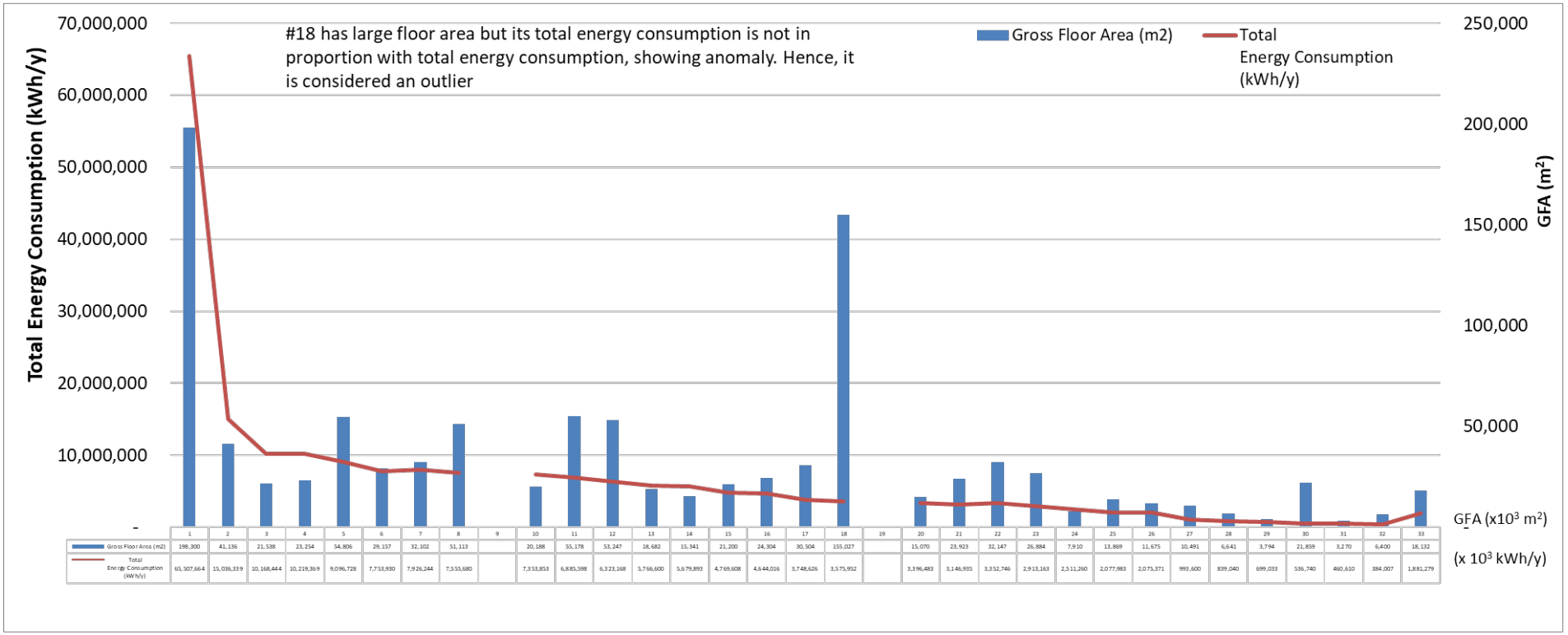
Following MPA's submission of its final report on 2 September 2022 and consolidated data on 7 September 2022, ERIA conducted a review and analysis, presented and explained in an online meeting on 4 October 2022. In addition to the anomalies in the GFA and total yearly energy consumption data highlighted above, Figures 2.13, 2.14, and 2.15 identified the outlier EUI data.

Figure 2.13. Illustration of 2018 Office Data Validation Exercise #1



Source: Author, based on MPA's submission of consolidated data in September 2022.

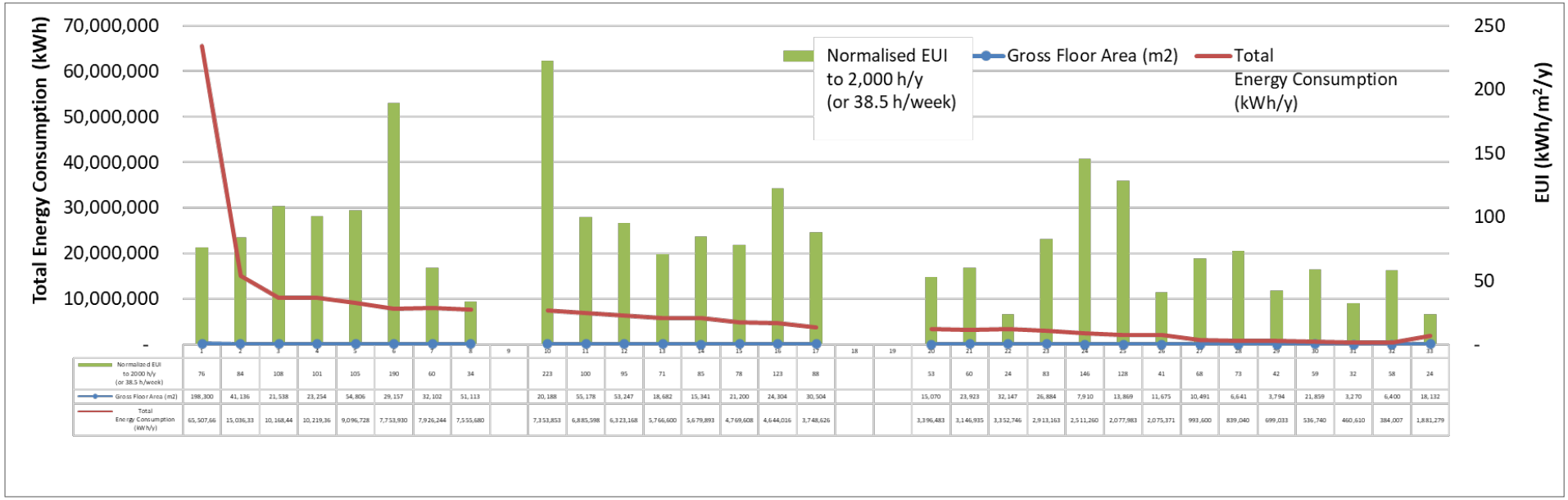
Figure 2.14. Illustration of 2018 Office Data Validation Exercise #2



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Gross Floor Area (m2)	198,300	41,136	21,538	23,254	54,806	29,157	32,102	51,113		20,188	55,178	53,247	18,682	15,341	21,200	24,304	30,504	155,027		15,070	23,923	32,147	26,884	7,910	13,869	11,675	10,491	6,641	3,794	21,859	3,270	6,400	18,132
Total Energy Consumption (kWh/y)	65,507,664	15,036,339	10,168,444	10,219,369	9,096,728	7,753,930	7,926,244	7,555,680		7,353,853	6,885,998	6,323,168	5,766,600	5,679,893	4,769,608	4,644,016	3,748,626	3,575,952		3,396,483	3,146,935	3,352,746	2,913,163	2,511,260	2,077,983	2,075,371	993,600	839,040	699,033	536,740	460,610	384,007	1,881,279

Source: Author, based on MPA's submission of consolidated data in September 2022.

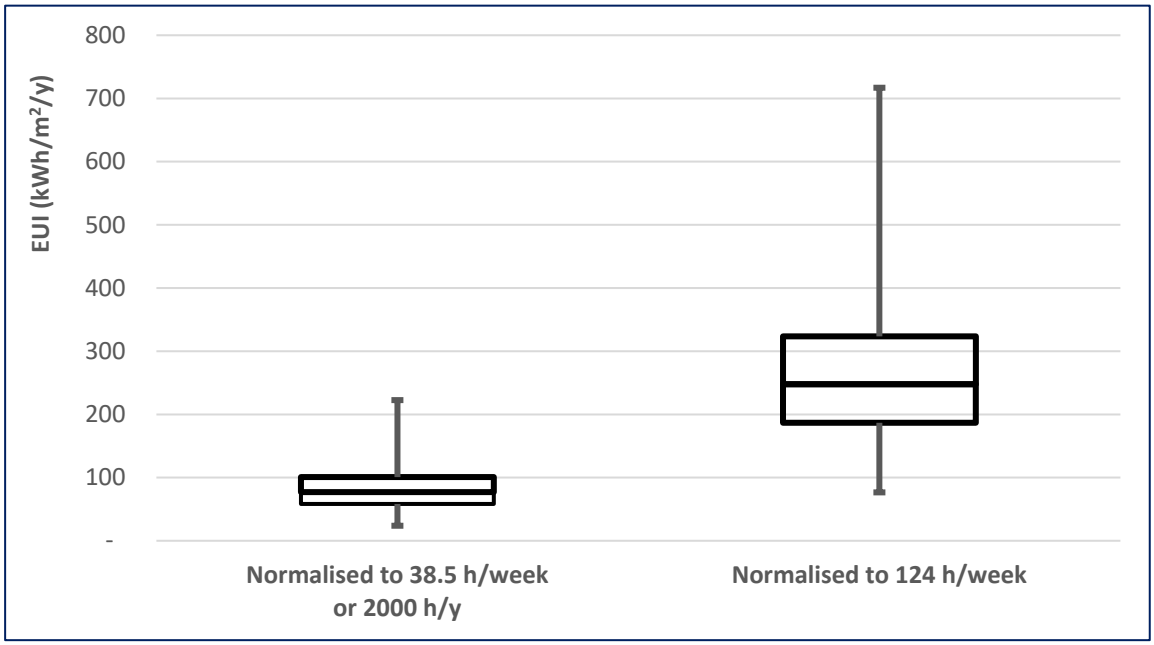
Figure 2.15. Illustration of 2018 Office Data Validation Exercise #3



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Normalized EUI to 2000 h/y (or 38.5 h/week)	76	84	108	101	105	190	60	34		223	100	95	71	85	78	123	88			53	60	24	83	146	128	41	68	73	42	59	32	58	24
Gross Floor Area (m2)	198,300	41,136	21,538	23,254	54,806	29,157	32,102	51,113		20,188	55,178	53,247	18,682	15,341	21,200	24,304	30,504			15,070	23,923	32,147	26,884	7,910	13,869	11,675	10,491	6,641	3,794	21,859	3,270	6,400	18,132
Total Energy Consumption (kWh/y)	65,507,66	15,036,33	10,168,44	10,219,36	9,096,728	7,753,930	7,926,244	7,555,680		7,353,853	6,885,598	6,323,168	5,766,600	5,679,893	4,769,608	4,644,016	3,748,626			3,396,483	3,146,935	3,352,746	2,913,163	2,511,260	2,077,983	2,075,371	993,600	839,040	699,033	536,740	460,610	384,007	1,881,279

Note: 3 sets of data (#9, 18, & 19) were excluded in the estimation of EUI.
Source: Authors, based on MPA's submission of consolidated data in September 2022.

Figure 2.16. Comparison of Average EUI from 2018 Office Data Based on the Normalisation of Average Operating Hours to 38.5 h/week and 124 h/week Using the Box and Whisker Method, Prepared by ERIA

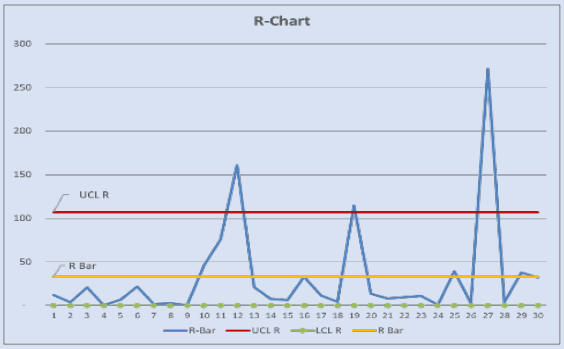
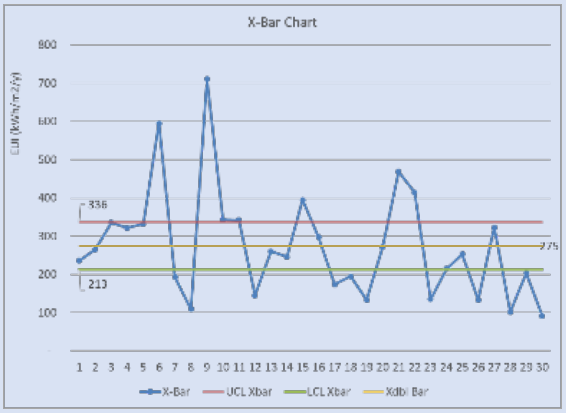
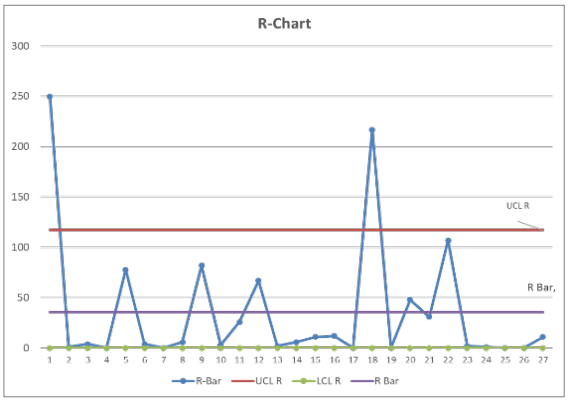
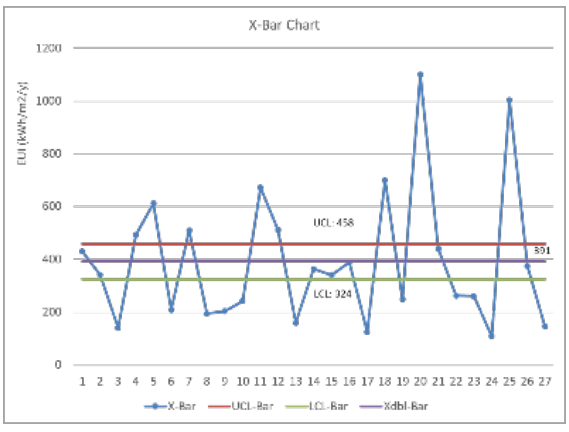


Source: Authors, based on MPA's submission of consolidated data in September 2022.

Figure 2.16 shows the results of using the Box and Whisker Plot method to estimate and compare the median values of the EUI, based on the normalisation of average operating hours of 38.5 hours/week (or 2,000 hours/y, based on the ASEAN Energy Award) and 124 hours/week, which was the average operating hours derived from respondents' survey data. Based on the average operating hours in the survey data, ERIA believed that 124 hours/week would reflect more accurately the energy consumption data obtained. Hence, the final analysis and computation of the EUIs would be based on the normalisation of operating hours of 124 hours/week derived from the survey data. The Box and Whisker method is useful if the yearly median value of the EUI is to be established. Yearly EUI data can be plotted in graphs for monitoring purposes, like Figure 1.6 on Singapore's EUI trend when sufficient yearly EUI data are established for various building categories.

In addition to the Box and Whisker Plot method, ERIA showed the MPA an alternative statistical analysis method in X-bar and R-chart for estimating EUIs during the online meeting on 4 October 2022. Table 2.18 summarises ERIA's estimation of average EUI for the office and retail buildings based on the 2018 and 2019 survey data, normalised to the respective average operating hours of 124 hours/week for office buildings, and 94 hours/week for retail buildings.

Table 2.18. Estimation of Average EUI from 2018 and 2019 Data Using X-Bar and R-Chart Method, Prepared by ERIA

	Computed EUI (kWh/m²/y)	Results of X-Bar and R-Chart Analysis
Office buildings	Based on 2018 & 2019 data and from X-Bar chart: Median EUI value = 275 kWh/m²/y Lower Control Limit (LCL) = 213 kWh/m²/y Upper Control Limit (UCL) = 336 kWh/m²/y	 
Retail buildings	Based on 2018 & 2019 data and from X-Bar chart: Median EUI value = 391 kWh/m²/y Lower Control Limit (LCL) = 324 kWh/m²/y Upper Control Limit (UCL) = 458 kWh/m²/y	 

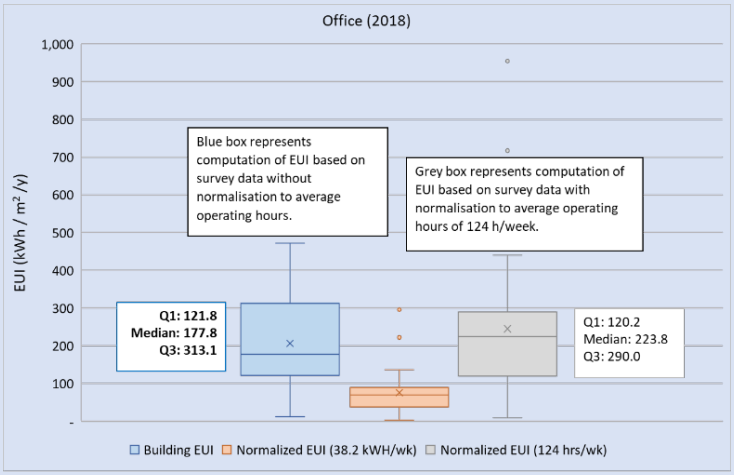
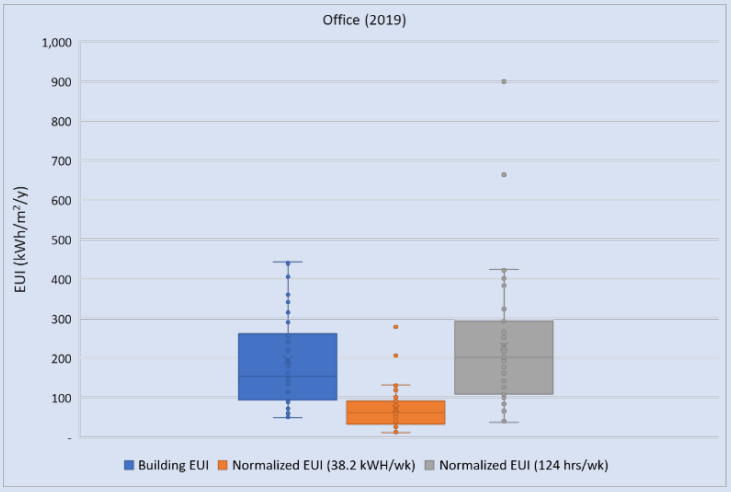
Source: Author, based on MPA's submission of consolidated data in September 2022.

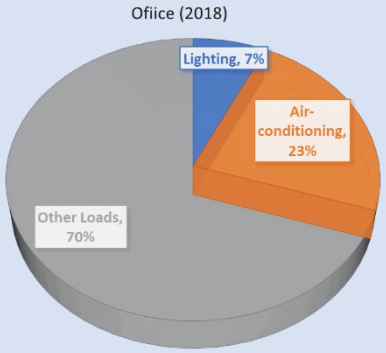
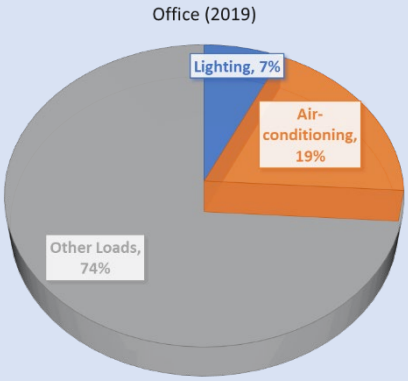
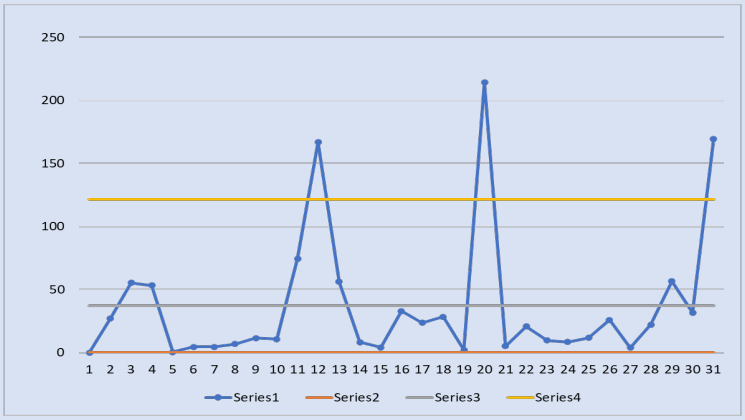
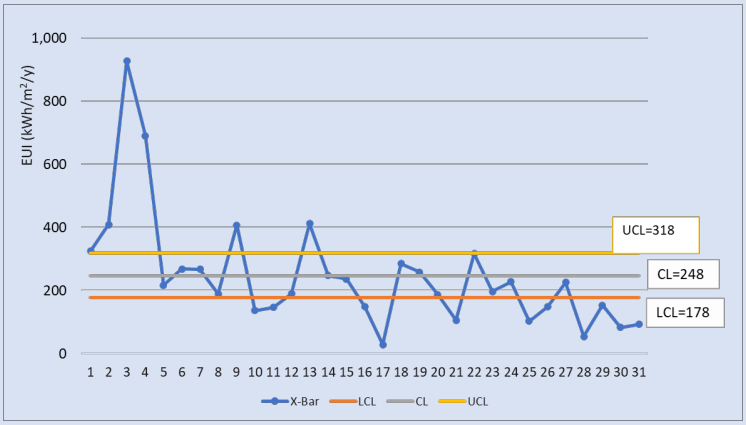
6.2. Commercial Sector Final Outcome per MPA Report

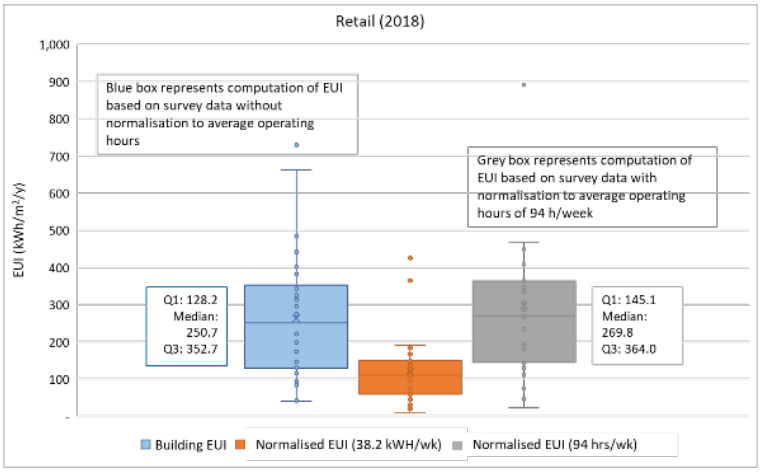
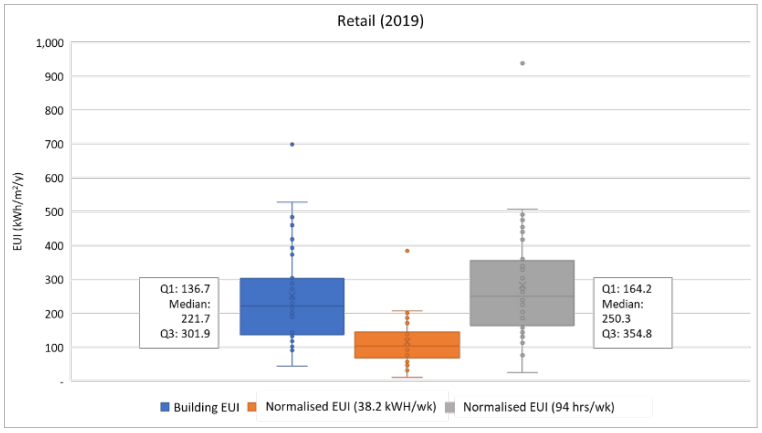
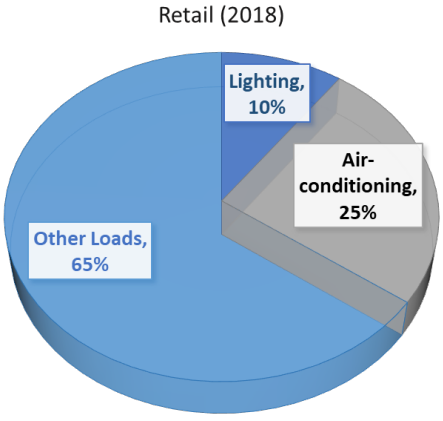
Following the review and discussion on 4 October 2022, the MPA submitted its final report on 20 December 2022. MPA's final analysis and computation of the EUIs are summarised in Table 2.19. The final computation of office building EUI is based on normalised operating hours of the average operating hours of 124 hours/week per office sector respondent, while that of retail buildings is based on the average operating hours of 94 hours/week per retail sector respondent. Table 2.19 summarises MPA's findings on estimating average EUIs with ERIA's input on the final analysis, and percentage shares of energy usage, based on the 2018 and 2019 survey data.

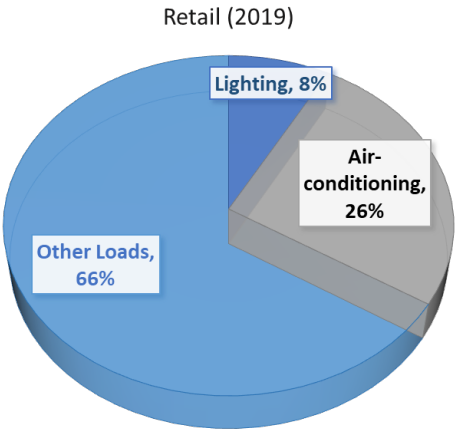
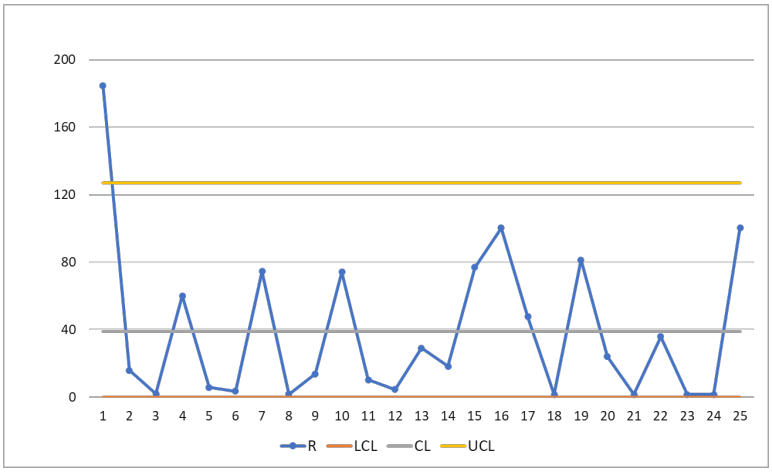
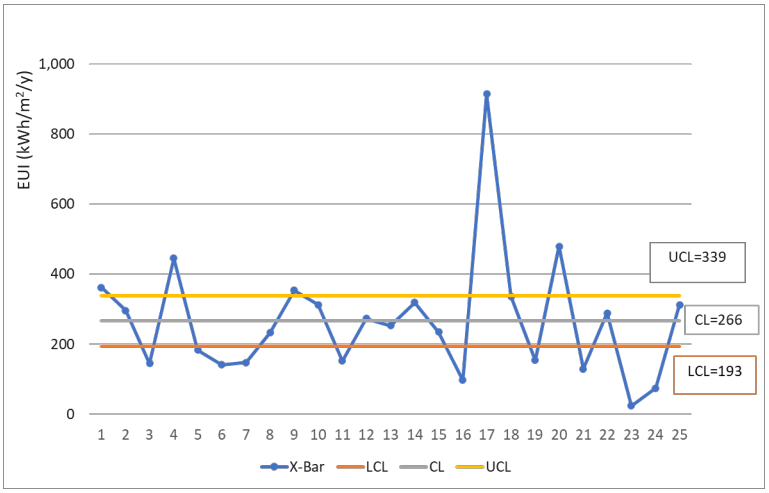
The MPA also collected data on the age and occupancy rates of office and retail buildings. However, it reported that correlations between the EUI and building age and occupancy rates for both types of buildings were weak to indiscernible.

Table 2.19. Final Analysis and Computation of EUIs Reported by the MPA

	Computed EUI (kWh/m²/y)	Results of Box & Whisker Plot Analysis
Office building	**Box and Whisker Plot Analysis:** Based on the survey data with normalization of average operating hours of 124, the median value of the 2018 office building EUI is about 224 kWh/m²/y. Based on the survey data with normalisation of operating hours, the median value of the 2019 office building EUI is about 202 kWh/m²/y.	 

	Computed EUI (kWh/m²/y)	Results of Box & Whisker Plot Analysis
	Percentage share of energy usage in office buildings in 2018: – Lighting: 7% – Air conditioning: 23% – Other loads: 70% Comment: The percentage share of air-conditioning load is unexpectedly low. Percentage share of energy usage in office buildings in 2019: – Lighting: 7% – Air conditioning: 19% Other loads: 74% Comment: The percentage share of air-conditioning load is unexpectedly low. **X-Bar and R-Chart analysis of 2018 and 2019 office data:** The median value of the office EUI data is 248 kWh/m²/y. **No. of samples used in computing for office EUIs:** **2018: 34** **2019: 40**	   

	Computed EUI (kWh/m²/y)	Results of Box & Whisker Plot Analysis
Retail building	**Box and Whisker Plot Analysis:** Based on the survey data with normalisation to average operating hours to 94 h/week, the median value of the 2018 retail building EUI is about 270 kWh/m²/y.	
	Based on the survey data with normalisation to average operating hours of 94 h/week, the median value of the 2019 retail building EUI is about 250 kWh/m²/y.	
	Percentage share of energy usage in retail buildings in 2018: – Lighting: 10% – Air conditioning: 23% Other loads: 65% Comment: The percentage share of air-conditioning load is unexpectedly low.	

	Computed EUI (kWh/m²/y)	Results of Box & Whisker Plot Analysis
	Percentage share of energy usage in retail buildings in 2019: – Lighting: 8% – Air conditioning: 26% Other loads: 66% Comment: The percentage share of air-conditioning load is unexpectedly low.	
	X-Bar and R-Chart analysis of 2018 and 2019 retail data: The median value of the retail building EUI data is 266 kWh/m²/y.	 
No. of Samples	**No. of samples used in computing for retail building EUIs:** **2018: 31** **2019: 33**	

Source: Author based on MPA's Excel file submitted on 20 December 2022.

Table 2.20. Number of Samples Collected and Used in Analysis

	Target Number of Samples	Number of Samples Collected	Number of Samples Used in Analysing and Computing EUIs
Office buildings	No breakdown was reported.	No breakdown was reported.	2018: 34 2019: 40
Retail buildings	No breakdown was reported.	No breakdown was reported.	2018: 31 2019: 33
Total	100	97 (Including condominiums)	2018: 65 2019: 73

Source: Authors, based on MPA's reports submitted in August and December 2022.

6.3. Summary of Commercial Sector Final Outcome

Since the main objective of this survey is to establish EEIs or EUIs for the commercial office and retail building sectors, this section focuses on the outcome of the analysis and computation of EUIs. Table 2.21 summarises the results based on the analyses and calculations of EUIs discussed in sections 5.1 and 5.2.

Table 2.21. Summary of EUIs Estimated by MPA and ERIA Based on the 2018–2019 Survey Data

	EUI Computed from Survey Data (Normalised to Average Operating Hours Derived from the Survey) by the MPA	EUI Computed from Survey Data (Normalised to Average Operating Hours Derived from the Survey) by ERIA	Remarks
Office buildings	Box and Whisker method: 2018: 224 kWh/m^2/y 2019: 202 kWh/m^2/y X-Bar and R-Chart method: 248 kWh/m^2/y.	X-Bar and R-Chart method: 275 kWh/m^2/y ERIA's estimation using the Box and Whisker method was 246 kWh/m^2/y (Figure 2.16).	The difference between MPA's and ERIA's EUI computations is due to the determination of outlier data. The MPA included EUI values < 100 kWh/m^2/y, which are considered unrealistic.

Retail buildings	Box and Whisker method: 2018: 270 kWh/m^2/y 2019: 250 kWh/m^2/y X-Bar and R-Chart method: 266 kWh/m^2/y.	X-Bar and R-Chart method: 391 kWh/m^2/y	Similarly, the difference between MPA's and ERIA's EUI computations is due to the determination of outlier data. The MPA included EUI values < 100 kWh/m^2/y, which are considered unrealistic.

Source: Authors.

The Building and Construction Authority (BCA), Singapore, has published the Building Energy Benchmarking Report annually since 2014. However, the program to implement improvements in building energy efficiency began in Singapore in 2005 under the Green Mark certification scheme. Given similar climatic conditions, it is appropriate to refer to Singapore's EUI benchmarking values of the same category of buildings. Since the Philippines' EEC Law was enacted in 2019, the EUIs derived from the survey in the Philippines should be compared with the respective EUI benchmarking values of 2008 in Singapore when the drive to improve energy efficiency in buildings was at the initial stage. The 2008 EUI for office buildings in Singapore was 267 kWh/m^2/y. Similarly, the 2008 EUI for retail buildings in Singapore was 401 kWh/m^2/y, (Figure 1.6).

Given the limitation of this survey due to the limited sample and the number of years and quality of data, it is impossible to identify a single benchmarking value from the analyses of this set of survey data in the commercial sector. Accordingly, a range of average EUIs derived from the survey may be considered. Using the X-Bar and R-Chart methods, the MPA computed an average EUI value of 248 kWh/m^2/y. In comparison, ERIA estimated an average EUI value of 275 kWh/m^2/y for office buildings in the Philippines for 2018–2019. Using the Box and Whisker method, the MPA estimated an average office building EUI value of 224 kWh/m^2/y for 2018 and 202 kWh/m^2/y for 2019. However, based on comparable data in Singapore and experiences in Malaysia, the range of average EUI for the office buildings in the Philippines for 2018–2019 should be based on ERIA's estimation given in Table 2.18.

Similarly, MPA's estimation of average EUI for retail buildings at an average EUI of 270 kWh/m^2/y for 2018 and 250 kWh/m^2/y for 2019 seems low when compared with the corresponding benchmarking value of 401 kWh/m^2/y in Singapore, as shown in Figure 2.17 for 2008. The Box and Whisker method used by the MPA is recognised as acceptable. However, due to the differences in data validation, MPA's computation of EUIs for the retail buildings is unacceptable. Therefore, the range of average EUI values for retail buildings in this survey should be based on ERIA's estimation (Table 2.18).

In summary, the range of average EUIs for office and retail buildings in the Philippines, based on the foregoing analyses of 2018 and 2019 survey data, is recommended to be as follows:

1) Office buildings:
    a) Median EUI value: 275 kWh/m^2/y
    b) Range of average EUIs: 213–336 kWh/m^2/y
2) Retail buildings:
    a) Median EUI value: 391 kWh/m^2/y
    b) Range of average EUIs: 324–458 kWh/m^2/y

Chapter 3
Conclusion

The project aimed to conduct an energy consumption survey and prepare EEIs for the industrial and commercial sectors. Although this project collected energy consumption data for 2 years (2018 and 2019) with a limited sample, a limited number of years of data, and constraints encountered during the survey due to the pandemic situation, which hampered the process of physical interaction and collection of data, the survey methodology, analyses, and development of EEI have provided valuable lessons for the collection of relevant data, and establishment of EEI and future benchmarking values when sufficient data and further in-depth indicators could be derived.

Due to the limitations and difficulties faced during the survey, and the lack of quality data, the estimates of average EUI data can be summarised as follows:

Commercial Sector

- Office building sector:
  - Range of average EUIs: 213–336 kWh/m^2/y
  - Median EUI: 275 kWh/m^2/y
- Retail building sector:
  - Range of average EUIs: 324–458 kWh/m^2/y
  - Median EUI: 391 kWh/m^2/y

Industrial Sector

- Cement sector average EUI: 3,097 MJ/MT/y
- Sugar sector average EUI: 42,058 MJ/MT/y
- Food sector average EUI: 3.14 MJ/kg
- Beverage sector average EUI: 0.61 MJ/litre

This project has provided some valuable lessons learned, such as the following:

1) This project has provided an opportunity to learn about the process and methodology of energy consumption surveys and subsequent analyses and computations of average EUIs.
2) The efficiency and effectiveness of the energy consumption survey can be improved if the awareness of stakeholders is enhanced in these areas:
   a) Knowledge on compilation of relevant data for EEI establishment and monitoring.
   b) The usefulness and benefits of EEIs.
   c) Trust and confidence in energy consumption survey.
3) Implementation of energy consumption survey for the establishment of EEI can be improved in these areas:
   a) Physical training on all aspects of energy consumption survey including dry runs, and methodology on analysis and validation of data is necessary.

b) Need to allocate time to review all preparatory work including energy consumption survey formats.
c) Focused survey effort should be made to achieve the planned objectives, programs, and targets.
d) Physical interviews and the collection of data are necessary.

Despite the difficulties brought about by the pandemic and the low acceptance and reluctance on the part of respondents due to their lack of familiarity, understanding, and confidence in such a survey exercise, the project has provided valuable experiences for everyone involved. However, more important is that this project has provided valuable insights and helpful information on data collection and computation of EUIs. This project can hopefully lead to future efforts in establishing and compiling more EUI data. The Singapore commercial building example has shown that tracking of EUIs for various categories of buildings can be used to track EUI trending and quantify energy savings in various energy end-use sub-sectors. Albeit the outcome of this project might not be ideal due to the said constraints, this project should not be detracted from its significance because it has provided several lessons learned, and it has demonstrated the methodology of energy consumption survey for the establishment of EUIs in industry and commercial sectors, including the dos and don'ts. Another significant outcome of compiling EUI data is the establishment of benchmarking EEI value once a sufficient number of years of data are collected. Benchmarking EEI values can drive the energy efficiency agenda for each sector and sub-sector.

References

APERC (2020), APEC (2019), *Energy Statistics 2018.* Tokyo.

Building and Construction Authority (BCA) (2021), Building Benchmarking Report. Singapore.

IEA (2014a), *Energy Efficiency Indicators: Fundamentals on Statistics*. Paris.

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

MPA (2022a), MPA Report No.1, Energy Consumption Survey of Commercial Buildings in Manila, 10 May, Manila.

MPA (2022b), MPA Final Report, Energy Consumption Survey for Commercial Buildings in Metro Manila (For Years 2018–2019), August, Manila.

MPA (2022c), MPA Final Report, Energy Consumption Survey for Commercial Buildings in Metro Manila (For Years 2018–2019), December, Manila.

PIEMPI (2022), PIEMPI Initial Status Report, Energy Consumption Survey of Industrial Factories in the Philippines, 14 May, Manila.

PIEMPI (2023), PIEMPI Final Report, Conducting Energy Consumption Survey in Industry Sector, Philippines, January, Manila.

Thinzar, D.W. and Haryanto (2021), 'Energy Efficiency of Indonesia's Sugar Industry', *Jurnal Akuntasi*, Vol 11, No. 1, February.

UNIDO (2012), Energy Management System Training Notes. Vienna.

Other Resources

MPA's Excel file on commercial buildings Data summary and analysis submitted in December 2022.

MPA's PowerPoint report presented in the 15 July 2022 meeting.

PIEMPI's Excel files on cement, sugar, food and beverages sectors submitted in October 2022.

Appendix A

Materials Submitted by PIEMPI in May 2022 and January 2023

PHILIPPINE INSTITUTE OF ENERGY MANAGEMENT PROFESSIONALS INC.

PIEMPI

14 May 2022

Project: Energy consumption survey of Industrial factories in the Philippines

Initial Status Report

Deployment:

1. Deployment of emails from PIEMPI started on May 2 after receiving the list of 100 companies (1st priority) and 85 companies (2nd priority) from DOE.
2. Statistics below is the result after 2 weeks of deployment (May 2 – 13, 2022)
3. Five Enumerators/EnMS Consultants handled 20 companies each.
4. Industrial sub-sectors were classified into:
   - Cement
   - Sugar
   - Food manufacturing
   - Beverage manufacturing
5. Anticipating confidentiality issues, PIEMPI sent out to all companies a Confidentiality letter assuring them that the data from them shall be treated only for the survey.

Initial Survey Statistics:

	Total number of companies	Email bounced	No response yet	Responded but not yet submitted	Survey sheet submitted for review	Survey sheet reviewed, final
Enumerator 1	23	4	3	4	7	5
Enumerator 2	18	4	8	4	2	
Enumerator 3	19	4	8	4	2	1
Enumerator 4	20	3	10	7		
Enumerator 5	19	3	7	8	1	
Total	99	18	36	27	12	6
Percent of total		18%	36%	27%	12%	6%

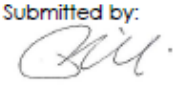
Notes to the above table:

1. There was duplication of a company in the list, the reason why the total is only 99.
2. PIEMPI shall ask for 20 companies to be replaced because of bounced email, no contact. Also, there are only 20 companies that remain in the 2nd priority list that are within the industrial sub-sector.
3. Those emailed to companies, did not bounce but no response yet, Enumerators made follow up by telephone/ mobile but cannot establish response due to:
   - No contact number in the list
   - Contact number indicated in the list cannot be reached.
   - Wrong number
   - Person is not anymore connected with the company.
4. Those companies who have responded are asking for some time to submit due to:
   - The representative needs to ask approval from their Top Management
   - One was still on vacation and shall attend to it the week after.
   - At least one company asked for a Non-disclosure agreement which PIEMPI signed even after sending to them the PIEMPI Confidentiality letter.
5. Bakery companies monitor their diesel consumption as Liters instead of Kg. We shall be using Diesel 1 liter = 0.95 Kg.

Next steps:

1. PIEMPI shall attempt to make contact with the companies with no response through the company's website or Facebook.
2. PIEMPI to coordinate with DOE for DOE to send the DOE survey letter to the additional 20 additional companies as replacement.
3. PIEMPI to continue the survey until all companies who responded have submitted the finalized survey sheet.
4. PIEMPI shall establish the sub-sector EUI's after the submission of the finalized survey sheet.

Submitted by:



Engr. Marionel Peralta
Lead Consultant and PIEMPI President


CONDUCTING ENERGY CONSUMPTION SURVEY IN INDUSTRY SECTOR, PHILIPPINES
Economic Research Institute for ASEAN and East Asia
Engr MARIONEL P PERALTA, RMEE
President - PIEMPI
Philippine Institute of Energy Management Professionals Inc
[1]

TABLE OF CONTENTS

[2]

ENERGY CONSUMPTION OF INDUSTRIAL FACTORIES IN THE PHILIPPINES
Economic Research Institute for ASEAN and East Asia

I. EXECUTIVE SUMMARY:

The Economic Research Institute for ASEAN and East Asia is an international organization based in ASEAN Secretariat Jl Sisingamangaraja 70A, South Jakarta, Indonesia established to undertake research and policy analyses of ASEAN Economic Community, promote wide economic integration and sustainable development in East Asia, and contribute to narrowing the development gaps in the region. To achieve these purposes, some of ERIA's key activities are the conduct of joint research and analysis, strategic planning, and providing tripartite forums for policymakers, researchers, and the business/civil community.

ERIA agreed to engage the services of PIEMPI for the successful completion of the Research Project by providing its best expertise, opinion(s), advice(s), time to attend meetings and/or discussions, as well as submitting reports or any other deliverable to ERIA (the "Service"). The Service was performed in accordance with the parameters agreed by both Parties.

This report contains the outcome of the survey conducted to obtain the profile of energy usage by the following manufacturing sectors:

a. Cement factory
b. Sugar factory
c. Food factory
d. Beverage factory

The focus of the study is to determine the energy use intensity (EUI) of the identified manufacturing companies, conditions influencing their energy use performance, and compare the metrics obtained with similar local and international industries. The Energy Efficiency Indicator (EEI) for Industrial Sector at Level 2 is the focal point of the study. This is the Energy Use Intensity (EUI) defined as the energy needed to produce one unit of physical output. For this survey, the 2018 and 2019 data were collected.

The computed EUI for each company per industrial sector were analyzed and outlier data were not included in the consolidated result, although they were further evaluated for possible reasons of deviation identified as follows:

- The factory has incomplete process (ex: bagging only in cement manufacture);
- Low-capacity utilization due to the pandemic that reduced demand;
- On-going construction during the year; and
- Differences in product and processes notable in the Food and Beverage sector which revealed a wide range of EUI.

For the cement industry, coal is the dominant fuel used followed by pet coke, fuel oil and solid fuel. Most of the energy is used for heating that converts raw material into cement.

In the sugar factories, bagasse is used as primary fuel to produce electricity and steam for the heating process. Two (2) sugar centrals showed high EUI, possibly due to age, an indication of low efficiency performance. Energy used in sugar centrals are shared practically in the same magnitude for heating and mechanical processes.

The beverage sector exhibited a wide range of EUI values brought about by the differences in type of product requiring varying amount of energy consumption. In terms of fuel used, most plants use diesel, coal, blended fuel for process heating. Most energy is used for heating, cooling, and mechanical processes.

In the same way, the type of product in the Food Sector influences the amount of energy consumption resulting to wide range of EUI. Most plants use diesel, coal and LPG as fuel in varying distribution percentage depending on the processing of products.

Although a varying range of EUI values were computed for each industrial sector, there are some enterprises that exhibited promising result wherein their energy consumption patterns can compete or at par with similar factories in the region.

The result of this survey will also serve as model for high energy consumers to assess their performance in order to remain competitive in their ventures.

II. BACKGROUND:

The Philippines has been marked with high economic growth in past 10 years and its energy demand also increased by more than 6% per annum, according to the GDP growth. The growth rate with biomass in 2010-2017 was 3.6% in term of TFEC (Total Final Energy Consumption) but the growth rate without biomass marked 4.5% from 2010 to 2017. The Philippines's energy outlook contained in the EAS (East Asia Summit) Energy Outlook published by ERIA (Economic Research Institute for ASEAN and East Asia), states that without any plan to control energy demand increase, TFEC without biomass in 2050 will be 3.2 times from 2017. Thus, the Philippine-Department of Energy (PDOE) established the Energy Efficiency and Conservation Act in April 2019 to implement energy efficiency and conservation activities described in the Act. Consequently, the PDOE requested ERIA to support the promotion of energy efficiency and conservation in the Philippines.

III. OBJECTIVES OF THE RESEARCH

This project is intended to support the Energy Utilization and Management Bureau (EUMB) of the PDOE to prepare energy efficiency indicators (EEI) that will focus on commercial buildings and industrial factories through capacity building of EUMB staff on the correct preparation of EEI by:

1. Conducting energy consumption survey of the industrial sector, covering:
    a. Cement factory
    b. Sugar factory
    c. Food factory
    d. Beverage factory

2. Using the data collected for the establishment Energy Efficiency Indicator (EEI) and shares of energy consumption by industrial processes.

IV. METHODOLOGY

Energy efficiency indicator (EEI) was used as a tool to monitor and evaluate the energy performance of a production process as it indicates the energy needed to produce 1 unit of production output. Hence, over time, the energy consumption trending can be charted for useful comparison within the factory. With sufficient EEI data for the industry sub sector, EEI bench-marking can be established. The energy performance of a production process can be cross-compared with the industry benchmark value of the same industry sub sector. The efforts of Energy Efficiency measures can be evaluated and quantified based on the factory's historical values of EEI.

The values of energy consumption and production output need to be in consistent units generally used by the industry.

1. PIEMPI organized the survey team for information and data gathering relevant in determining the energy use characteristic of the identified companies referred by Department of Energy.

2. The survey conducted used a questionnaire that will acquire the following information:

    Table 1: General information

    Table 2: Energy consumption data including fuels and electricity from utility and onsite generation and production output data.

    Table 3: Energy consumption breakdowns for production processes.

    Table 4: Energy consumption breakdowns for products having different measurement units.

    Contents of above Tables in Excel form shown in Appendix 5.

    The survey form was provided by ERIA.

3. Data obtained from companies/respondents and relevant information needed for analysis was computed by consultants using the forms in excel format from ERIA.

Definition of EUI: Energy Use Intensity that measures how much energy is needed to produce one unit of physical output.

EUI = Annual Total Energy Consumption / Annual Total Production Output

For this survey, the 2018 and 2019 data were collected. The values of energy consumption and production output need to be in consistent units, such as kilograms, tons, or liters for each type of industry.

Energy consumption data collected was used to compute the percentage shares of energy usage.

Understanding Energy Efficiency Indicators

Energy Data Collected:

a. Diesel for standby genset power
   Data (kg) x CV = thermal energy (MJ)
b. Fuel oil
   Data (kg or m3) x CV = thermal energy (MJ)
c. Natural gas
   Data (kg) x CV = thermal energy (MJ)
d. Fuel wood
   Data (kg or tons) x CV = thermal energy (MJ)
e. Electricity
   Data (kWh) x 3.6 MJ/kWh = thermal energy (MJ)

Fuel Calorific Value (CV) used in determining thermal energy.

Bituminous coal	- 24,618 kJ/kg
Diesel	- 42,600 kJ/kg
Fuel oil	- 42,600 kJ/kg
LPG	- 47,700 kJ/kg
Natural gas	- 36,031 kJ/kg
Fuel wood and wood waste	- 15,500 kJ/kg

where: CV = calorific value expressed in MJ / unit of fuel

Sources: Actual CV values to be obtained from fuel supply companies. APEC Energy Statistics 2018
Table of Conversion from DOE between energy types (e.g.: kWh to diesel, fuel oil, biomass)

Expected Outcome of the Survey

1. Main outcome is the establishment of EUI for:

[6]

- Sugar factories
- Cement factories
- Food factories
- Beverage factories

2. Percentage shares of energy consumption for the production processes:
    - Steam
    - Heating
    - Drying
    - Process cooling
    - Production process

3. Level 2: Sub-sector energy consumption per unit of physical output

V. DELIVERABLES

The following deliverable were documented for submission to ERIA:

1. Survey report
2. Excel file to include the consolidated survey data:
    a. Computed EUI of surveyed companies per industrial sector.
    b. Analysis of the outcome of information obtained.
3. Presentation Materials (Power Point) used at the working meetings
4. Financial report to include daily working sheet of lead consultant, support staff and enumerators, receipts of payment to enumerators.

The PIEMPI submitted consolidated reports and/or other written and electronic/non-electronic documents, in English language, to ERIA as required in the TOR and/or appendices. As provided in the agreement all reports, notes, drawings, specifications, statistics, plans, and other documents as well as data compiled or produced by the PIEMPI while performing the Service shall be the sole and exclusive property of ERIA.

VI. ANALYSIS OF DATA GATHERED

A. REPORT ON OUTCOME OF RESULTS

Initial Report on Energy Use Intensity (EUI) of the Industrial Sectors: (Cement, Sugar, Food, Beverage)

Industrial sector EUIs were analyzed according to values. Outlier data were not included in the EUI analysis, but further analyzed for possible reasons of deviation identified as follows:

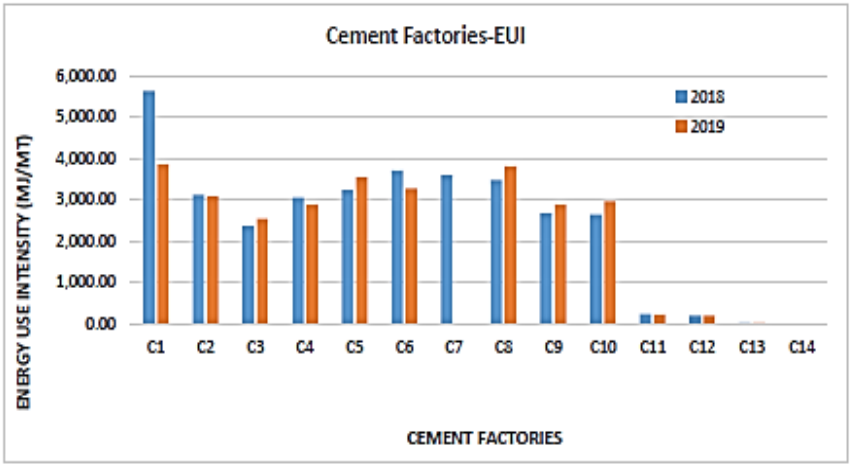
- The factory has incomplete process (ex: bagging only)
- Low-capacity utilization due to the effect of pandemic
- On-going construction during the year
- The Food and Beverage sector reveal a wide range of EUI due to differences in product and processes.

Details are found in the accompanying summary tables excel sheets (See Appendices).

B. CEMENT SECTOR

Table 1 – Range of ENERGY USE INTENSITY of CEMENT SECTOR

YEAR OF STUDY	2018	2019
AVERAGE EUI, MJ/MT	3,095	3,206
MEDIAN EUI, MJ/MT	3,118	3,075
Lowest Computed EUI, MJ/MT	2,364	2,548
Highest Computed EUI, MJ/MT	3,706	3,864



[8]

Table 2 – DISTRIBUTION of ENERGY USAGE in CEMENT SECTOR

DISTRIBUTION OF ENERGY USAGE	% of energy contribution range
Coal	89%
Fuel oil	14%
Pet coke	53%
Solid fuel	42%
Electricity	14%
Others	4% - 11%

Analysis of Energy Usage:

1. Coal is the fuel most often used in all cement factories
2. Coming in at second is pet coke, used in 6 out of 10 plants
3. The 3rd most used fuel is fuel oil and solid fuel, both utilized in 4 out of 10 plants
4. Electricity accounts for 14% or less of energy usage.

Table 3 – DISTRIBUTION of TOTAL ENERGY IN PROCESS in CEMENT SECTOR

PROCESS	% ENERGY DISTRIBUTION RANGE
Heating	82% - 97%
Mechanical process/electricity	3% - 18%

Analysis on Distribution of Total Energy:

1. Majority of energy in cement plants is used for heating (clinkering process), which converts the raw material into cement material.

   This is shown above in the Distribution of Energy in Process.

2. Electricity for mechanical processes account for as low as 3% up to 18% of the total energy used.

[9]

C. SUGAR SECTOR

Table 4 – Range of ENERGY USE INTENSITY of SUGAR SECTOR

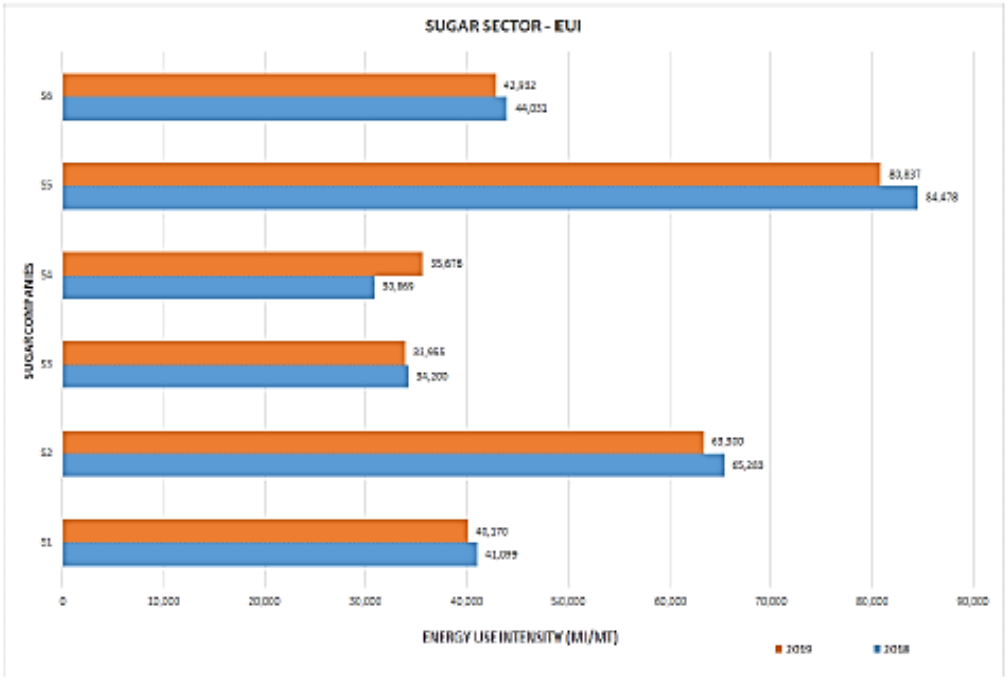
YEARS OF STUDY	2018	2019
AVERAGE EUI, MJ/MT	49,993	49,478
MEDIAN EUI, MJ/MT	42,565	41,551
Lowest Computed EUI, MJ/MT	30,869	35,676
Highest Computed EUI, MJ/MT	84,478	80,837

Two sugar centrals revealed consistently high EUIs, possibly due to the age of the factories, a common state of this sector in the Philippines.

In terms of fuel used, all factories use bagasse as fuel to produce electricity and steam for heating process.

Diesel or bunker fuel usage is very small compared to other fuels consumed.

In terms of energy used in process, all except one, reported an almost equal % of energy used in heating and mechanical process (Table 5).



[10]

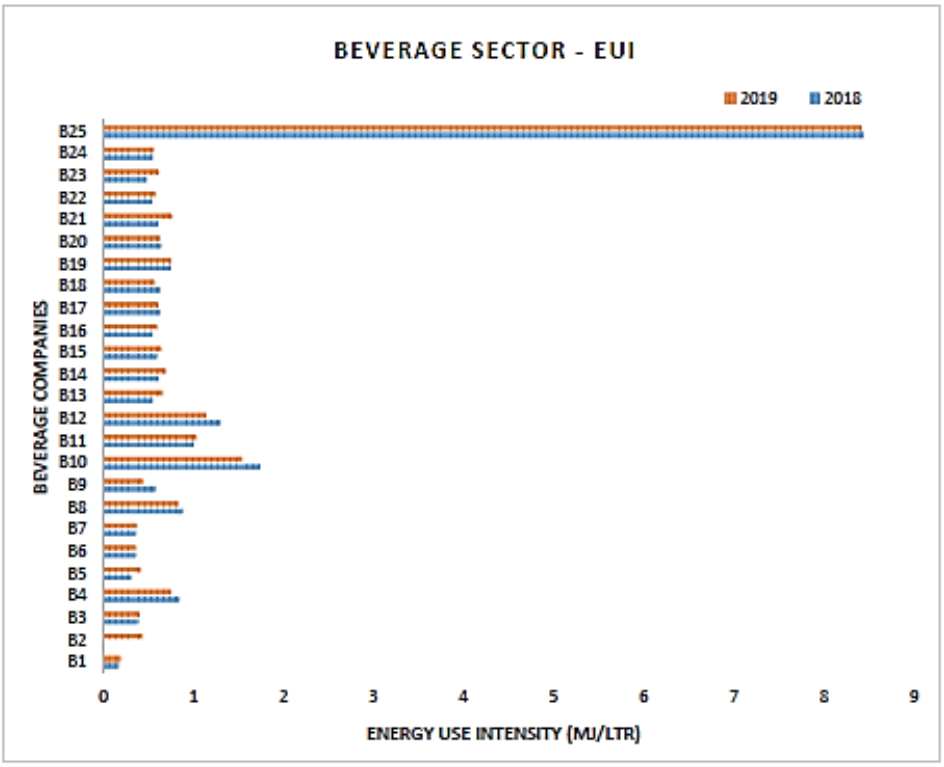
Table 5 – DISTRIBUTION of TOTAL ENERGY IN PROCESS of SUGAR SECTOR

TYPE OF PROCESS	% Range of energy use
Heating	40% - 56%
Mechanical	44% - 60%

D. BEVERAGE SECTOR

Table 6 – Range of ENERGY USE INTENSITY of BEVERAGE SECTOR

YEARS OF STUDY	2018	2019
Average EUI, MJ/liter	0.66	0.66
Median EUI, MJ/liter	0.60	0.62
Lowest Computed EUI, MJ/liter	0.18	0.2
Highest Computed EUI, MJ/liter	1.74	1.55



[11]

1. Type of product determines the range of EUI as follows:

Bottled water	0.18 - 0.44	MJ/Liter	
Softdrinks	0.49 - 0.77	MJ/Liter	
Beer	1.0 - 1.04	MJ/Liter	
Energy drink	0.84 - 1.74	MJ/Liter	
Mixed bev and food	1.15 - 1.31	MJ/Liter	This company EUI is mixed on beverage and food products
Soya based drink	8.4 - 8.42	MJ/Liter	The product entails cooking of soya beans before making the beverage drink.

2. In terms of fuel used, most plants use diesel, coal, blended fuel for process heating.
   Company B3 to B7 plants mainly use diesel fuel, while B13 to B24 plants use blended fuel (diesel and bunker).

Table 7 – DISTRIBUTION of ENERGY USAGE in BEVERAGE SECTOR

TYPE OF FUEL	% Range of energy use
Electricity	25 - 85
Fuel	15 - 75

3. In terms of process, most energy is used for heating, cooling and mechanical processes.

Table 8 – DISTRIBUTION of TOTAL ENERGY in PROCESS of BEVERAGE SECTOR

TYPE OF PROCESS	% Range of energy use
Heating	15 - 74
Cooling/Mechanical	26 - 85

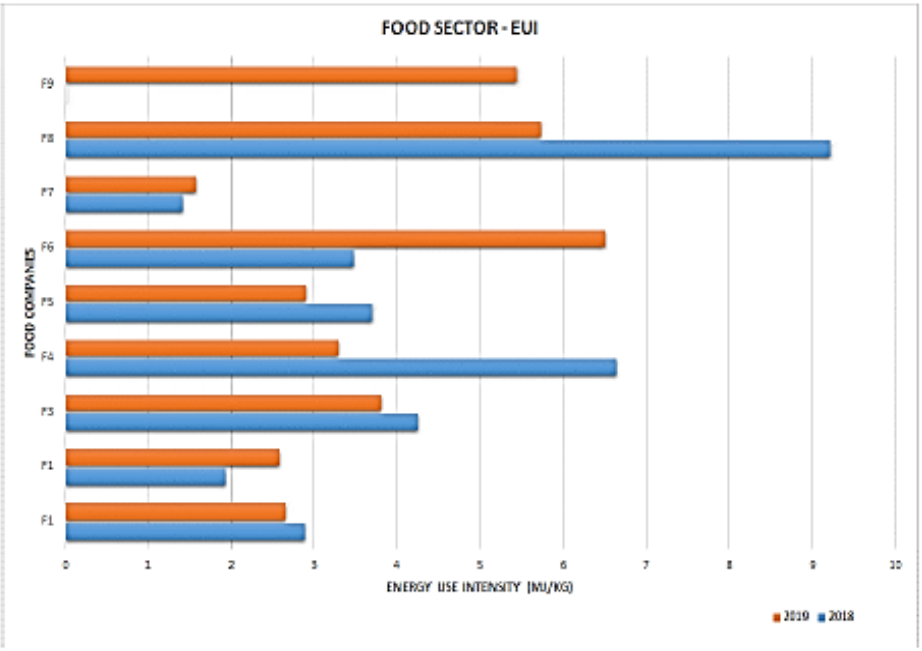
E. FOOD SECTOR

Table 9 – Range of ENERGY USE INTENSITY of FOOD SECTOR

YEARS OF STUDY	2018	2019
Average EUI, MJ/kg	2.94	3.50
Median EUI, MJ/kg	3.18	3.10
Range EUI lowest, MJ/kg	1.42	1.58
Range EUI highest, MJ/kg	4.25	5.74

1. The type of product determines the range of EUI as follows:

Food snack(chips)	1.42 - 1.58	MJ/kg	
Bakery products	1.94 - 4.25	MJ/kg	
Varied Products	5.44 - 5.74	MJ/kg	Plants producing a variety of products.



2. In terms of fuel used, most plants use diesel, coal and LPG.

Table 10 – DISTRIBUTION of ENERGY USAGE in FOOD SECTOR

TYPE OF FUEL	% Range of energy use
Electricity	20 – 72
Fuel	28 – 80

3. In terms of process, most energy is used for heating and mechanical processes.

[13]

Table 11 – DISTRIBUTION of TOTAL ENERGY in PROCESS of FOOD SECTOR

TYPE OF PROCESS	% Range of energy use
Heating	27 – 81
Mechanical	19 – 73

VII. CHALLENGES ENCOUNTERED

1. PIEMPI encountered Indifference of targeted respondent companies. Complete with a formal letter from the Phil. Dept. of Energy, a lot of respondent companies ignored PIEMPI's efforts of establishing connection by not replying to emails, answering calls or blocking off emails. This created so much delay in completing the survey project.

   For the companies who submitted the survey sheet, some company data were unclear and cannot be reconciled. PIEMPI efforts to further clarify the data submitted encountered no response.

   PIEMPI surveyed a total of 185 companies in 3 batches to be able to complete the survey project. Thanks to the assistance of the Phil. Dept of Energy and the openness of ERIA to encountered problems that this project was finalized.

2. Some survey data submitted were unreliable that they cannot be used for computation and analysis of their energy use performance. Some data or information are erroneous, incomplete or inconsistent with what is expected with the respondents' nature of operation.

3. Not all companies in the cement sector have the complete process of producing cement from clinkering to finished cement. A few companies undertake only a stage/s of the process which hinders our effort of reconciling the data / information obtained.

4. The absence of compelling reason for respondent companies to provide information also deterred our effort to collect needed data. We can only request or try to explore influencing methods or factors to convince them to submit, but nevertheless rejection citing data privacy issues in some cases prevented enumerators from pursuing the leads.

The historical summary of responses obtained from respondents and accumulated information is presented in the table below. The initial list of companies contacted is

shown in Appendix 10 and the final listing of companies with valid data included in this report is shown in Appendices 1 to 4.

HISTORICAL SUMMARY OF DATA COLLECTION

SECTOR	TARGET NUMBER	COLLECTED DATA	COMPLETED DATA
CEMENT	15	15	14
SUGAR	10	7	6
FOOD	35	16	9
BEVERAGES	40	29	25
OTHERS		2	
TOTALS	100	69	54

ACTIVITY	NUMBER
Companies assigned and contacted by enumerators	185
Total Companies submitted data within the sectors	54
Submitted data excluded from source outside sectors	7
Submitted data excluded from analysis	8

NOTE: *Valid data from seven (7) respondents (Appendix 5) were obtained but they were not used in the study since their respective companies did not fall within the identified sectors. Data submitted by eight (8) companies were also excluded by reason of deficient information that will allow logical analysis.*

VIII. SUMMARY and RECOMMENDATIONS

1. A separate analysis provided by Mr. Leong of ERIA shows R-chart analysis for each of the industrial sector with data values within the acceptable range. (See Appendix 6).

2. As shared by Mr. Leong of ERIA in the presentation on "Energy Consumption Survey and EEI Preparation for Industrial Sector", the Indonesian average for the sugar sector EUI = 36,500 MJ/MT. The Philippine sugar companies come closely to this level. Based on the results of the survey, the Dept. of Energy may establish a Minimum Energy Performance (MEP) level for this industrial sector.

3. Again, as shared by Mr. Leong of ERIA, the international average for the cement sector EUI = 3,300 to 4,000 MJ/MT. Two of the Philippine cement companies EUI are within this range, while others are above the international average possibly due to the age of the factories which were established so many years ago. The Dept. of Energy may also establish an MEP for this sector to encourage the companies above the MEP to come up with programs to reduce their EUI.

4. The Food Sector in the Philippines reveal a wide range of EUI due to the variations of their processes and products produced (different snacks and bakery products, etc.). It will be difficult to establish an MEP for the Food sector based on the results of the survey. It is possible to set an MEP per sub sector (bakery companies, snack food companies, etc.) but more industry data need to be established. In the meantime, we recommend setting a target of % EUI reduction over 5 years.

5. Like the Food sector in the Philippines, the Beverage sector reveals a wide range of EUI due to variations of processes and products (mineral water, soft drinks, soya drinks, etc). It will be difficult to establish an MEP for the beverage sector based on the survey. It is also possible to set an MEP per sub sector (mineral water companies, soft drink companies, etc.) but more industry data must be established. In the meantime, we recommend setting a target of % EUI reduction over 5 years.

6. For a better representation of energy consumption of identified sectors, the measurement of EUI must be reckoned also based on the nature of product or processes.

7. Based on PIEMPI's experience in assisting companies establish an Energy Management System based on ISO 50001, it may be possible to set a target energy consumption reduction over 5 years as in the following example:

First year	3% energy consumption reduction from previous year
Second year	2% energy consumption reduction from previous year
Third year	1% energy consumption reduction from previous year
Fourth year	1% energy consumption reduction from previous year
Fifth year	1% energy consumption reduction from previous year

Total over 5 years = 8% energy consumption reduction from baseline year.

Appendix 1 – CONSOLIDATED ANALYSIS of the CEMENT

No.	Company Name	Energy Use Intensity		Conversion	Unit of Production	Main Products	Type of fuel Used aside from	Distribution of Energy Usage		Distrbution of Total Energy in Process		Category of production process	Remarks
		2018	2019					2018	2019	2018	2019		
1	C1	5,622.98	3,863.81	MJ/MT	MT	Portland Cement	Fuel Oil, Diesel, Coal, Rice Husk, Petcoke, 0ther solid fuels	Other Solid fuels: 41.91% Petcoke: 28.97% Coal: 18.94% Electricity: 5.63% Rice Husk: 4.27% Fuel Oil: 0.28%	Petcoke: 41.23% Coal: 31.05% Rice Hustlk: 10.45% Electricity: 8.53% Other Solid Fuels: 8.39% Fuel Oil: 0.35%	Heating: 96.71% Mechanical Process : 3.24% (Finishing Mill) Mechanical Process: 0.05% (Packing/Dispatching)	Heating: 96.91% Mechanical Process: 5.02% (Finishing Mill) Mechanical Process: 0.07% (Packing/Dispatching)	Heating	PROCESS: a) Clinkerization b) Finish Mill c) Dispatch
2	C2	3,117.52	3,075.04	MJ/MT	MT	Portland Cement	Diesel Oil, Coal	Coal: 88.73% Electricity: 11.16% Diesel Oil: 0.10%	Coal: 99.79% Diesel Oil: 0.20% Electricity: 0.01%	NOTE: Reported total energy usage only.	NOTE: Reported total energy usage only.	Heating (Clinkerization)	PROCESS: a) Raw material preparation b) Raw mill preparation c) Clinkerization d) Finish Mill
3	C3	2,364.59	2,548.36	MJ/MT	MT	General Purpose Cement	Fuel Oil, Waste Oil, Coal, Rice Husk, Petcoke, Other Solid Fuels	Petcoke: 53.35% Coal: 28.39% Electricity: 13.79% Rice Husk: 2.01% Other Solid Fuels: 1.82% Fuel Oil: 0.59% Waste Oil: 0.05%	Petcoke: 50.78% Coal: 30.47% Electricity: 14.23% Other Solid Fuels: 1.96% Rice Husk: 1.59% Fuel Oil: 0.96%	Heating: 91.26% Mechanical Process: 8.15% (Cement Production) Mechanical Process: 0.59% (Packing/Dispatching)	Heating: 91.46% Mechanical Process: 7.92% (Cement Production) Mechanical Process: 0.62% (Packing/Dispatching)	Heating (Clinkerization)	PROCESS: a) Raw material preparation b) Raw mill preparation c) Clinkerization d) Finish Mill
4	C4	3,048.44	2,889.80	MJ/MT	MT	General Purpose Cement	Fuel Oil, Diesel, Coal, Rice Husk, Petcoke, other solid fuels	Coal: 43.77% Petcoke: 41.97% Electricity: 8.55% Other Solid Fuels: 2.23% Fuel Oil: 1.65% Rice Husk: 1.34% Diesel Oil: 0.49%	Coal: 49.24% Petcoke: 33.05% Electricity: 9.18% Other Solid Fuels: 6.12% Fuel Oil: 1.07% Diesel Oil: 0.78% Rice Husk: 0.56%	Heating: 95.46% (Clinker Production) Mechanical Process: 4.26% (Finishing Mill) Mechanical Process: 0.28% (Packing/Dispatching)	Heating: 94.75% (Clinker Production) Mechanical Process: 4.94% (Finishing Mill) Mechanical Process: 0.30% (Packing/Dispatching)	Heating (Clinkerization)	PROCESS: a) Raw material preparation b) Raw mill preparation c) Clinkerization d) Finish Mill
5	C5	3,231.42	3,542.92	MJ/MT	MT	Cement	Diesel, Fuel Oil, Coal, Rice Husk, AFR, Petcoke	Coal: 80.68% Electricity: 9.64% AFR: 4.26% Petcoke: 3.56% Fuel oil: 1.85%	Coal: 81.23% Electricity: 8.62% Petcoke: 4.78% AFR: 4.02% Diesel: 0.89% Fuel oil: 0.41% Rice Husk: 0.04%	Heating: Fuel 90.36% Others: Mechanical Processes 9.64%	Heating: Fuel 90.48% Others: Mechanical Processes 9.52%	Crusher, Raw Mill, Kiln, Cement Mill, Dispatch	No report for 2019. Year 2020 was taken instead. Diesel used in cement mill not kiln.
6	C6	3,706.85	3,271.71	MJ/MT	MT	Cement	Diesel, Fuel Oil, Used Oil, Coal, Rice Husk, AFR, Petcoke	Coal: 78.99% AFR: 8.24% Electricity: 7.67% Rice husk: 2.56% Petcoke: 2.40% Diesel oil: 0.06% Fuel oil: 0.06% Waste oil: 0.06%	Coal: 70.80% AFR: 8.66% Petcoke: 8.64% Electricity 8.14% Rice husk: 3.62% Fuel oil: 0.08% Waste oil: 0.06%	Heating: Fuel 92.33% Others: Mechanical Processes 7.67%	Heating: Fuel 91.86% Others: Mechanical Processes 8.14%	Crusher, Raw Mill, Kiln, Cement Mill, Dispatch	Process starts at kiln - calcining up to dispatch.
7	C7	3,593	NO OPN	MJ / MT	MT	Cement	Sub-bitumin Coal B F O Waste Oil Other Solid Fuel	Sub-bituminous Coal: 79.09% Electric: 11.23% B F O: 1.88% Waste Oil: 0.01% Other Solid: 7.79%	NO OPERATION	Heating: 88.77% Others: Mechanical Process 11.23%	NO OPERATION	Heating	All fuel are consumed for heating operation. Other aspects of manufacture use electrical power from external source.

Appendix 1 [Continuation] – CONSOLIDATED ANALYSIS of the CEMENT

No.	Company Name	Energy Use Intensity		Conversion	Unit of Production	Main Products	Type of fuel Used aside from	Distribution of Energy Usage		Distrbution of Total Energy in Process		Category of production process	Remarks
		2018	2019					2018	2019	2018	2019		
8	C8	3,479.18	3,809.95	MJ/MT	MT	Portland & Blended Cement	Fuel Oil, Coal, Rice Husk, Petcoke, AFR	Coal: 64.37% Rice husk: 11.29% AFR: 10.45% Electricity: 9.70% Petcoke: 3.09% Fuel oil: 1.10%	Coal: 62.68% Petcoke: 12.42% Rice husk: 8.65% Electricity: 8.95% AFR: 6.09% Fuel oil: 1.20%	Heating: Fuel 90.30% Others: Mechanical Processes 9.70%	Heating: Fuel 91.05% Others: Mechanical Processes 8.95%	Crusher, Raw Mill, Kiln, Cement Mill, Dispatch	All fuel fed to kiln.
9	C9	2,664	2,884	MJ / MT	MT	Cement	Coal Fuel Oil RDF Alt Fuel	Coal: 78.22% Fuel Oil: 13.8% Electric: 5.8% Alt Fuel: 1.40% RDF: 0.78%	Coal: 84.92% Electric: 10.84% Fuel Oil: 2.98% RDF: 1.19% Alt Fuel: 0.07%	Heating (Clinker): 81.89% Heating (Finish): 0.52% Mechanical Process: 17.59%	Heating (Clinker): 88.42% Heating (Finish): 0.28% Mechanical Process: 11.3%	Heating; Milling; Electricity Generation	Uses fuel-fired genset to produce electricity. Purchased additional electricity requirement from local source.
10	C10	2,648	2,964	MJ / MT	MT	Cement	Coal Fuel Oil RDF Alt Fuel	Coal: 71.77% Electric: 12.88% RDF: 7.7 % Fuel Oil: 4.92% Alt Fuel: 2.73%	Coal: 74.06% Electric: 13.62% RDF: 9.23% Alt Fuel: 1.63% Fuel Oil: 1.46%	Heating: 83.7% Mechanical Processes: 16.3%	Heating: 85.79% Mechanical Process: 14.21%	Heating; Electricity Generation	Uses fuel-fired genset to produce electricity. Auxiliaries refer to other machineries supporting manufacture.
11	C11	238	228	MJ/MT	MT	Cement	Diesel, Fuel oil	65% - Electricty 31% - Diesel 4% - Fuel Oil	63% - Electricty 37% - Diesel 0% - Fuel Oil	Drying - 35% Mechanical Process - 65%	Drying - 37% Mechanical Process - 63%	Drying	Finishing plant only
12	C12	195.76	194.87	MJ/MT	MT	Cement	Diesel	Diesel 16.64%, Electricity 83.36%	Diesel 23.15%, Electricity76.85%	Mechaniccal Processes - 100%	Mechaniccal Processes - 100%	MILLING	GRINDING ONLY, diesel used for standby generator
13	C13	20.97	25.04	MJ/MT	MT	Finished Cement coming from other HOLCIM Plants is put into bag / packages	NONE	Electricity - 100%	Electricity - 100%	Electricity - 100% (Packing/Dispatching)	Electricity -100% (Packing/Dispatching)	Packaging of Finshed Cement	PROCESS: Finished cement from other Cement Plants are put into bag and packages
14	C14	0.031	0.043	MJ/PC	PCS	Cement Bags	NONE	Electricity 100%	Electricity 100%	Mechanical Process: Electricity 100%	Mechanical Process: Electricity 100%	SEWING	BAG MAKING ONLY

Appendix 2 – CONSOLIDATED ANALYSIS of the SUGAR

No.	Company Name	Energy Use		Conversion	Unit of Production	Main Products	Type of fuel Used aside from	Distribution of Energy Usage		Distribution of total energy in process		Remarks
		2018	2019					2018	2019	2018	2019	
1	S1	41,099	40,170	MJ / MT	LKG	Raw Sugar	Bagasse Diesel	Bagasee: 99.91% Electricity: 0.09	Bagasee: 99.89% Electricity: 0.11	Heating: 56% Mechanical Process: 44%	Heating: 56% Mechanical Process: 44%	Steam used to generate electricity and process.
2	S2	65,283	63,300	MJ / MT	MT	Raw Sugar	Diesel. Bagasse, Wood Chips	Bagasse: 99.8% Diesel: 0.2%	Bagasse: 99.7% Diesel: 0.3%	Heating: 48% Mechanical Process: 52%	Heating: 44% Mechanical Process: 56%	Bagasse and diesel used to generate electricity. Purchased electricity used in office and auxilliary services.
3	S3	34,200	33,955	MJ/MT	LKG	Raw Sugar	Diesel, Bagasse	Baggase: 100%	Baggase: 100%	Heating: 52% Mechanical Process: 48%	Heating: 40% Mechanical Process: 60%	No metering for other areas. Electricity is sourced from bagasse.
4	S4	30,869	35,676	MJ/MT	LKG	Raw Sugar	Bagasse	Baggase: 100%	Baggase: 100%	Heating: 55% Mechanical Process: 45%	Heating: 50% Mechanical Process: 50%	
5	S5	84,478	80,837	MJ / MT	MT	Raw Sugar Special Raw Sugar Muscovado Sugar	Diesel, Bagasse	Baggase: 100%	Baggase: 100%	Plant only has main metering. No breakdown of energy in processes.	Plant only has main metering. No breakdown of energy in processes.	Steam Generation and Heating
6	S6	44,031	42,932	MJ/MT	LKG	Raw Sugar Refined Sugar	Diesel, Fuel Oil (bunker) Bagasse	Electricity: 3.99% Baggase: 96.01	Electricity: 3.81% Baggase: 96.19	Heating: 96.19% Mechanical Processes: 3.81%	Heating: 96.19% Mechanical Process: 3.81%	

Appendix 3 – CONSOLIDATED ANALYSIS of the FOOD SECTOR

No.	Company Name	Energy Use		Conversion	Unit of Production	Main Products	Type of fuel Used aside from	Distribution of Energy Usage		Distribution of total energy in process		Remarks
		2018	2019					2018	2019	2018	2019	
1	S1	41,099	40,170	MJ / MT	LKG	Raw Sugar	Bagasse Diesel	Bagasee: 99.91% Electricity: 0.09	Bagasee: 99.89% Electricity: 0.11	Heating: 56% Mechanical Process: 44%	Heating: 56% Mechanical Process: 44%	Steam used to generate electricity and process.
2	S2	65,283	63,300	MJ / MT	MT	Raw Sugar	Diesel. Bagasse, Wood Chips	Bagasse: 99.8% Diesel: 0.2%	Bagasse: 99.7% Diesel: 0.3%	Heating: 48% Mechanical Process: 52%	Heating: 44% Mechanical Process: 56%	Bagasse and diesel used to generate electricity. Purchased electricity used in office and auxilliary services.
3	S3	34,200	33,955	MJ/MT	LKG	Raw Sugar	Diesel, Bagasse	Baggase: 100%	Baggase: 100%	Heating: 52% Mechanical Process: 48%	Heating: 40% Mechanical Process: 60%	No metering for other areas. Electricity is sourced from bagasse.
4	S4	30,869	35,676	MJ/MT	LKG	Raw Sugar	Bagasse	Baggase: 100%	Baggase: 100%	Heating: 55% Mechanical Process: 45%	Heating: 50% Mechanical Process: 50%	
5	S5	84,478	80,837	MJ / MT	MT	Raw Sugar Special Raw Sugar Muscovado Sugar	Diesel, Bagasse	Baggase: 100%	Baggase: 100%	Plant only has main metering. No breakdown of energy in processes.	Plant only has main metering. No breakdown of energy in processes.	Steam Generation and Heating
6	S6	44,031	42,932	MJ/MT	LKG	Raw Sugar Refined Sugar	Diesel, Fuel Oil (bunker) Bagasse	Electricity: 3.99% Baggase: 96.01	Electricity: 3.81% Baggase: 96.19	Heating: 96.19% Mechanical Processes: 3.81%	Heating: 96.19% Mechanical Process: 3.81%	

Appendix 4 – CONSOLIDATED ANALAYSIS of the BEVERAGE

No.	Company Name	Energy Use		Unit of Measure	Main Products	Unit of Production	Distribution of Energy Usage		Distribution of total energy in		Remarks
		2018	2019				2018	2019	2018	2019	
1	B1	0.18	0.2	MJ/liter	Bottled Water	liter	Electricity: 85% LPG: 15%	Electricity: 84% LPG: 16%	Mechanical Process: 85% Heating: 15%	Mechanical Process: 84.6% Heating: 16.4%	
2	B2	**NO OPN**	0.44	MJ/liter	Bottled Water)	liter	**NO OPERATION**	Electricity: 56% Bituminous Coal: 39% Fuel Oil: 5%	**NO OPERATION**	Heating: 77.8% Mechanical Process: 27.8%	No data for 2018 due to non operation
3	B3	0.39	0.4	MJ/liter	Carbonated non-alcoholic drinks. Flavored products of Coke, Royal, and Sprite. Packaging sizes are 237ml, 355ml, and 750ml.	liter	Diesel: 54% Electricity: 46%	Diesel: 52% Electricity: 48%	Heating: 54.4% Cooling Process: 45.6%	Heating: 51.7% Cooling Process: 48.3%	
4	B4	0.85	0.76	MJ/liter	Carbonated beverages	liter	Rice hull: 98% Fuel Oil: 2%	Rice hull: 94% Fuel Oil: 6%	Steam: 100% For electricty and process heating.	Steam: 100% For electricty and process heating.	EUI is higher compared to other coca-cola plants due to electricity generation using rice hull as fuel.
5	B5	0.32	0.42	MJ/liter	Carbonated Drinks and Distilled Water	liter	Diesel: 50% Electricity: 50%	Diesel: 51% Electricity: 49%	Heating: 50% Cooling Process: 50%	Heating: 51% Cooling Process: 49%	
6	B6	0.37	0.37	MJ/liter	Non-alcoholic Beverages(softdrinks)	liter	Diesel: 52% Electricity: 48%	Diesel: 53% Electricity: 47%	Heating: 51.6% Mechanical Process: 48.4%	Heating: 53.4% Mechanical Process: 46.6%	
7	B7	0.37	0.38	MJ/liter	Carbonated Softdrinks	liter	Electricity: 56% Diesel: 44%	Electricity: 50% Diesel: 50%	Cooling Process: 55.8% Heating: 44.2%	Cooling Process: 50.4% Heating: 49.9%	

Appendix 4 [Continuation] – CONSOLIDATED ANALAYSIS of the BEVERAGE

No.	Company Name	Energy Use		Unit of Measure	Main Products	Unit of Production	Distribution of Energy Usage		Distribution of total energy in		Remarks
		2018	2019				2018	2019	2018	2019	
8	B8	0.89	0.84	MJ/liter	Energy drink	liter	Coal: 67% Electricity: 32% Fuel Oil: 1%	Coal: 64% Electricity: 34% Fuel Oil: 2%	Heating: 67.8% Cooling Process: 32.2%	Heating: 65.5% Cooling Process: 33.5%	
9	B9	0.59	0.45	MJ/liter	Carbonated drinks	liter	Electricity: 100%	Electricity: 100%	Process Cooling: 100%	Process Cooling: 100%	This plant uses electricity only for process cooling
10	B10	1.74	1.55	MJ/liter	Cobra Energy Drink	liter	Coal: 61% Electricty: 16% Diesel: 15% Bunker Oil: 8%	Coal: 70% Electricty: 16% Diesel: 12% Bunker Oil: 2%	Heating: 68.9% Mechanical Process: 31.1%	Heating: 71.5% Mechanical Process: 28.5%	Steam generation for Heating, Process cooling, Water treatment, Low Pressure Compressed Air, Bottling Line, Waste water treatment
11	B11	1.00	1.04	MJ/liter	Beer Beverages	liter	Bunker Fuel Oil: 74% Electricity: 26%	Bunker Fuel Oil: 75% Electricity: 25%	Heating: 74.4% Process Cooling: 25.6%	Heating: 74.6% Process Cooling: 25.4%	
12	B12	1.31	1.15	MJ/liter	beverages and canned & packaged food)	liter	Diesel: 72% Electricity: 28%	Diesel: 72% Electricity: 28%	Heating: 72% Mechanical Process: 28%	Heating: 71.8% Mechanical Process: 28.2%	
13	B13	0.56	0.66	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 68% Electricity: 24% Diesel: 8%	Blended fuel : 59% Electricity: 36% Diesel: 4% LPG: 1%	Heating: 68% Process cooling: 32%	Heating: 60% Process cooling: 40%	Steam is used for heating, LPG is used to pre-heat/start-up the boiler.
14	B14	0.62	0.70	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 62% Electricity: 38%	Blended Fuel: 65% Electricity: 34% Diesel: 1%	Heating: 61% Process cooling: 39%	Heating: 65% Process cooling: 35%	Steam is used for heating,

Appendix 4 [Continuation] – CONSOLIDATED ANALAYSIS of the BEVERAGE

No.	Company Name	Energy Use		Unit of Measure	Main Products	Unit of Production	Distribution of Energy Usage		Distribution of total energy in		Remarks
		2018	2019				2018	2019	2018	2019	
15	B15	0.60	0.65	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 69% Electricity: 30% Diesel: 1%	Blended fuel: 72% Electricity: 28%	Heating: 70% Process cooling: 30%	Heating: 72% Process cooling: 28%	Steam is used for heating, LPG is used to pre-heat/start-up the boiler.
16	B16	0.55	0.60	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 66% Electricity: 34%	Blended fuel: 69% Electricity: 31%	Heating: 66% Process cooling: 34%	Heating: 69% Process cooling: 31%	Steam is used for heating
17	B17	0.64	0.61	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 62% Electricity: 36%	Blended fuel: 58% Electricity: 40% Diesel: 2%	Heating: 62% Process Cooling: 38%	Heating: 58% Process cooling: 42%	Steam is used for heating. LPG is used to pre-heat/start-up the boiler.
18	B18	0.64	0.58	MJ/liter	Beverage (Softdrinks)	liter	Purchased steam: 60% Electricity: 26% Blended fuel: 13% Diesel: 1%	Purchased steam: 65% Electricity: 25% Blended fuel: 9.8% Diesel: 0.2%	Heating: 74% Process Cooling: 26%	Heating: 75% Process Cooling: 25%	Steam is used for heating, LPG is used to pre-heat/start-up the boiler.
19	B19	0.75	0.76	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 67% Electricity: 32% Diesel: 1%	Blended fuel: 67% Electricity: 31% Diesel: 2%	Heating: 67% Process cooling: 33%	Heating: 67% Process cooling: 33%	Steam is used for heating,
20	B20	0.65	0.64	MJ/liter	Beverage (Softdrinks)	liter	Purchased steam: 47% Blended fuel: 25% Electricity: 25% Diesel: 3%	Blended fuel: 56% Electricity: 26% Purchased steam: 17% Diesel: 1%	Heating: 73% Process cooling: 27%	Heating: 73% Process cooling: 27%	Steam is used for heating,
21	B21	0.61	0.77	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 65% Electricity: 33% Diesel: 2%	Blended fuel: 62% Electricity: 38%	Heating: 65% Process cooling: 35%	Heating: 62% Process cooling: 38%	In 2019, the plant did not use diesel and LPG.

Appendix 4 [Continuation] – CONSOLIDATED ANALAYSIS of the BEVERAGE

No.	Company Name	Energy Use		Unit of Measure	Main Products	Unit of Production	Distribution of Energy Usage		Distribution of total energy in		Remarks
		2018	2019				2018	2019	2018	2019	
22	B22	0.54	0.59	MJ/liter	Beverage (Softdrinks)	liter	Electricity: 52% Blended fuel: 48%	Electricity: 58% Blended fuel: 42%	Process cooling: 52% Heating: 48%	Heating: 58% Process cooling: 42%	Steam is used for heating
23	B23	0.49	0.62	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 62% Electricity: 29% Diesel: 9%	Blended fuel: 63% Electricity: 34% Diesel: 3%	Heating: 62% Process cooling: 38%	Heating: 63% Process cooling: 37%	Steam is used for heating. LPG is used to pre-heat/start-up the boiler
24	B24	0.56	0.57	MJ/liter	Beverage (Softdrinks)	liter	Blended fuel: 57% Electricity: 34% Diesel: 9%	Blended fuel: 52% Electricity: 27% Diesel: 21%	Heating: 57% Process cooling: 43%	Heating: 52% Process cooling: 48%	Steam is used for heating
25	B25	8.44	8.42	MJ/liter	Soy-based Beverage (Vitamilk)	liter	Bituminous coal: 80% Electricity: 20%	Bituminous coal: 83% Electricity: 17%	Heating: 40.9% Cooling Process: 59.1%	Heating: 47% Cooling Process: 53%	

[vi]

Appendix 5 – OUTSIDE SECTOR

No.	Company Name	Energy Use Intensity		Unit of Measure	Main Products	Unit of Production Output	Distribution of Energy Usage		Distribution of total energy in process		Remarks
		2018	2019				2018	2019	2018	2019	
1	OS1	15.96	15.88	Caps or Kg	Metal Closure: Twist-Off Caps and PT Caps	Kg					No data submitted.
2	OS2	98,240	68,312	MJ/Kg	Sugar	Kg	Bagasse: 79% Bunker: 13% Wood: 8%	Bagasse: 76% Wood: 16% Bunker: 8%	**NO DATA**	**NO DATA**	Steam for Heating and Power Generation.
3	OS3	356.76	358	MJ/MT	Cement	MT	Electricity: 98% Diesel: 2%	Electricity: 95% Diesel: 5%	**NO DATA**	**NO DATA**	
4	OS4	30,796	25,660	MJ/MT	Ethanol and Alcohol	MT	Coal: 81.57% Spentwash: 16.09 Diesel: 2.33%	Coal: 77.40% Spentwash: 22.41 Diesel: 1.81%	Steam: 97.67% Electricity Generation: 2.24 Others: 0.10	Steam: 99.89% Electricity Generation: 1.69% Others: 0.11	
5	OS5	51	42	MJ/MT	Cooking Oil	MT	NO INFO AVAILABLE	NO INFO AVAILABLE	NO INFO AVAILABLE	NO INFO AVAILABLE	
6	OS6	3,758,222	6,753,451	MJ/MT	Baked Food	MT	Electricity: 70.84% LPG: 29.16%	Electricity: 69.70% LPG: 30.3%	**NO DATA**	**NO DATA**	
7	OS7	**No Data**	14,665,805	MJ/MT	**Bread and Pastries**	MT	Electricity: 71.68% Diesel: 28.32%	Electricity: 72.26% Diesel: 27.74%	Production: 100%	Production: 100%	

A C K N O W L E D G E M E N T S

On behalf of the **PHILIPPINE INSTITUTE of ENERGY MANAGEMENT PROFESSIONALS INC.**, we would like to express our gratitude to all who have entrusted to us the implementation of this project. Thank you very much for your guidance and support in assisting PIEMPI :

1. Mr. Shigeru Kimura, ERIA Special Advisor to the President on Energy Affairs
2. Ir Leong Siew Meng of ERIA
3. Director Patrick Aquino, Phil. Dept. of Energy
4. Asst. Director Art Habitan, Phil. Dept. of Energy
5. Jim Balunday, OIC, EPMPD, Phil. Dept. of Energy

and to all companies and their representative who unselfishly shared and provided the information that made this project a reality.

MARIONEL P. PERALTA
President - PIEMPI

E N D O F R E P O R T

Appendix B

Materials Submitted by the MPA in May 2022 and January 2023

MPA Report submitted in May 2022

MERALCO POWER Academy

May 10, 2022

ERIA Economic Research Institute for ASEAN and East Asia

REPORT NO. 1

Energy Consumption Survey of Commercial Buildings in Manila

In support of Meralco Power Academy to Philippine Department of Energy (DOE) and Energy Research Institute for ASEAN and East Asia (ERIA) in their objective to have have a better understanding and appreciation of the current energy efficiency performance situation, gaps and challenges, and energy performance baseline as input or reference to the establishment of the performance standards and energy efficiency indicators for commercial buildings defined as Energy Use Intensity or Building Energy Intensity, MPA is pleased to present the progress and partial results of the activities related to the conduct of energy survey of commercial buildings in Metro Manila.

MERALCO POWER Academy

INITIAL COORDINATION REPORT

A. CONTACT

- Number of companies in the DOE list received April 19, 2022: 100
- Number of companies contacted by MPA: 100 (100%)
  - Follow-up emails were sent to all 100 companies on April 21, 2022
- Amended List with contact numbers and additional 100 companies was received on April 22, 2022
- Additional companies invited to replace erroneous entries : 32

B. METHOD OF CONTACT (MPA) as of May 6

- Email: 132 / 100 (32% over the target)
  - Successfully sent: originally planned for 100 respondents (100%)
    - Responded: 79
    - No response yet: 22
    - Calls made Telephone/Mobile Phone: 32
    - Additional emails to contact after first email: 16

C. REPLACEMENTS

The list below are the companies that were included in the original DOE List but were replaced by MPA due to several reasons

Companies Removed from Original List	Reason for Replacement
1. PPC ONE ESTATE CORPORATION / THE UPPER CLASS 2. VFC Land Resources, Inc – Puregold Paso de Blas 3. MJ Corporate Plaza 4. CTP R.E.D. 1 CORP.	Emails Bounced
1. The Brilliance Center 2. Circuit Makati Hotel Ventures, Inc. 3. Kroma Tower 4. THE JMT CONDOMINIUM CORPORATION 5. HSBC Centre 6. One Corporate Plaza Condominium Corporation 7. PNB Julia Vargas Building 8. BG North Properties - AVIDA One Park Drive 9. CW Marketing and Development Corp. 10. One Park Drive 11. RJM Merchandise Link, Inc 12. Bonifacio One Technology Tower	No Response

1. Cloverleaf Mall (North Eastern Commercial Corp.) 2. Alveo Corporate Center 3. Makati Stock Exchange Building 4. UP North Property Holdings Inc PM2 5. UP North Property Holdings Inc. 6. UP North Property Holdings Inc. PM1 7. Glorietta 5 BPO 8. Glorietta Corporate Center 1 9. Glorietta Corporate Center 2 10. MDC Corporate Center 11. AERIT INC./Solaris One	Double Entry
1. Vertis North Estate 2. Makati Central Estate Association, Inc. 3. Circuit Makati Estate 4. Ayala Center Estate Association, Inc.	Not considered as buildings
1. World Commerce Place Building Administration, Inc.	Building under construction

D. COMPLETION

Number of companies Confirmed: 79

- No. of companies with 100% Completion: 18 (23%)
  - Alliance Global Tower Building Administration Inc.
  - Alveo Land Corp. / Alveo Corporate Center
  - Ayala Land Inc - Makati Stock Exchange
  - Ayala Malls Marikina (Arvo Commercial Corp)
  - Circuit Corporate Center 1
  - Circuit Corporate Center 2
  - Circuit Mall (Makati Cornerstone Leasing Corp.)
  - Cloverleaf Mall (North Eastern Commercial Corp.)
  - Ecommerce Plaza Building Administration Inc.
  - Fairview Terraces - North Ventures Commercial Corporation
  - First Gateway Real Estate Corporation
  - Glorietta Complex - ACCI
  - Market! Market! (Station Square East Commercial Corporation)
  - Seda Hotel BGC (Bonifacio Hotel Ventures,Inc)
  - Sun Life Centre

- Two Parkade
- Universal Re Condominium Corporation
- SouthPark Mall & Corporate Center

- Number of companies with 50% Completion: 10 (13%)
  - Ascott Makati, Inc.
  - BHS Central C3 Expansion / EWOK (Fort Bonifacio Development Corporation
  - Bonifacio High Street East
  - Bonifacio Stopover 1
  - Deutsche Bank Group
  - NexGen Tower
  - One Bonifacio High Steet
  - Philippine Stock Exchange
  - Serendra Retail
  - SQ Resources Inc. / Somerset Millennium Makati

- Number of Companies with less than 50% Completion: 51 (64%)

E. INSIGHTS

- Preparation of Master List and Communications
  - Preparation and updating of the Master List could be improved in order to fast track survey implementation. On Week 2 of roll-out, we are still catching up on getting the right contacts.
    - Need to update contact person, contact number prior to start of Survey rollout
    - Cleanup/removal of duplications – companies listed twice etc.
  - Several companies claimed that they did not receive the email from DOE.

- Company/Respondent's receptiveness, organization, and response:
  - Most companies selected were knowledgeable on EEC law and practices and had submitted annual reports. Data was available.
  - Most companies were willing to contribute and participate in the survey.

- Data gathering and provision of information:
  - Using the Survey Data Gathering Flow (Attached), we observed that the initial interview is critical in getting Buy In to the project. Enumerators covered the objectives, scope, contents and how to's of the survey.
  - Some companies like BPO, requested for an excel form as their company policy restricted them from accessing external apps and websites. MPA provided the survey in digital, PDF and excel format (See links)

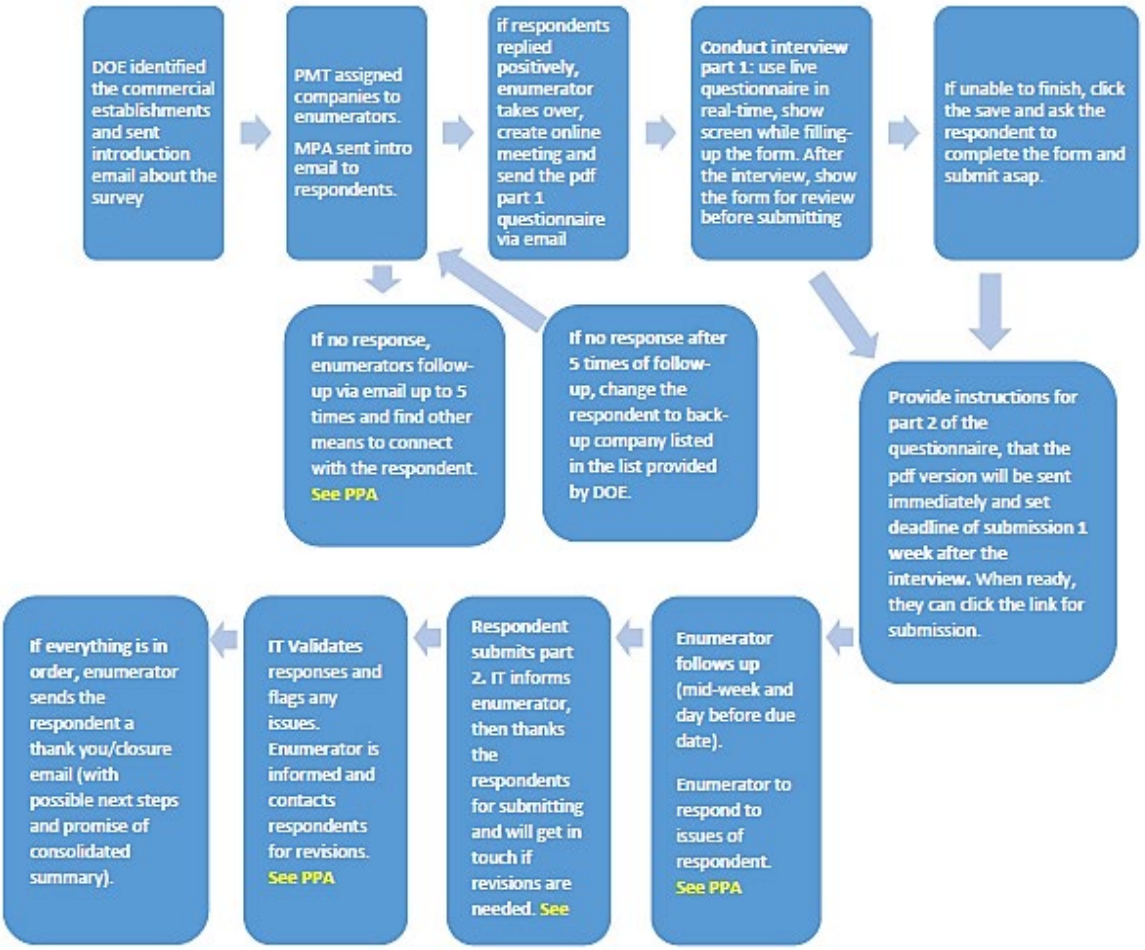
- Data Validation
  - In the attached Part 1, 2018 and 2019 Excel files, we have highlighted data which are for validation by the enumerators with their respondents. Among them:
    - GFA is not equal to Building Footprint x No of Floors

- Operating Days is only 1 or 1.5 days/ week
- Data for electricity and water consumption is only for half year

- Other matters:
  - We received requests for a Certificate of Participation.
  - We received requests and issued Survey Consent and Confidentiality Forms. (Attached)
  - We received inquiries on the next steps after this survey.

MERALCO POWER Academy

Survey Data Gathering Workflow



MERALCO POWER Academy

TIMELINE & DELIVERABLES

PHASE 0: PREPARATION & MOBILIZATION

Start of phase 0 is on April 4, upon receipt of signed-off contract of engagement from ERIA.

	Deliverables	Completion
Done	Selection of Survey Software and IT Lead, Support	March 21, 2022
Done	Selection and Engagement of Enumerators	March 21, 2022
Done	Received a signed-off contract of engagement	April 4, 2022
Done	Mobilized MPA Manpower	April 5, 2022
Done	Project kick-off Trained Enumerators ready for data gathering *c/o ERIA*	April 7, 2022

- Agreed Duration: 14 days
  (Duration stated in the contract of engagement to complete all activities in the current phase)
- Actual Duration: 3 days
  (No. of days from day 1 until the actual completion of the last activity in the current phase)
- Running Agreed vs. Actual Duration: 3 of 14 days
  (Agreed vs. actual no. of days from day 1 of Phase 0 until the completion of the last activity in the current phase)
- Running days from Day 1 (April 4): 3 of 105 days
  (Actual number of days lapsed from start of Phase 0 up to the total duration of the contract of engagement – 15 weeks or equivalent to 105 days)

PHASE 1: PRE-SURVEY PREPARATIONS

Start of phase 1 is on April 12, upon receipt of the data gathering tools from ERIA.

	Deliverables	Completion
Done	Finalized data gathering tools *Note: initial data gathering tool provided by Citra Endah last April 12, 2022 was improved by MPA to make it simpler and easier to understand by the respondent while retaining the integrity and completeness of the required data.*	April 19, 2022 *Note: April 13 – 17 is holy week*
Done	Finalized the working survey program	April 21, 2022
Done	Enumerator's Training on Survey Instrument % MPA	April 22, 2022
Done	Testing of survey instrument with pilot respondents	April 23-25

- Agreed Duration: 21 days
- Actual Duration: 13 days
- Running Agreed vs. Actual Duration: 16 of 35 days
- Running days from day 1: 16 of 105 days

PHASE 2: SURVEY PROPER & INITIAL VALIDATION

Start of phase 2 is on April 19, upon receipt of the list of companies for survey from DOE *(List of companies to be surveyed was provided by DOE c/o Jim Balunday on April 19 but with addition/revision on April 22).*

	Deliverables	Start	Completion
Ongoing	Started contact with the respondents via call, email, letters, etc. (Note: Some respondents	April 22, 2022	Ongoing
Ongoing	Oriented the respondents	April 25, 2022	Ongoing
Ongoing	Filled-out of the survey by the respondents	April 27, 2022	Ongoing
Ongoing	Validated data with the respondent	April 30, 2022	Ongoing
Ongoing	Reviewed initial raw data in excel from survey program	April 30, 2022	Ongoing
	Approved initial tables and results as basis for FGD with DOE and/or ERIA	-	-

- Agreed Duration: 42 days
- Actual Duration: 21 days (ongoing)
- Running Agreed vs. Actual Duration: 37 of 77 days
- Running days from day 1: 37 of 105 days

PHASE 3: COLLATION, ANALYSIS, AND FINAL VALIDATION

Start of phase 3 is estimated on May 13, after initial presentation & validation of survey data with ERIA.

	Deliverables	Completion
	Integrated final raw data in excel from survey program	-
	Approved final tables and results as basis for FGD with DOE and/or ERIA	-
	Drafted study report and presentation to principals	-
	Submitted executive summary for companies	-

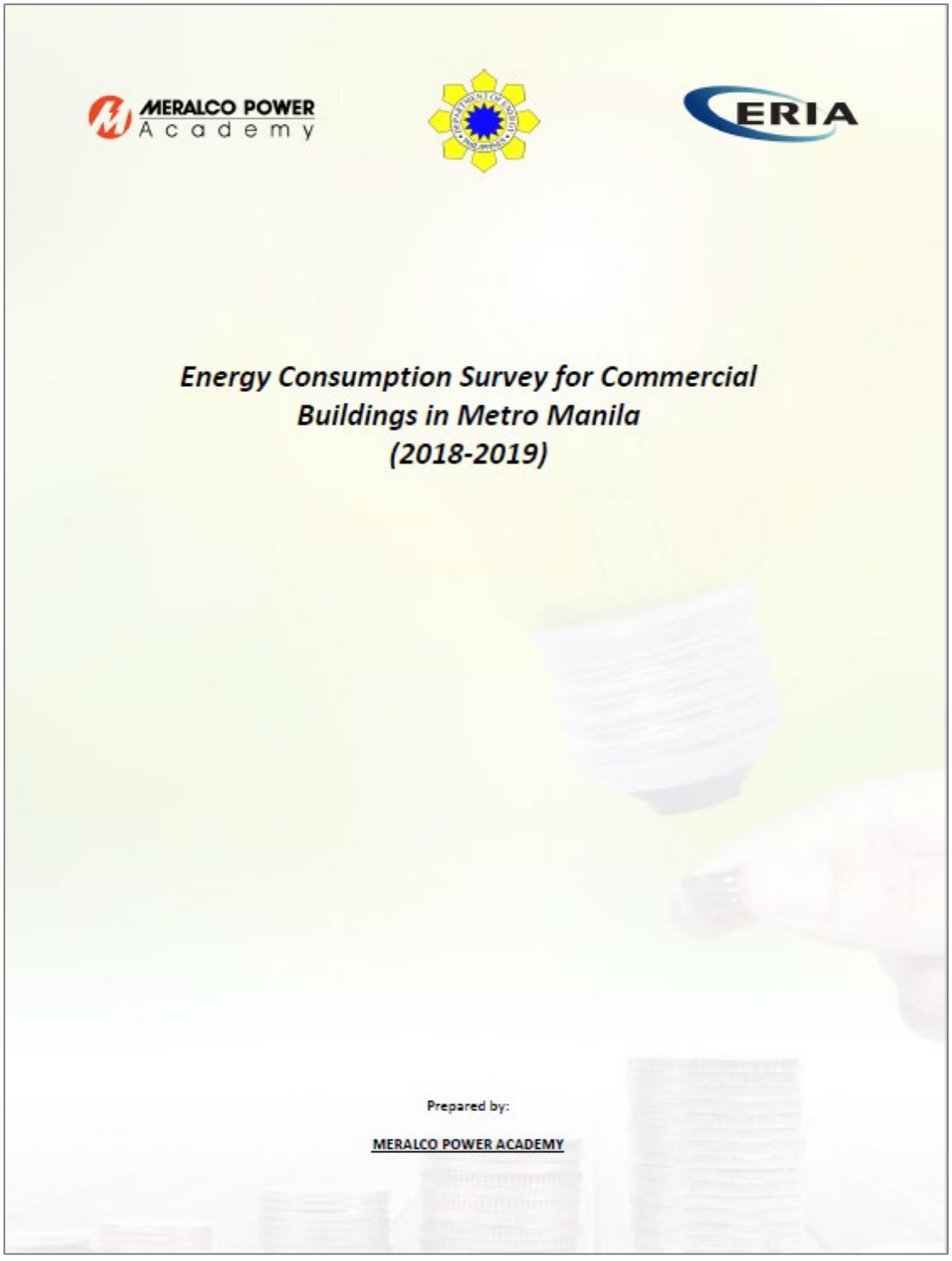
- Agreed Duration: 63 days
- Actual Duration: To be started
- Running Agreed vs. Actual Duration: To be started
- Running days from day 1: To be started

Prepared by:

Engr. Marc Lester P. Malibiran
Head, Program Management
Meralco Power Academy

Engr. Eugene F. Araullo
Director, Energy Research & Program Development
Meralco Power Academy

MPA Report submitted in January 2023



MERALCO POWER Academy

Acknowledgements

Contributors

The academy would like to acknowledge the contributions of the following experts who contributed contacts, insights and substantive up-to-date material and review for the sections of this study:

- Mr. Shigeru Kimura and Mr. Leong Siew Meng of the Economic Research institute for ASEAN and East Asia (ERIA)
- Engr. Artemio Habitan and Engr. Jimwell B. Balunday of the Energy Utilization Management Bureau of the Department of Energy (DOE)
- Engr. Arnold C. Rivera, Engr. Charles Emil D. Hernandez and Engr. Raul C. Castro of the Ayala Properties / Ayala Land Inc. group
- Mr. Nestor Rene Arnobit, Vice President and Head, Mall Operations of Megaworld Commercial Division

Disclaimer

This report has been produced independently by Meralco Power Academy on the request of and according to the Terms of Reference approved by the Economic Research Institute for ASEAN and East Asia (ERIA). The views expressed in this report are not necessarily the views of ERIA. Meralco Power Academy does not accept any duty of care to any other person or entity than ERIA and DOE, and no representation, warranty, assurance or undertaking (express or implied) is or will be made to other parties.

The information, statements, statistics and commentary (together the 'Information') contained in this report have been prepared by Meralco Power Academy from publicly available material and from discussions held with stakeholders. Meralco Power Academy does not express an opinion as to the accuracy or completeness of the information provided, the assumptions made by the parties that provided the information, or any conclusions reached by those parties.

Meralco Power Academy have based this report on information received or obtained, in good faith and on the basis that such information is accurate and, where it is represented as such, complete. The information contained in this report has not been subject to an audit.

Energy Consumption Survey for Commercial Buildings in Metro Manila (2018-2019)

Table of Contents

Abbreviations

In addition to the below list, several single-use abbreviations and acronyms are also defined throughout the document text.

ASEAN	Association of Southeast Asian Nations
ASHRAE	American Society of Heating, Refrigerating and AC Engineering
AEECR	Annual Energy Efficiency and Conservation Report
AEUR	Annual Energy Utilization Report
BPO	Business Process Outsourcing
CEA	Certified Energy Auditors
CECO	Certified Conservation Officer
CEM	Certified Energy Manager
COP	Conference of Parties
DOE	Philippines Department of Energy
EE&C	Energy Efficiency and Conservations Act of 2019
ECCR	Annual Energy Consumption and Conservation Report
EUI	energy use intensity
EUMB	(DOE Office of) Energy Utilization Management Bureau
HVAC	heating, ventilation, air conditioning
HHV	High Heating Value
MEPS	Minimum Energy Performance Standards
M&V	measurement and verification
Meralco	Manila Electric Company
NEECP	National Energy Efficiency and Conservation Program
PSA	Philippine Statistics Authority
RTI	Recognized Training Institutions
TESDA	Technical Education and Skills Development Authority

Executive Summary

With the Department of Energy (DOE) as its leading proponent, the Energy Consumption for Commercial Establishments survey was conducted in support of the implementing guidelines of RA 11285.

The market survey intends to provide baseline data, determine the energy intensity performance for office and retail in the commercial sector and recommend energy efficiency performance indicators/action plans to help DOE formulate and implement effective strategies for the industry.

An online survey was conducted to gather pertinent information on energy use from commercial establishments, mainly in the National Capital Region (NCR). The list of companies from DOE yielded 97 respondents categorized into Retail, Office, and Condominium for 2018 and 2019.

The initially completed calculations of the EUI for both office and retail had shown an extensive range of EUI from as low as 50 to as high as 700 kWh/m2; furthermore, after several analyses and iterations, we had seen no particular pattern when correlated with the building GFA, age, occupancy, hours of operation, energy consumption and even who are the owners of the facility.

After normalizing the data for offices using the ASEAN benchmark practice (using 124 hours/week for office buildings and 94 hours/week for retail buildings), the results indicated a range of EUI performance of 202.4 – 269.8 kWh/sqm/year for office buildings in the Philippines. However, since the data is normalized using a function, it is recommended to assume the EUI for offices at 245-261 kWh/sqm/year with a range from 109.0-294.0 kWh/sqm/year and a median value of 223.8 for 2018 and 202.4 kWh/sqm/year in 2019.

For retail establishments, a normalized EUI had shown a range from 145.1 to 364.0 kWh/sqm/year; for this retail segment, it is recommended to assume the EUI at 297 kWh/sqm/year for 2018 and 283 kWh/sqm/year in 2019, with a median value of 269.8 in 2018 and 250.3 kWh/sqm/year in 2019.

We recommend these normalized ranges for the office and retail establishments, given the early stages in the energy management adoption in the country in these market segments and other previous findings identified in this report.

There is a need to understand the nature of the businesses' operations to set acceptable or realistic standards in the Philippine scenario. There should be an effort to gather as much literature and information on these companies as to understand their energy use and issues.

A more thorough study should be done on specific factors that affect energy consumption and how we can improve the EUI data gathering and monitoring for commercial establishments, given our survey experience with them, such as data quality issues, availability, and energy management knowledge. This survey study details our findings, assessments, learnings, recommended policy interventions and next steps in the succeeding sections of the report.

1. Study Background

Objectives

Prior to the enactment of the Energy Efficiency and Conservation Law (RA 11285), energy consumption by end use were limited and electricity consumption by commercial retail and offices in Metro Manila were not broken down by end-use. There is limited evidence on Metro Manila's commercial retail and office spaces energy consumption data, types of fuel used, and other valuable information needed to implement energy efficiency measures. Energy baselining in the commercial sector must be understood, hence, this survey is conducted from February to end of March 2022.

The primary goal of this study is to obtain comprehensive and reliable source of information that will serve as a reasonable and defined starting point for comparison of Building Energy Intensity (BEI) for commercial retail and office spaces. The survey results may be used to evaluate the effects of policy interventions, and track progress of an improvement measures and programs to improve sustainability through efficient use of energy. Specifically, the survey was designed to accomplish the following:

1. Determine the energy consumption performance and profiles of 100 commercial establishments provided by the Department of Energy (DOE)
2. Establish performance standards and energy efficiency indicators for commercial establishments, including:
    a. Energy Use Intensity (EUI) in kWh/sqm/year
    b. Percentage share of electricity and other fuel use in retail and office spaces
    c. Median age of commercial establishments
3. Establish baseline data and statistics of energy consumption from commercial establishments for energy policy analysis and energy consumption trends
4. Determine challenges and areas of energy efficiency improvement in commercial establishments

The baseline data used in benchmarking EUI in this survey was the ASEAN EUI standard as noted in a United Nations report in 2020.

Project Team Responsibility

- Conduct energy surveys to a selection of 100 commercial establishments from the list of companies provided by the DOE covering the years 2018-2019. Parameters to include:
    - Types of energy utilized;
    - Monthly and annual electricity and water consumption;
    - Gross Floor Area (GFA);
    - Energy consumption for air-conditioning and lighting when available
- Provide the team including senior consultants, IT technical support and enumerators as project members to ensure project completion in accordance to time and quality;

- Develop the survey instruments based on provided samples and data requirements of ERIA, DOE and the technical direction of MPA's energy experts;
- Provide and utilize established ICT tools to collect survey data and transfer the data to excel file as a dataset;
- Produce and provide regular reports including raw data, preliminary graphs and charts;
- Conduct validation, provide feedback and analysis; and
- Prepare a terminal report summarizing all items covered in the scope of engagement.

Figure 1. Project Timeline

PHASE 0 Mobilization		PHASE 1 Pre-Survey Preps		PHASE 2 Survey Proper & Initial Validation		PHASE 3 Collation, Analysis & Final Validation	
Week: 1 to 2 | Apr 4 – 18 **Start:** Upon receipt of contract		**Week** 3 to 5 | Apr 19 – May 9 **Start:** Upon receipt of data gathering tool from ERIA		**Week** 6 to 11 | May 10 – Jun 20 Upon receipt of list from DOE		**Week:** 7 to 15 | May 17 – Jul 18 After initial presentation & validation of data w/ ERIA	
Actual: Wk 1 April 4 - 7		**Actual:** Wk 2 – 3 Apr 12 - 25		**Actual:** Wk 3 to 11 Apr 22 – June 20		**Actual:** Week 7 to 15 May 13 – Ongoing	
3/21	Selection of Survey Software	4/19	Finalized data gathering tool	4/22	Started contact with the respondents via call, email, letters, etc.	7/1	Validation with respondents
3/21	Selection of IT Lead, Supports, and enumerators	4/21	Finalized working survey program	4/25	Oriented the respondents	7/14	Submit final excel file to ERIA/DOE with tables
4/4	Received signed contract	4/22	Training of enumerators on survey instrument c/o MPA	4/27	Respondents started filling-out the survey	7/18	Submit final report and presentation to principals
4/5	Mobilization of survey team	4/25	Testing of survey instrument w/ Pilot respondents	4/30	Reviewed and validated initial raw data	7/18	Submit executive summary to respondents
4/7	Project kick-off: Training of team c/o ERIA			5/23	Approved initial survey data and result by ERIA		
				6/20	Complete the survey activities		

There were adjustments towards the end of the project timetable which pushed back the submission of this final report, including directions to make additional analysis based on the normalized data of the companies.

Limitations and challenges

It is appropriate in this brief report to acknowledge some of the limitations and research challenges in the information presented. Energy use and fuel consumption estimates are based in part on self-reported from survey respondents. It would have been preferable to estimate aggregated revenue reports from actual M&V, and back up evidence-based derivations with further expert corroboration to best represent the EUI of Commercial Buildings in Metro Manila.

It is also worth noting that the sample size are pre-determined list from the Department of Energy (DOE). The criteria for the sample size suggested that the list are few of the sample establishments that have best available data. And due to time constraints, it would be beneficial to utilize the list instead of undergoing rigorous sampling.

It would be best to chase responses from building expert to have granular data visibility and representation.

2. Methodology

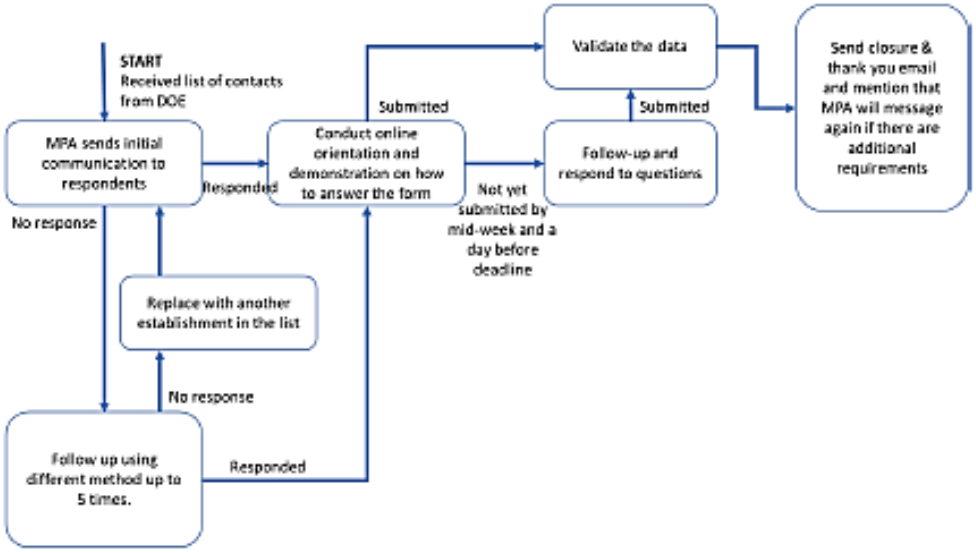
Pre-Survey Stage

A pool of educators, trainers, operations professionals and experienced data gatherers and evaluators who are proficient in English, Filipino as well as digital and work applications were identified and selected.

All Team Members underwent several training sessions on the following: Energy Efficiency concepts, standards and benchmarks, Philippine Energy Law and the use of the data gathering tools.

An Operations (OP) Manual containing important information was created as a reference for the Team. The project team was also guided by the survey workflow that was developed for more efficient data gathering.

Figure 2. Survey Gathering Workflow



Sampling Stage

The DOE Designated Establishment (DE) list. The survey used a predetermined set of 100 companies which were selected from the list of the Department of Energy (DOE) as its total population for the survey. This list included companies that have previously submitted Energy Efficiency Reports to DOE. Likewise, there is a good balance between designated establishments type 1 and type 2.

The first list had 100 companies that were categorized into the following: Real Estate & Renting, Multiple occupancy, Office, BPO, Malls and Hotels & Other Accommodations. Three main classifications emerged: Retail, Offices and Hotel/Condo. The goal was to successfully survey and **achieve a sample size of least 30 companies in Retail and 30 in Offices**. It was later decided not to proceed in analyzing hotels and condos due to the different parameters needed and insufficient data available for the survey.

This initial list contained the names of the companies, addresses, names of point persons, and type of energy used. However, they lacked the important contact numbers. The DOE addressed this by sending the revised list with contact numbers on April 22, 2022 (Attachment B) . Challenges began to

arise in the second week of data gathering. There were multiple emails that bounced. Dozens of companies did not respond. Several contact persons have changed. A second list of additional companies was then requested from the DOE. The second list provided 100 additional companies to replace non-responses and duplicate entries in the first list.

In the process of going through the list, additional concerns were encountered such as incorrect point persons or contact details, double entries of buildings that are listed under different company names, and commercial buildings which were not operational in 2018 or 2019.

These issues led to the delay of engaging the survey participants and eventually pushed back the timetable dedicated for the data gathering and validation parts of the survey. Of the **200** companies in the DOE lists, MPA reached out to **185** (93%), **92** were successfully contacted and responded while **93** (47%) were removed or not considered due to the following reasons: Did Not Respond (51), Decline to Participate (13), 22 Double Entries and 7 were Not Qualified to take part in the survey.

An additional **five (5)** companies that were not part of the DOE list were added to augment the number of respondents needed to achieve the proper sample size for the retail category. This brought the total number of respondents to **97**.

Please note that for purposes of understanding the nature of the establishment's operations and analyzing the data, this report contains information such as company names, addresses, contact persons etc

Survey Tool Design, Questionnaire Development and Implementation

The survey tool was derived from the initial Excel file provided by ERIA which had been used in their previous energy efficiency surveys. The ERIA Excel file had 4 parts: General Information, Energy Consumption, Air Conditioning System and Lighting Installations.

With the directions from DOE, ERIA and MPA, the team reviewed the ERIA Excel file and developed a survey tool form with a link that could be directly sent to the respondents. The first draft was shown to energy practitioners for feedback prior to deployment.

It was also decided to implement the survey through digital/online platforms. The country and Metro Manila were still under changing COVID-19 restrictions, which made in-person implementation difficult to carry out at that time.

Finally, data for the years 2018 and 2019 were selected as the data from the more recent years (2020 & 2021) were deemed not to be representative of the normal operations of commercial establishments due to the pandemic.

The survey tool was designed to have four parts for better organization of information and to allow users to review, save, exit after each part, and return to their saved work based on their availability.

Part 1 - The Introduction and General Information page

- Introduction to the survey, instructions and contact details of the primary and alternate respondents of the company.
- Building descriptions: Building footprint (in sqm), number of floors, age of building, Gross Floor Area (GFA in sqm), operating hours, estimated occupancy rate and fields for general descriptions of the establishments facility, operations and energy efficiency initiatives.

Part 2 - The Types of Fuel Used

- Respondents were asked to input the annual and monthly electricity energy consumption (kwh), consumption of other types of fuel such as water (liters), diesel (liters), LPG (kgs), coal (kgs), renewable energy (kWh) and other sources, if any.
- Open-ended portions were provided in order to allow respondents to describe any incident that may have resulted in irregular or unusual energy use during the period.

Part 3 - Air Conditioning Section

- The initial question asked was if the company had available data on their monthly and annual energy consumption of their air conditioning system. Sources of data to come from sub-metering and other recording means available.
- If this was not available, respondents were asked to identify which type of aircon systems were in use. Examples: centralized, VRV/VRF, split type, others.
- For each type of aircon unit, they were asked on the floor areas (sqm) of various sections of the buildings (public areas, restaurants, stores, offices, etc. as well as the COP of the A/C system.

Part 4 – Lighting Section

- First question in this section was if the company had data on monthly and annual energy consumption of their lights
- If none, they were asked about the areas of various sections of the buildings (public areas, restaurants, stores, offices, total floor area, etc.)

Additional versions of the survey tool were developed to accommodate respondents who had difficulties accessing the form due to company policies and security firewalls.

- An Excel file format where the respondent could accomplish offline. The Excel files were emailed to the respondents and were sent back for inclusion in the main survey file.
- An Abridged Version of the survey composed only of Parts 1 and 2 was also developed in both Excel and digital formats in order to address the setbacks experienced in gathering data for Parts 3 and 4. This was created on June 2, 2022 as a strategy to draw back respondents to participate.

Refer to Attachment A for links to the various versions of the survey form.

Data Gathering and Survey Process

The Survey Enumerators. Eight (8) enumerators were trained to engage the respondents and to provide technical support during the data gathering activities. They were tasked to contact the respondents and provide guidance throughout the survey process.

The enumerators were provided with an operations manual that included the rationale and background information on the project, general instructions, presentation materials, risk management matrix and script that were used in their initial interviews with the respondents. They also took care of sending the Consent and Confidentiality forms to the respondents.

Some strategies used in the initial engagements with respondent were:

- Group orientations were conducted for engineers and energy managers for companies / buildings belonging to a conglomerate (example: Ayala Malls Inc. / Ayala Properties Inc.) with the presence of a point person who helped gather and give instructions to the different building respondents.

- The enumerators started with an orientation and guided interview to provide the background and rationale of the survey, to make introductions between the enumerators and respondents, to get basic understanding of the companies and their operations and to handhold the respondents on answering Part 1 and provide the directions in completing Parts 2-4.

The Respondents. There were 97 companies who participated in the project. Out of this, 90 completed the survey while 3 gave partial responses and 4 provided data outside of the requested 2018 / 2019 consumption. The data from these 7 companies were not included in the results, charts and graphs.

Issues and Challenges in Data Gathering. The first major hurdle was establishing first contact with the respondents due to the erroneous names, contact numbers and email addresses of point persons in the two sets of lists provided by the DOE. The second hurdle involved getting immediate responses from those they were able to connect with. There were also technical issues in the use of the form and access to the link. Respondents with unstable internet connections took longer to finish and upload their forms while those with strict data privacy set-up had to be sent the Excel format via email which were then inputted in the main data file.

For example, two (2) enumerators had to contact 31 companies each in order to accomplish their individual quotas of 13 respondents each.

Data Consolidation and Validation

Even though all these companies had previously submitted energy consumption reports to the DOE, there was a need to check on their responses in the survey forms. After the first set of data came in, an initial validation of the results was done to check on the numbers and trends in energy consumption and EUI.

The first stage of review focused on checking on the completeness of responses (all fields filled in, verification of non-completion where companies are only operational for certain months) validation of obvious errors in encoding etc.

The progress report meetings with ERIA and DOE also served as a good avenue for validation since they provided feedback on the data and charts of the survey. The Project Team took note of ERIA's and DOE's recommendations and were guided by their insights including:

- Instructions to focus on achieving a sample size of at least 30 companies each for both retail and offices. MPA clarified that since DOE's list included some condos and hotels, these companies were included in the data gathering. However, they were later dropped in the final analysis.

- Suggestion to complete monthly and annual energy use by averaging and inputting figures for the months with no operations.

- Feedback to review operating hours, as it was noted that there were some exceedingly high figures. This was validated with the respondents and corrected. However, some companies like BPOs maintained their numbers at 168 hours/ week reflecting their 24-hour daily operations.

- Mr Artemio Habitan of DOE suggested normalizing operating hours by using the ASEAN standard of 2000 hours per year.
- Recommendation to not include company names in presenting data during presentations to protect the privacy of all respondents.
- Instruction to categorize the buildings according to function in order to maintain the consistency of data to be presented.

On the second stage of validation by Week 8, the graphs were still showing irregularities from the expected rates of EUI for retail and office buildings. Enumerators went back to the respondents to gather additional information. Some common observations and findings we found from this questioning are:

- Gross Floor Area varied greatly from the formula of Building Footprint times the number of conditioned Floors, due to:
    - Erroneous entry of number of floors - non-conditioned areas were included, non-existent floors eg 13th floor etc.
    - Companies have their own measurements for GFA based on floor plans.
    - Respondents found it difficult to segregate GFA for multi-use and multi-purpose buildings.
    - Possible dubious sources of GFA - use of business permits. In the Philippines, the GFA used in the business permits may be under-declared or not updated when there are additional features built.
- Energy consumption, types of fuel, occupancy rates and operating hours were also reviewed because they were key factors in determining EUI.

Additional Sources of Validation. On top of gathering information from the respondents, the Project Team also referred to the following sources to countercheck information and understand the facility better:

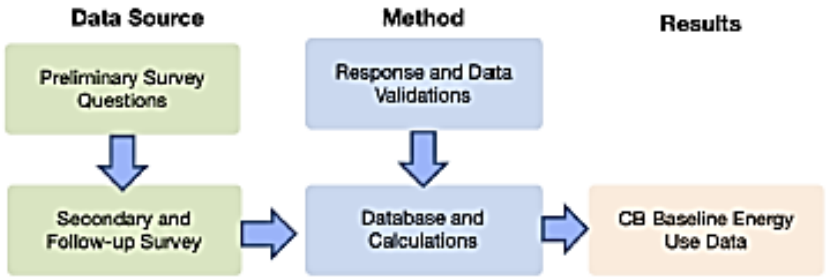
- Company websites;
- Annual reports and other secondary data sources;
- YouTube and other videos providing a virtual tour or walk through of the building;
- Area Calculator Applications to determine Building Footprint;
- Skyscraper City, an online community of properties and people in the real estate development industry, and
- Physical observation through site visits of some buildings.
- Interviews with occupants of some of the buildings

Issues and Challenges in Validation. The EUIs of some buildings were found to be unusually high or very low. The respondents of these buildings were asked to review, validate and/or clarify their GFAs, their energy consumption rates per month and even their aircon and lighting sub-meter rates. Several respondents were able to reply and provide updated information but some were no longer responsive to the validation inquiries.

Data Processing and Analysis

Data from the respondents who completed the survey were consolidated in an excel form and were categorized into Retail, Office and Condo as well as by year (2018 & 2019). Outlier data were then identified from the consolidated figures. This prompted the project team to validate with the respondents. Data cleaning, removing duplicate entries and validating completeness and accuracy of submitted data were performed through coordination with the enumerators. Figure 3 summarizes how the data are used in this study.

Figure 3. Data Process Flow



Data that are used to determine the baseline EUI indicators includes: GFA, Diesel kWh equivalent, Percent of Total Energy Used, LPG kWh equivalent, Percent of Total Energy Used (LPG), Total kWh Consumption.

To convert fuel used in Liters to energy (in kW), the formula is used:

$$Diesel\ kWh\ equivalent = \frac{Diesel\ used\ (L) x\ HHV\ for\ fuels\ (39\ GJ\ for\ Diesel)}{3.6MJ}$$

To determine the Building EUI, the following formula is used:

$$EUI = \frac{\sum Reported\ Monthly\ Energy\ Consumption + Energy\ Equivalent\ of\ fuels\ used}{Gross\ Floor\ Area\ (m^2)}$$

To generalize the EUI value for Office and Retail Spaces using statistical analysis, four assumptions must be met:

- **Assumption of Normality**, which means that the data have a normal distribution or at least symmetrical.
- **Assumption of Homoscedasticity**, which assumes that data from groups have the same variance
- **Assumption of Linearity**, which assumes that data have a linear relationship
- **Assumption of Independence**, which assumes that data are independent

However, in actual cases, data gathered from actual surveys are inherently non-normal. There is nothing inherently wrong with non-normal data, however, researchers needs to be aware of whether

their variables follow normal or non-normal distributions since this influences how data will be described and analyze.

Dealing with extreme values and non-normal data can be best summarized with medians and frequency distribution rather than mean and standard deviation. Analyzing continues data (t-test, ANOVA, linear regression) may also perform poorly in non-normal data but only if the sample size is smaller than 30.

There are strategies in dealing with non-normal data (Sainani, K.L., 2012 and Buthmann, A., 2018):

1. Identify and address reasons for non-normality
2. Use tools that do not require normality (Kruskal-Wallis, Run Chart, Mood's median test)

For the benefit of this study, since the main objective is to generalize EUI for office and retail establishments, the best approach is to force the non-normal data to fit a normal curve using a function.

Since one of the input when determining the EUI is the operating hours, it is logical to use this input in establishing a function to normalize the dataset. This is also necessary since the survey results show that the reported operating hours have a varied value. In the interest of this study, the following strategies were implemented and tested to produce the most realistic EUI value for commercial establishments in Metro Manila:

- Normalized Operating hours of 38.2 hours/week or 2000 hours/year as suggested by the Department of Energy
- Normalized Operating hours of 124 hours/week (6,888 hours/year) for Office Buildings and 94 hours/week (4,888 hours/year) for Retail buildings using averaging the operating hours from each building type.

3. Results

Profile of Respondents

Majority of the survey respondents are directly in charge of the respective facilities. These were Property Managers/ Engineers, Facilities Manager / Engineer, Energy Manager, Engineering Director, General Manager, Building Administrator / Engineer, ECO, Electrical Section Head, Safety Officer, Chief Engineer, Engineering Supervisor; while there were 2 respondents who are Executive Assistant and Engineering Coordinator.

Profile of Companies

The companies provided by the DOE were composed of retail establishments (malls), office buildings (corporate offices, buildings with leased spaces for offices and BPOs) as well as residential condominium buildings. Several properties are mixed use such as residential condominiums with retail floors; malls with BPO offices and office buildings with retail shops. Majority of the companies are located in the National Capital Region. Most of the malls, office buildings and condos in the list belong to the Ayala group, where the assigned enumerators were able to coordinate easier due to a single contact person per cluster.

The designated establishments use of commercial property in the PH commercial sector is varied, multi-use, multi-purpose, multi-user, flexible and may all co-exist in the same building and even on the same floor. This makes sectoral industry surveys challenging and complex which impact on establishing their optimal energy intensity.

Figure 4. Number of Respondent Companies (by Category)

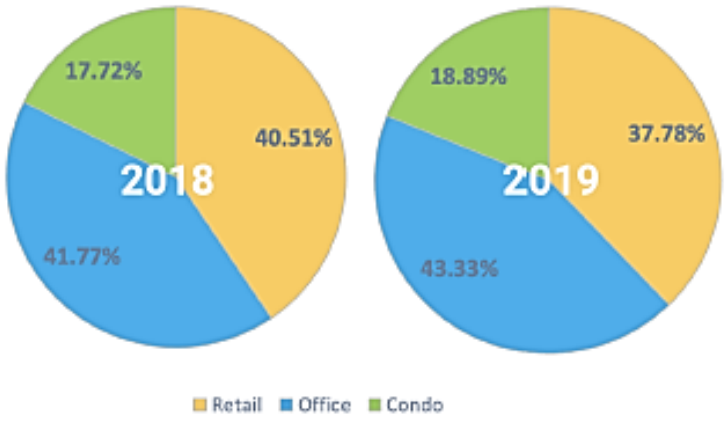


Figure 4 summarizes the number of companies who responded per category and per year. A multi-use facility may have responded in one or more categories. A number of companies in the DOE list were determined to be in the condominium or hotel category and were initially included in the data gathering efforts. However, the team felt that there is a need for a different set of parameters for this category in order to generate more meaningful EUI. These companies were therefore not included in the Energy Efficiency Data analysis and graphs.

On Aircon and Lighting Data Attachment C summarizes percentage completion of the various parts of the survey. Unfortunately, some companies interviewed had no available data on their monthly and annual aircon and lighting energy consumption. Please refer to the table below for the actual number.

Table 1. Companies with no annual/ Monthly aircon and Lighting Data

Type	2018			2019		
	Total Submitted	No Annual AC Data	No Annual Lighting Data	Total Submitted	No Annual AC Data	No Annual Lighting Data
Retail	32	7	9	34	9	10
Office	33	16	20	39	22	24
Condo	14	8	8	17	11	11

Energy Efficiency Survey Results

General Findings

The survey results (removing the extreme outliers) showed a wide range of EUI performance for offices, retail, and condo in the Philippines. These approximate the extreme ranges (from best and worst) versus the EUI of other markets in mature economies like Singapore, Malaysia, Japan, Hong Kong, and others.

After normalizing the data, the EUI average from different buildings are more convincing. There was an effort to explore and analyze further some correlations or patterns using several drivers or variables, as shown on the following graph, with the intent to find some reason or answers to the EUI variations across these commercial establishments; Attempts were also made to investigate establishment sample clustering by end-use or purpose to determine some patterns. The findings show no pattern or strong correlation between the building EUI versus GFA, kWh total usage, age, location, occupancy rate, hours of operation, and even the property owner. Hence, there was no conclusive evidence to suggest that there exists some direct correlation between these factors.

Based on the experience in the survey, client validations, and analysis, there were many factors identified that may have affected the EUI, such as data quality, competency of the property manager/energy practitioners on energy performance, the multi-use/purpose and functions of the building, characteristics, features, age, design of buildings and behavior of the users.

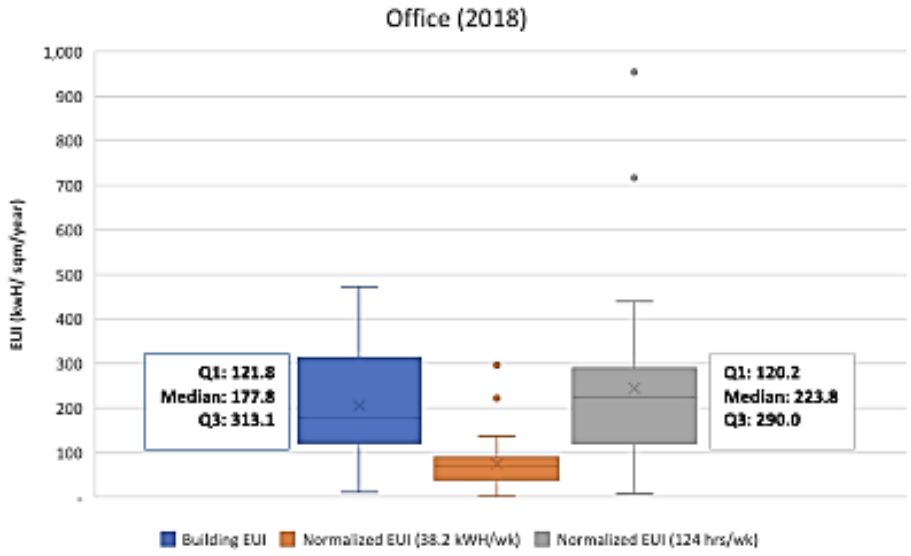
Assessment/Insights about the Respondents

1. Some of the contact persons or the appointed Energy Managers and staff need to strengthen their data collection and control the data quality as there are undocumented building/ facilities/ energy parameters.
2. The low and inconsistent data quality indicates the need for respondents to improve their awareness and importance of the DE energy performance, energy baselining, use of energy performance indicators, and benchmarking.
3. There are plenty of opportunities to improve energy management processes and systems in these companies, as seen in the lack of reliable and available data on SEUs, energy balance, baseline, and the respondents' ability to present the information.
4. The use of commercial properties in the Philippines commercial sector (multi-use, multi-purpose, multi-user, and flexible) is a factor that affected establishing optimal energy intensity gathered from our survey results and respondents' validations where the project focus is the office and retail categories only.

Building Energy Utilization for Offices (2018 and 2019)

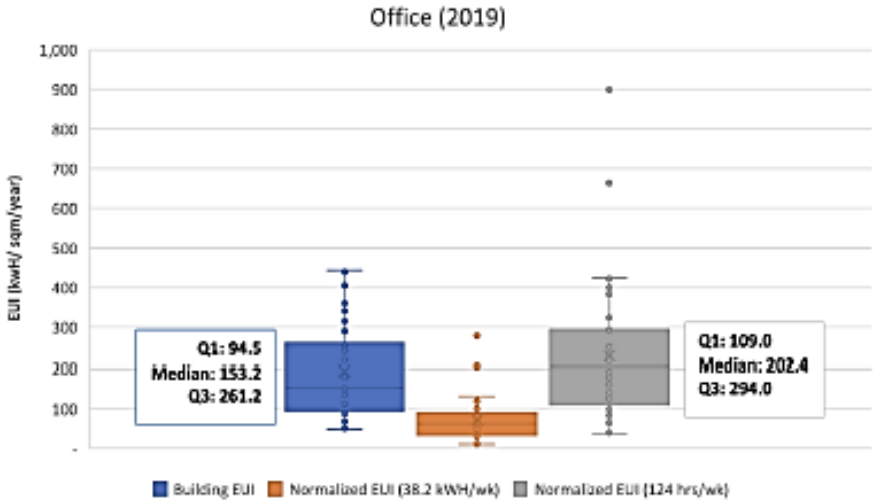
It can be inferred from the Box Plots (see Figure 5) that Office Spaces in Metro Manila has a median value of 177.8 kWh/sqm/yr. However, due to the non-normal distribution of the data set, the reported building EUI was normalized using operating hours at 124 hours/week (6888 hrs/year). It shows that the median EUIs for Office Spaces in 2018 was 223.8 kWh/sqm/the year 2018. However, there was an improvement of 9.5% EUI in 2019 at 202.4 kWh/sqm/year.

Figure 5. Spread of Numerical EUIs for Office Spaces compared with non-normal data (2018)



Source: MPA, 2022

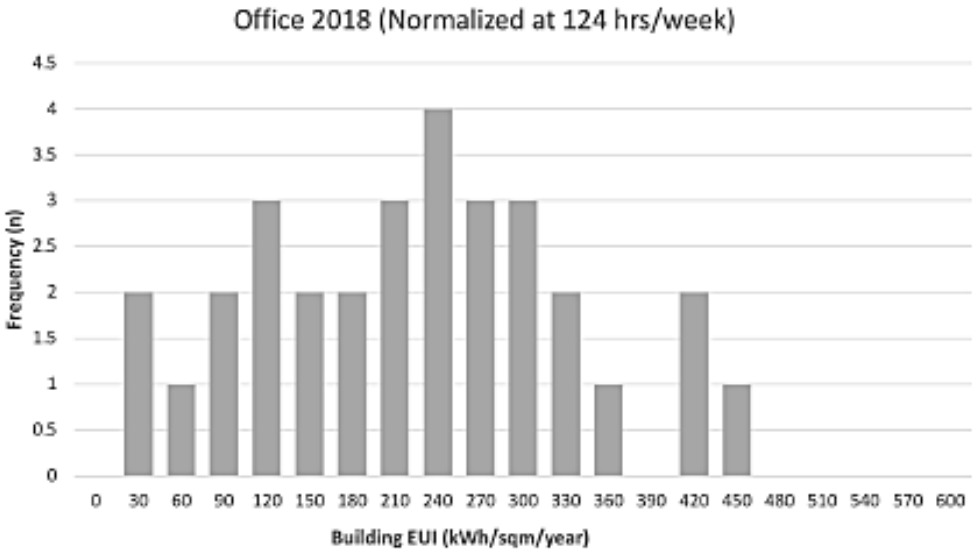
Figure 6. Spread of Numerical EUIs for Office Spaces compared with non-normal data (2019)



Source: MPA, 2022

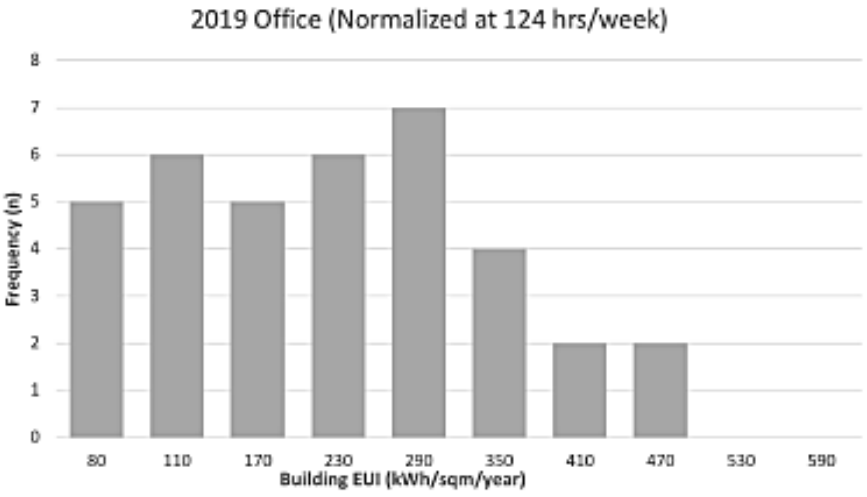
EUIs can also be estimated using frequency distribution, wherein we take the mode value of EUIs in the distribution. However, this is only an estimation that Office Spaces EUI using this method would suggest a value of 240 kWh/sqm/year in 2018 and 290 kWh/sqm/year in 2019.

Figure 7. Frequency Distribution of EUIs for Office Buildings (2018)



Source: MPA, 2022

Figure 8. Frequency Distribution of EUIs for Office Buildings (2019)

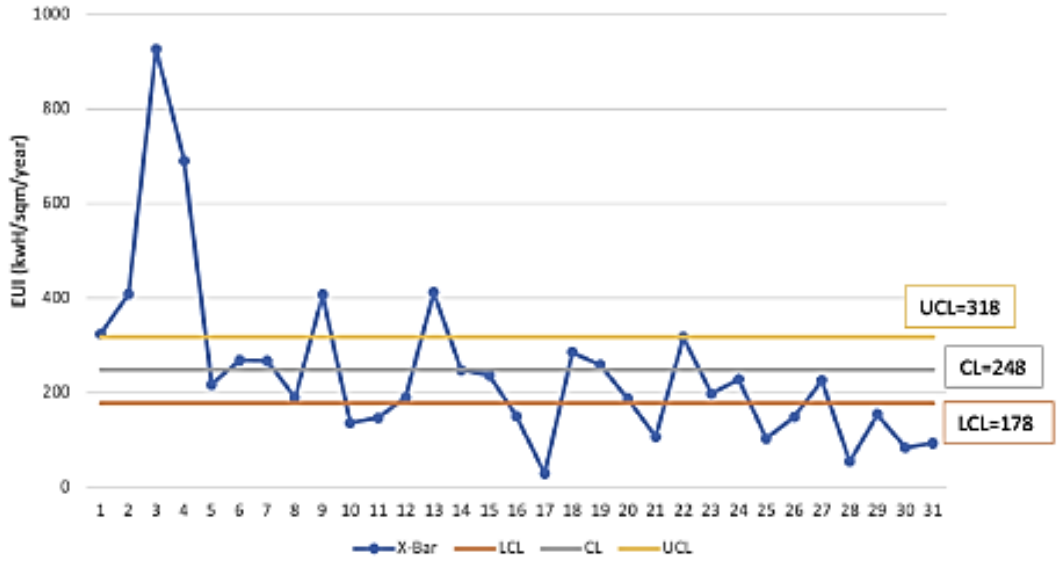


Source: MPA, 2022

An alternative way to determine the EUIs will be to use control charts. With control charts we can study how our EUI observations changes over time, in this case for 2018 and 2019. Figure 9 shows that

the Center line for EUI observations in Office spaces is at 248 kWh/sqm/year, which also represents the actual process average. This is approximately consistent with the value suggested by the box and whisker method.

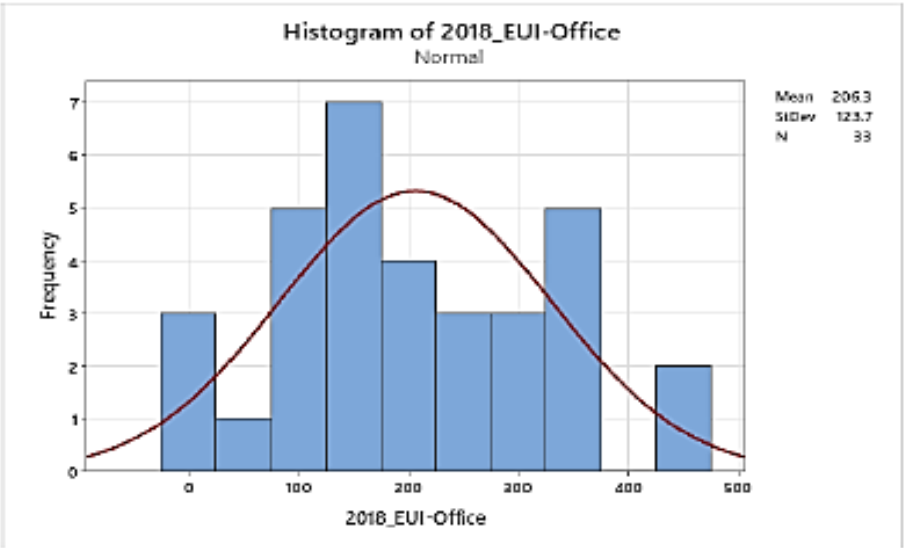
Figure 9. X-bar Chart for Office Normalized at 124 hours/week EUIs (2018-2019)



Source: MPA, 2022

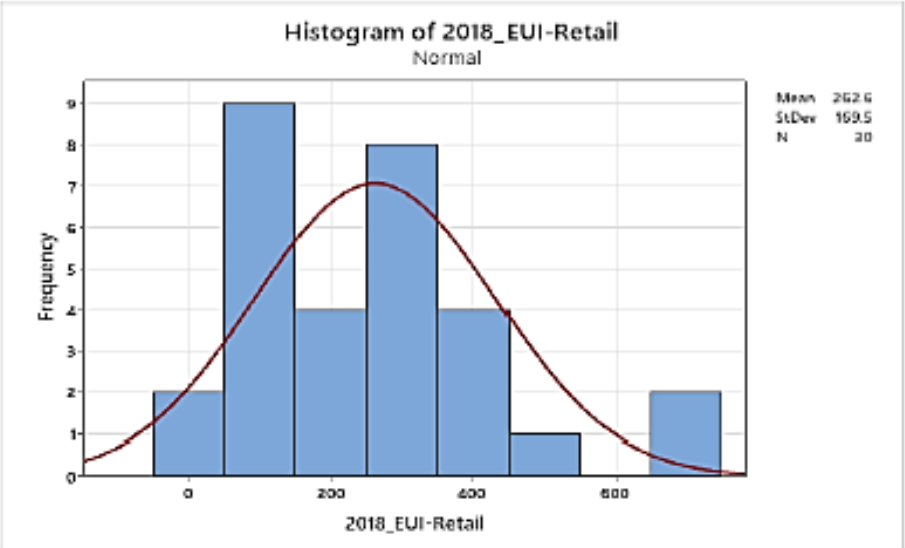
It will be worth noting that determining the central tendency of EUI distribution will depend on the type of data. It is usually inappropriate to use the mean in such situations where your data is skewed (as seen in Figure 10 and 11). You would normally choose the median or mode, with the median usually preferred. Since a multi-modal distribution can happen, as in the case of Figure 10, or a bi-modal distribution can also happen, as seen in Figure 11.

Figure 10. Sample Skewed Distribution of EUIs for Office Buildings (2018)



Source: MPA, 2022

Figure 11. Sample Multi-modal Distribution of EUIs for Office Buildings (2018)

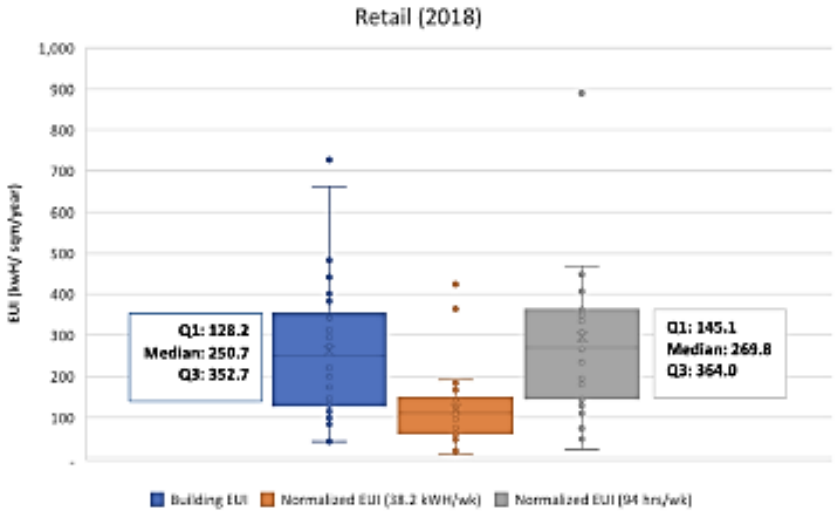


Source: MPA, 2022

Building Energy Utilization for Retail Spaces (2018 and 2019)

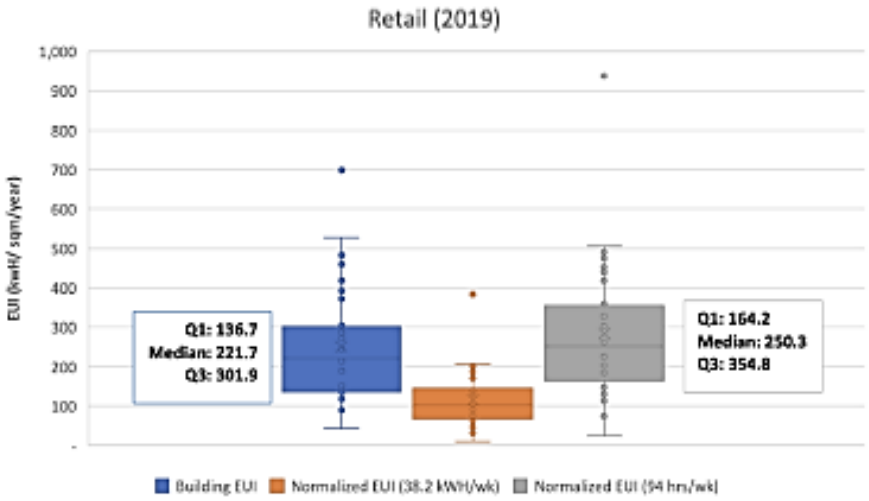
It can be inferred from the Box Plots (see Figures 12 and 13) that retail spaces in Metro Manila has a median value of 250.7 kWh/sqm/yr. However, due to the non-normal distribution of the data set, the reported building EUI was normalized using operating hours at 94 hours/week (4888 hrs/year). It shows that the median EUIs for Retail Spaces in 2018 was 269.8 kWh/sqm/the year 2018. However, there was an improvement of 7.2% EUI in 2019 at 250.3 kWh/sqm/year.

Figure 12. Spread of Numerical EUIs for Retail Spaces compared with non-normal data (2018)



Source: MPA, 2022

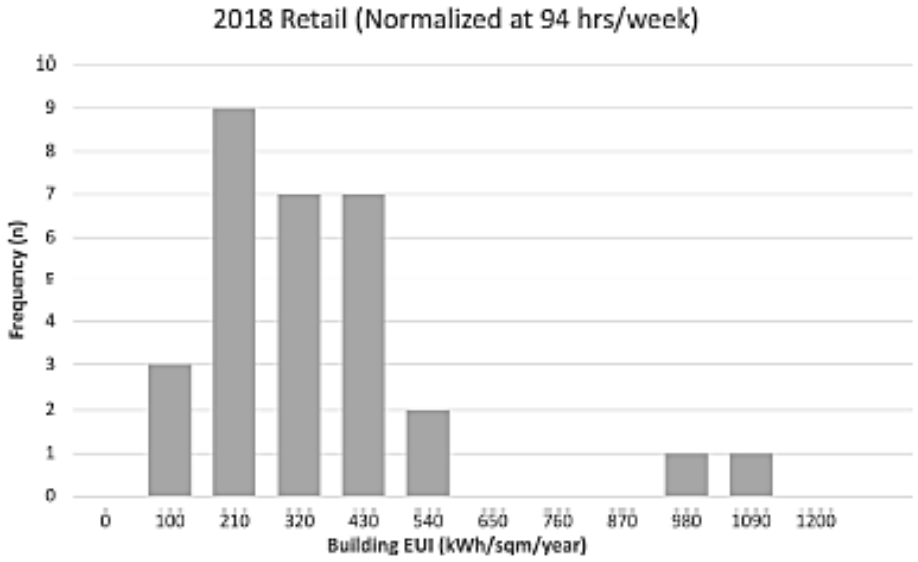
Figure 13. Spread of Numerical EUIs for Retail Spaces compared with non-normal data (2019)



Source: MPA, 2022

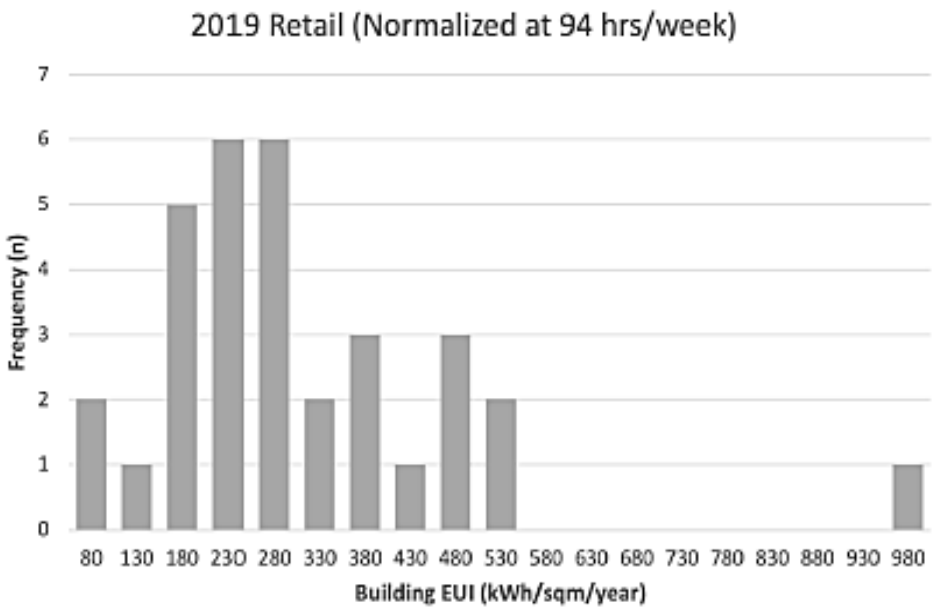
It can also be observed that the EUI using frequency distribution would suggest a value of 210 kWh/sqm/year for retail building in 2018 and an EUI of 230-280 kWh/sqm/year in 2019. This is a classic example that even when data forced to be normalized, bi-modality and multi-modality can still occur.

Figure 14. Frequency Distribution of EUIs for Retail Buildings (2018)



Source: MPA, 2022

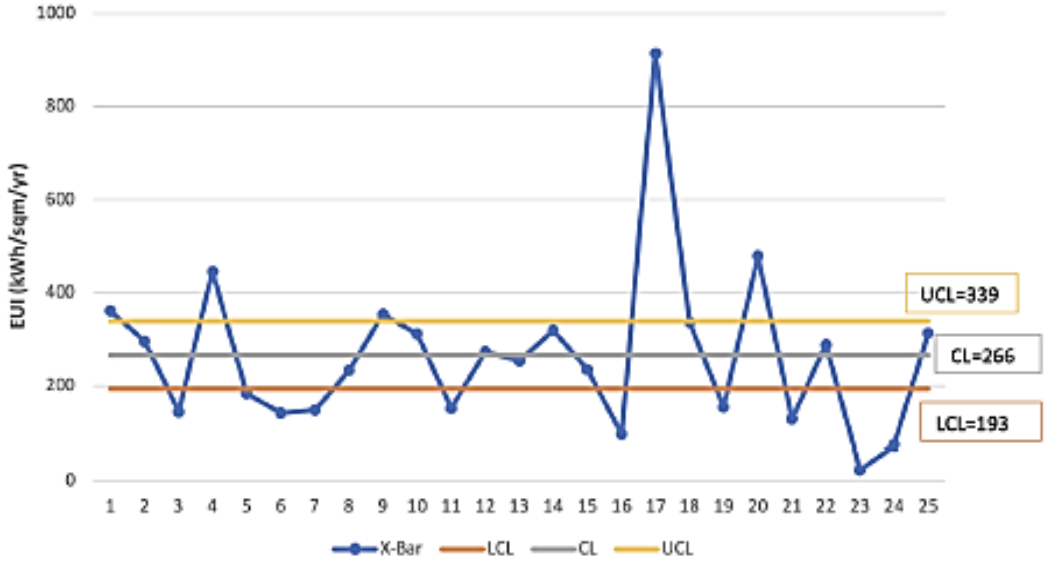
Figure 15. Frequency Distribution of EUIs for Retail Buildings (2019)



Source: MPA, 2022

Using the control chart X-bar value, the retail Center line, which represents the actual process average value is observed to be 266 kWh/sqm/year. This approximately on par with the value determined using the box and whisker method.

Figure 14. X-bar Chart for Retail Normalized at 94 hours/week EUIs (2018-2019)

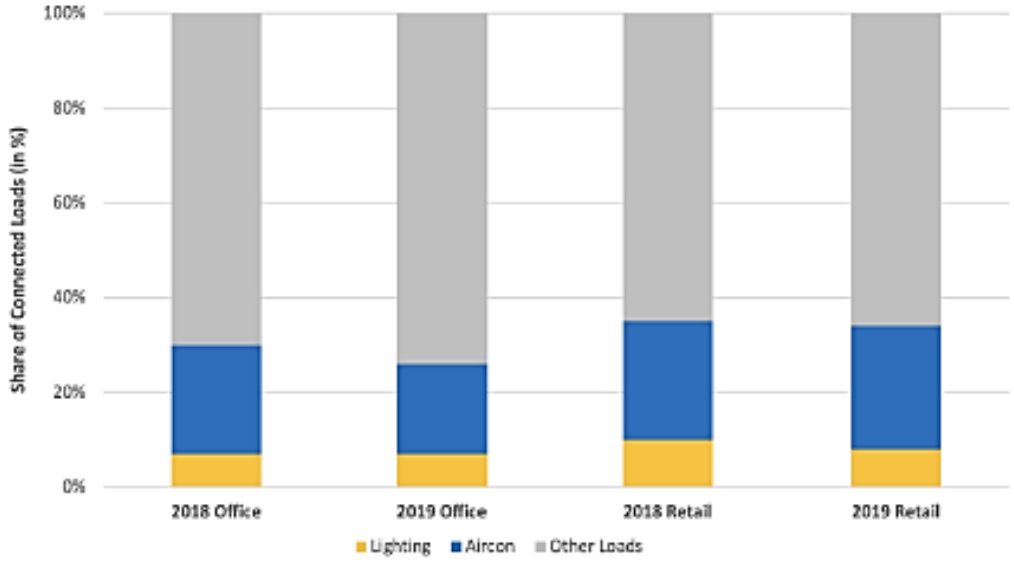


Source: MPA, 2022

Building End-use Energy Utilization Profile

Retail buildings surveyed consumed mainly electricity, although a few large shopping malls also utilised LPG, primarily in their food and beverage section, and diesel, as fuel for back- up generators. Like offices, these buildings had different operating hours but averaged 94 hours weekly, which corresponded to 4,888 hours annually. Therefore, total energy consumption was adjusted to reflect the same operational hours of 4,888 hours per year to rationalise energy consumption for comparison purposes.

Figure 14. Energy End-use for each Building Type (2018-2019)



Source: MPA, 2022

It can be seen from Figure 14 that 'Other loads' take up an average of 72% of energy use for office buildings, while it is 62% of energy use for retail buildings. Cooling solutions consumed the next energy use at 21% for office spaces, and 26% for retail spaces. While lighting loads has a discernible consumption at 7% in office spaces, and 9% in retail spaces.

There can be an ambiguity of other loads having a substantial share of connected loads compared to lighting and cooling solutions. Possible reason would be underreporting of district cooling and heating for multi-use spaces which sometimes, the respondents categorize them as loads that does not belong to either lighting or cooling. This is apparent for office buildings, however, the argument may hold evident for retail spaces, where large shopping malls and retail complex in the Philippines have high concentration of eateries and restaurants.

Therefore, it would be best to explore this in future studies to evolve the findings of this study.

4. Summary of Findings

The key findings from the commercial energy consumption survey can be summarised as follows:

a. The average BEI values derived from the survey are summarised in Table 2. Because of the limited number of survey samples, these BEI values were indicative baseline average values only for conventional buildings without energy efficiency measures. The BEI values for conventional retail buildings, and offices were not conclusive and should be analysed further using more samples and taking the study at a national level to best represent the EUI baseline in the Philippines.

From the statistical analysis performed in Section 3 of this report, normalizing EUI by a function using operating hours would be the best course to determine the EUI. The summary provided in Table 2, suggests that the EUI for **Office Spaces in 2018 is 245 kWh/sqm/year and 261 kWh/sqm/year in 2019.** For retail buildings, the EUI is approximately at **283 to 297 kWh/sqm/year.**

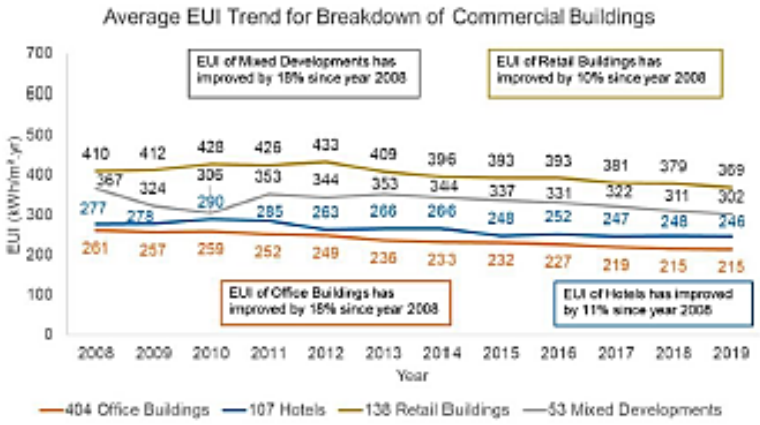
Different approaches to determine the expected EUIs were presented in this report, however, it is recommended to determine the non-normal and normalized EUIs using box and whisker method to determine the EUI distribution. Since the data presented are also normalized, taking the mean (average value) can perform well in this situation.

Table 2. Summary of EUIs for Commercial Establishments (2018-2019)

Building Type	Average EUI (kWh/sqm/year)	Control Chart CL	EUI Ranges (kWh/sqm/yr)		
			Q1	Median	Q3
Office (2018)	245	248	120.2	223.8	290.0
Office (2019)	261		109.0	202.4	294.0
Retail (2018)	297	266	145.1	269.8	364.0
Retail (2019)	283		164.2	250.3	354.8

b. Average BEI values by building type can help in monitoring national trends in building energy efficiency. Figure 14 shows average EUI (or BEI) against years, illustrating the trend of energy performance of Singapore office buildings, hotels, retail buildings, and mixed developments that have attained Green Mark certification since 2008. The EUI of office buildings has improved by 19% since 2018, retail buildings by 8%, and mixed developments by 13%.

Figure 14. Average EUI Trend Breakdown for Commercial Buildings



Source: Building and Construction Authority of Singapore (2022)

At the commencement of Energy Efficiency and Conservation Act (RA11285) in Philippines, it is expected to have greater energy savings because of the Philippines after establishing the values reported in this study which shows that Retail and Office spaces in Metro Manila has comparable EUIs to Buildings in Singapore 14 years ago, as seen in Figure 13.

5. Recommendations

There is a need for a further and more thorough study on specific factors that affect energy consumption and how we can improve the EUI data gathering and monitoring for commercial establishments, given our survey experience with them, such as data quality issues, availability, and energy management knowledge.

Below are the recommended interventions to address these gaps, provide a stronger foundation for energy performance review and monitoring, and as well as support the DOE's strategic plans for their energy management program:

1. Educate or Train the Designated Establishments (DE) on proper data definition, gathering plan, monitoring, recording, collection, and establishment of their energy performance measurements, EUI, and energy baseline. This is a common weakness among designated establishments as they tend to focus right away on projects or technology upgrades without understanding the essentials of energy management.

2. Recognized Training Institutions (RTI) must reinforce training/education of CEM, CECO, and CEA on the proper energy management framework, the importance of data quality, energy performance analysis, baselining and benchmarking. Proper reporting to ensure that we capture the actual performance of the DEs as part of the annual reporting to DOE.

3. Designated establishments (DE)'s must include in their monitoring and reporting their energy performance trend versus EUI baseline utilizing their current and past/historical performance figures.

4. Designated Establishments must provide support and incentives in developing CEM, CECO, and CEA capabilities in designing their own Energy Management programs, goals, strategies, and plans for improving their EUI.

5. Integrate organization development and project management in energy programs, so Energy Managers and Conservation Officers have a more holistic perspective on using energy in their facilities.

6. DOE may also include the assessment of the DE's energy management performance and accomplishments (e.g., adoption of the energy management system, presence of a baseline, EUI, and performance trend) in the required regular energy audit report or annual energy reports soonest to support the planned MEP and NZEB program in 2025. This is consistent with the expected obligations (integrate an energy management program) of the DEs as stipulated in the implementing rules and regulations. The energy audit is not simply focusing on specific technology issues/project opportunities but also the presence and effectiveness of the energy management system, programs, processes, practices, organization, people, and the DE's regulatory compliance.

7. Likewise, Energy Auditors, in conducting an energy audit, must also include the assessment of the Des energy management program, presence of a baseline, EUI, and performance trends, among others, in the initial phase of the energy audit following best practices. This was also identified in the DOE's department circular on the role of the Energy Auditor.

8. DOE can consider using the above recommended initial EUI information in establishing the industry/sector initial EUI or energy performance standard as the basis for inputs to the planned MEP requirements in 2025. Commercial building EUI can further be classified beyond the office and retail (e.g., BPO, mixed-use, hospital, schools, data center, etc.) subject to the availability of reliable data in the commercial sector for more focused application of energy performance.

9. Feedback / Requests from respondents:

   a. There was an expressed need for developing awareness and capacity building of businesses (especially Energy managers).

   b. Request to share results of the survey

   c. Request for updates from DOE on the next steps.

References

Buthmann, A. (2018). *Dealing with Non-normal Data: Strategies and Tools*. Researchgate. https://www.researchgate.net/file.PostFileLoader.html?id=55ca31c860614b35218b45d0&assetKey=AS%3A273670528798725%401442259546595

Department of Energy. 2019. 2019 Philippine Power Situation Report. Retrieved on November 10, 2022: https://www.doe.gov.ph/sites/default/files/pdf/electric_power/2019-power-situation-report.pdf?withshield=1

Department of Energy. 2019. Philippine Power Statistics. *Department of Energy, December 2019. https://www.doe.gov.ph/energy-statistics/2019-power-statistics?withshield=1*

Department of Energy. 2019. Republic Act 11285: An Act Institutionalizing Energy Efficiency And Conservation, Enhancing The Efficient Use Of Energy, And Granting Incentives To Energy Efficiency And Conservation Projects. *Department of Energy. https://www.doe.gov.ph/laws-and-issuances/republic-act-no-11285?withshield=1*

Department of Energy. 2022. IAEECC Resolution No. 5 Series of 2022: Directing All Government Entities (GEs), including the Local Government Units (LGUs) and Foreign Service Posts to Observe the Approved Government Energy Management Program (GEMP) Guidelines. Retrieved on November 10, 2022: https://www.doe.gov.ph/sites/default/files/pdf/energy_efficiency/iaeecc-resolution-no-5-s-2022.pdf

Department of Public Works and Highways (DPWH). 2015. Philippine Green Building Code. Retrieved on November 6, 2022: https://www.dpwh.gov.ph/DPWH/sites/default/files/laws_codes_orders/PgbcBooklet23March.pdf

Hasan, A. M., Tuhin, R. A., Ullah, M., Sakib, T. H., Thollander, P., & Trianni, A. (2021). A comprehensive investigation of energy management practices within energy intensive industries in Bangladesh. Energy, 232, 120932. https://doi.org/10.1016/j.energy.2021.120932

Sainani, K. L. (2012). *Dealing With Non-normal Data*. PM&R, 4(12), 1001-1005. https://doi.org/10.1016/j.pmrj.2012.10.013

Appendices

Appendix A. Survey Links

PART 1
https://apspinoy.info/form/view.php?id=40399

PART 2-4 (2018)
https://apspinoy.info/form/view.php?id=38898

PART 2-4 (2019)
https://apspinoy.info/form/view.php?id=40122

EXCEL SURVEY LINK
https://drive.google.com/file/d/1kS8FNn8oRYgC8Lv2_zot0ZNyJB3pHzWQ/view?usp=sharing

Appendix B. List of Companies provided by DOE

https://drive.google.com/file/d/11SRV3IccxaNYU0NHvz3Nta57rhwBgUqz/view?usp=sharing

Appendix C. List of Companies (According to Responses by Category)

https://drive.google.com/file/d/1KsuOyU87hKf96-Lj4Bpgz3xN37d6ghwZ/view?usp=sharing

Appendix D. Presentation Materials

- Project Team Presentations
  https://drive.google.com/drive/folders/1vKrnA6-Ol8SrnT475yTMd2d8p2jawk2S?usp=sharing

- Reports to DOE and ERIA
  https://drive.google.com/drive/folders/1VtBilqcZ_w1i4Pd88Mekf0li-ikeGhK9?usp=sharing

Appendix E: Project Resource Guide (Operations Manual)

https://drive.google.com/file/d/19VcuFW48IvfJ2I-DpWj0tGrHlag7XP67/view?usp=sharing

Appendix F: Supplementary Survey Results/ Analysis and Other Information

https://docs.google.com/document/d/1jx5InLJyQr-GCPL6UgElbTqKOOlBd0vUPxCP6Suxjms/edit?usp=sharing

I. Energy Efficiency Data using Building EUI for Commercial Offices (2018 and 2019)

   A. Correlated with Total kWh Consumption (Sorted from highest to lowest - 2018 and 2019)

   B. Correlated with Total Gross Floor Area (GFA) (Sorted from highest to lowest - 2018 and 2019)

II. Energy Efficiency Data using Building EUI FOR Commercial Retail (2018 and 2019)

   A. Correlated with Total kWh Consumption (Sorted from highest to lowest - 2018 and 2019)
   B. Correlated with Total Gross Floor Area (GFA) (Sorted from highest to lowest - 2018 and 2019)

III. kWh Load Breakdown for Office and Retail (2018 and 2019)

   A. kWh Load Breakdown Office (2018 and 2019)

   B. kWh Load Breakdown Retail (2018 and 2019)

IV. Water Utilization (in Li) and Water Use Intensity (Li/m2) for Commercial Office and Retail (2018 and 2019)

   A. Water Utilization (in Li) Correlated with Water Use Intensity (Li/m2) for Commercial Office (2018 and 2019)
   B. Water Utilization (in Li) correlated with Water Use Intensity (Li/m2) for Commercial Office -Sorted by EUI (2018 and 2019)
   C. Water Utilization (in Li) Correlated with Water Use Intensity (Li/m2) for Commercial Retail (2018 and 2019)
   D. Water Utilization (in Li) Correlated with Water Use Intensity (Li/m2) for Commercial Retail – Sorted by EUI (2018 and 2019)

V. Monthly Energy Use (in kWh) for Commercial Office (2018 and 2019)

   A. Electricity Consumption (in kWh) for 2018 and 2019

   B. Diesel Consumption (in Li) for 2018 and 2019

   C. Water Consumption (in Li) for 2018 and 2019

VI. Monthly Energy Use (in kWh) for Commercial Retail (2018 and 2019)

   A. Electricity Consumption (in kWh) for 2018 and 2019

   B. Diesel Consumption (in Li) for 2018 and 2019

   C. Water Consumption (in Li) for 2018 and 2019

   D. LPG Consumption (in kgs) for 2018 and 2019

Appendix G: Raw Data in Excel Format

https://drive.google.com/drive/folders/1oMrhckWPoxR6xry_v1pwcMCAi51onsna

Appendix H: Calculation and Characterization of Commercial buildings

https://docs.google.com/spreadsheets/d/13c541J2fONsLesHKliaUHdxDr_EX-zfs/edit?usp=sharing&ouid=111155141937253252522&rtpof=true&sd=true

Appendix C

Energy Consumption Survey Questionnaire for the Industry Sector

Table AC-1. General Information

Company name:							
Address of factory:							
Contact person, & position:	**Name:**		**Position:**				
Contact phone no. & email:	**Telephone:**		**Email:**				
Industry category: (To indicate the industry category that best describes the factory production)	**1) Sugar factories** **2) Cement factories** **3) Food factories (beverages and canned & packaged food)**						
Desription of products (please state type of main products and measurement of production outputs, e.g. kg, tonnes, m^3, liter, etc.):	**1) Main products:** **2) Unit of production output:**						
Type of fuels used:	**1) Bituminous coal**	**2) Diesel**	**3) Fuel oil**	**4) LPG**	**5) Natural gas**	**6) Fuel wood & wood waste**	
Calorific value of respective fuels:	**1) 24,618 kJ/kg**	**2) 42,600 kJ/kg**	**3) 42,600 kJ/kg**	**4) 47,700 kJ/kg**	**5) 36,031 kJ/kg**	**6) 15,500 kJ/kg**	
Category of production processes (to indicate which processes are deployed in factory):	**Examples:** **1) Steam generation:** **2) Heating:** **3) Process cooling:** **4) Others (to specify):**	*To fill in details below.* *1.* ..... *2.* ..... *3.* ..... *4.*					

Table AC2. Energy Consumption and Production Data of Industrial Sector

	Year	Electricity (utility bills)	Onsite power generation consumption)	Fuel #1 (State fuel type & consumption)		Fuel #2 (State fuel type & consumption)		Fuel #3 (State fuel type & consumption)		Total Thermal Energy [G+I+K]	Total Electricity Consumption [D+E]	Equivalent Electricity Consumption in MJ/y [M x 3.6]	Total yearly energy consumption [L+N]	Production output #1	Production output #2	Production output #3	Production output #4	Total production output [P+Q+R+S]	Energy Use Intensity, EUI [O/T]	Remarks
Fuel type:		Electricity									Electricity									To state fuel type used (eg. fuel oil, diesel, natural gas) and respective CV values
Calorific Value		N/A	N/A																	1) To obtain fuel consumption in physical unit of fuels from survey respondents.
Unit		(kWh)	(kWh)	(.....)	(MJ/y)	(.....)	(MJ/y)	(.....)	(MJ/y)	(MJ/y)	(kWh/y)	(MJ/y)	(MJ/y)	(production unit/y)	(production unit/y)	(production unit/y)	(production unit/y)	(production unit/y)	(MJ/prod unit/y)	2) Fuel energy consumption is computed from the amount of fuels consumed and respective calorific values.
	TOTAL Year #1: 2018				0		0		0	0	-	-	-					0		3) Equivalent electricity consumption in Column N is a direct conversion from electricity consumption to equivalent thermal energy unit, based on 1 kWh = 3.6 MJ.
	TOTAL Year #2: 2019				0		0		0	0	-	-	-					0		4) The computation of EUI is estimated in Column U.

Table AC-3. Breakdown of Energy Consumption in Processes

	Production Processes with energy consumption breakdowns														
		Fuel 1		Fuel 2		Fuel 3		Fuel 4			Electricity				
	To state processes in application of energy and electricity (e.g. steam, drying, process cooling, process automation, etc.)	Fuel 1 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 1 Energy Consumption ..... (MJ/y)	Fuel 2 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 2 Energy Consumption ..... (MJ/y)	Fuel 3 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 3 Energy Consumption ..... (MJ/y)	Fuel 4 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 4 Energy Consumption ..... (MJ/y)	Total Thermal Energy [E+G+I+K]	Electricity (utility bills) (kWh/y)	Onsite Power Generation (kWh/y)	Equivalent Electricity Consumption in thermal energy unit (MJ/y)	Total yearly energy consumption (MJ/year) [L+O]	Remarks
Year #1 2018										0			0		Note: 1) The main purpose of this table is to estimate % share of energy consumption by respective processes. 2) Equivalent electricity consumption in ColumnSM & N is a direct conversion from electricity consumption to equivalent thermal energy unit, based on 1 kWh = 3.6 MJ. 3) The total yearly consumption of all processes should tally with the corresponding values in Table 2.
										0			0		
										0			0		
										0			0		
										0			0		
Total Year #1										0			0	0	
Year #2 2019										0			0		
										0			0		
										0			0		
										0			0		
										0			0		
Total Year #2										0			0	0	

Table AC-4. Computation of EUI with Product Breakdowns for Different Products with Different Measurement Units

Energy consumption breakdowns and product breakdowns for factories that produce different products having different measurement units, e.g. ton, m^3, etc.																	
	Fuel 1		Fuel 2		Fuel 3		Fuel 4			Electricity							
	Fuel 1 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 1 Energy Consumption ..... (MJ/y)	Fuel 2 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 2 Energy Consumption ..... (MJ/y)	Fuel 3 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 3 Energy Consumption ..... (MJ/y)	Fuel 4 ..... (To state type & physical unit of consumption per year, e.g. tonnes/y)	Fuel 4 Energy Consumption ..... (MJ/y)	Total Thermal Energy (MJ/y) [D+F+H+J]	Electricity (utility bills) (kWh/y)	Onsite Power Generation (kWh/y)	Equivalent Electricity Consumption (including onsite generation) in thermal energy unit (MJ/y)	Total yearly energy consumption (MJ/year) [K+N]	Total Yearly Production Output (ton/m^3/.....)	EUI (MJ/production output/y) [O/P] MJ/production output/y	To state unit of EUI	Remarks
Calorific Value of fuel																	
Product #1									0			0	0				Note: 1) If the production output of a factory is measured by a singular and consistent unit, it is not necessary to compute EUI by individual products. 2) Equivalent electricity consumption in Column N is a direct conversion from electricity consumption in kWh to equivalent thermal energy unit (MJ) based on 1 kWh = 3.6 MJ.
Product #2									0			0	0				
Product #3									0			0	0				
Product #4									0			0	0				

Appendix D

Energy Consumption Survey Questionnaire for the Commercial Sector

Table AD-1. General Information

Commercial Sector:	1) Office building			2) Retail building		
Company name:						
Address of building:						
Contact person, & position:	Name:			Position:		
Contact phone no. & email:	Telephone:			Email:		
Desription of building:				1) Building footprint (length x width in m): 2) No. of storeys: 3) Age of building		
Gross Floor Area [excl covered carpark area] (GFA in m^2):						
Type of fuels used beside electricity:	1) Bituminous coal	2) Diesel	3) Fuel oil	4) LPG	5) Natural gas	6) Fuel wood & wood waste
Calorific value of respective fuels:	1) 24,618 kJ/kg	2) 42,600 kJ/kg	3) 42,600 kJ/kg	4) 47,700 kJ/kg	5) 36,031 kJ/kg	6) 15,500 kJ/kg

Table AD-2. Energy Consumption and Building Data of Office and Retail Buildings

	Year	Electricity from utility bills	Onsite power generation	Fuel #1 (state fuel type & consumption)		Fuel #2 (state fuel type & consumption)		Fuel #3 (state fuel type & consumption)		Total Thermal Energy (MJ) (G+I+K)	Total Electricity Consumption (D+E)	Equivalent Thermal Energy in kWh	Total energy consumption [M+N]	Gross Floor Area (GFA)	Building Energy Intensity BEI (preliminary estimates) [O/P]	Estimated floor vacancy in percentage	Building Operating Hours	Rationalised BEI (To be computed after establishing national average building operating hours per week)	Remarks
Fuel type:		Electricity																	Notes: 1) The thermal energy conversion in columns G, I & K is based on calorific value (CV) in MJ/tonne or MJ/m^3. If CV is in other unit, appropriate conversion factor needs to be used to work out energy consumption in MJ/year. 2) Onsite power generation to be in kWh. 3) Column O is a direct conversion from MJ to kWh based on 1 kWh = 3.6 MJ 4) GFA to exclude carpark area inside building, i.e. basement carpark area.
Calorific Value		N/A	N/A																
Unit		(kWh)	(kWh)	(.....)	(MJ)	(.....)	(MJ)	(.....)	(MJ)	(MJ)	(kWh)	(kWh)	(kWh)	(m^2)	(kWh/m2/y)	(%)	(Hours/week)	(kWh/m2/y)	
	TOTAL Year #1 2018									-	-	-	-						
	TOTAL Year #2 2019									-	-	-	-						

Table AD-3. Details of Air-conditioned Spaces for Estimating Energy Consumption by Air-conditioning System

	Retail Building / Block								Office Building / Block									
	Retail air-conditioned area including Podium Block (m^2)	Common area including lobby, corridors, promotion area, etc. (m^2)	Other area (To specify ..... (m^2)	Retail - Podium Block State no. of floors	Estimated years of service for A/C system (No. of years)	A/C system Operating Hours (hours/week))	COP of A/C system	TOTAL Floor area (m^2)	Office Block Air-conditioned Area (m2)	Common area including lobby, corridors, etc. (m^2)	Other area (To specify ..... (m^2)	Office Block (State no. of floors)	Estimated years of service for A/C system (No. of years)	A/C system Operating Hours (hours/week))	COP of A/C system	TOTAL Floor area (m^2)		Remarks
Centralised conditioning system with water-cooled chillers. Floor areas are served by AHU																		Note: 1) Air-conditioned floor area includes all air-conditioned usable spaces including common areas such as corridors, lobby, pantries, etc. 2) Comparing the total air-conditioned area with the building GFA, what is the percentage difference? If the difference ≥ 30% for retail building and ≥ 20% for office bilding, please revisit and check again to improve the accuracy. 3) Obtain COP of main air-conditioning equipment, such as chillers, VRV/VRF, split unit air conditioners from nameplates, O&M manuals, etc.
Centralised conditioning system with air-cooled chillers. Floor areas are served by AHUs																		
VRV / VRF air-conditioning system																		
Split unit air-conditioners																		
Other A/C system (to specify.....)																		
Total																		**Total GFA= .....**

Table AD-4. Lighting Installations in Retail Buildings for the Estimation of Electricity Consumption by Lighting

	Main & side entrances, promotion areas, etc.		Fine merchandising area		General, food & miscellaneous merchandising		Snack Bars & cafeteria + Leisure & Dining Bar		Storage area		Common Area incl. Corridors/Closets		Miscellaneous Area (loading area, etc.) @3 W/m2		Continuous lighting area for security & safety purposes		Other area (To specify .....)		Total Area	Total Lighting Power	Operating Hours per week	Total Lighting Electricity Consumption	Remarks
	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(h)	(kWh/y)	
High traffic area @100 W/m^2		0																		0		0	Note:
Light traffic area @10 W/m^2		0																		0		0	1) Total breakdown floor areas should be equal to GFA. If there is a difference, it should be within 5%.
Retail stores Type A Fine & Mass Merchandising @23 W/m^2				0																0		0	2) External carpark area is not included.
Retail stores Type B General, Food & Misc l Merchandising @22 W/m^2						0														0		0	3) Column X Operating Hours per week should be the same as the building operating hours in Table 2.
General shopping arcades @15 W/m^2						0														0		0	
Snack bars & cafeteria + leisure & dining bar @14 W/m^2								0												0		0	
Storage area @4 W/m^2										0										0		0	
Corridors / Closets @4 W/m^2												0								0		0	
Misc l area incl loading area @3 W/m^2														0		0				0		0	
Total Area (m^2)	0		0		0		0		0		0		0		0		0		0				
Total Lighting Electricity Consumption (kWh)																						0	

Table AD-5. Lighting Installations in Office Buildings for the Estimation of Electricity Consumption by Lighting

	Entrance area		Office area		Common area e.g. corridors, closets		Storage area		Miscellaneous Area (loading area, etc.) @3 W/m^2		Continuous lighting area for security purposes		Other area (To specify.....)		Total area	Total Lighting Power	Operating Hours per week	Total Lighting Electricity Consumption	Remarks
	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(m^2)	(kW)	(h/week)	(kWh/y)	Note: 1) Total breakdown floor areas should be equal to GFA. If there is a difference, it should be within 5%. 2) External carpark area is not included. 3) Column T Operating Hours per week should be the same as the building operating hours in Table 2.
Light traffic area @10W/m^2		0														0		0	
Office area @10 W/m^2				0												0		0	
Common area @4 W/m^2						0										0		0	
Storage area @4 W/m^2								0								0		0	
Miscl area @3 W/m^2										0		0				0		0	
Total Area	0		0		0		0		0		0				0				
Total Lighting Electricity Consumption																		0	