

# REPORT

## Survey on Household Use of Energy Efficient Light Bulbs in North Sumatera



### Submitted to:

DANIDA Environmental Support Program (ESP3)

and

Directorate General of New, Renewable Energy, and Energy  
Conservation (EBTKE) Ministry of Energy and Mineral Resources  
(MEMR)



Indonesian Institute for Energy Economics (IIEE)

**Jakarta, March 2016**

# Table of Contents

Table of Contents .....	ii
List of Tables .....	v
List of Figures .....	vii
Executive Summary .....	viii
Average daily energy use of light bulbs .....	viii
Availability and price of lamps in the market .....	ix
Energy saving potential .....	x
Cost-benefit of CFL to LED replacement.....	xii
Implementation mechanism of lamp replacement program .....	xii
Monitoring and evaluation framework .....	xii
Chapter 1.....	1
INTRODUCTION.....	1
1.1    Background.....	1
1.2    Objective.....	2
1.3    Expected Output .....	2
1.4    Benefit of the Survey.....	3
Chapter 2.....	4
METHODOLOGY .....	4
2.1    Research Approach and Design .....	4
2.2    Survey Preparation and Data Collection .....	5
2.2.1    Survey Preparation.....	5
2.2.2    Data Collection Instrument.....	6
2.3    Survey Method.....	7
2.3.1    Survey Sites .....	7
2.3.2    Sampling Size Determination and Selection of Respondents .....	8
2.4    Data Analysis Technique.....	9

2.4.1	Output 1 - Average daily energy use of light bulbs in selected areas of North Sumatra Province	9
2.4.2	Output 2 - Data on energy saving light bulbs available at the retail market in selected areas of North Sumatra Province .....	9
2.4.3	Output 3 - Potential for energy saving from replacing existing lamps with energy efficient types	10
2.4.4	Output 4 - Investment needs to replace existing light bulbs with energy efficient lamps in a selected area of North Sumatra Province .....	10
2.4.5	Output 5 - Selection criteria and number of households that will be appropriate beneficiaries of energy efficient light bulbs replacement program .....	11
2.4.6	Output 6 - Monitoring and evaluation framework for energy savings and cost-benefit of replacement program.....	11
Chapter 3.....		13
GENERAL PROFILE AND ELECTRICITY SECTOR IN SURVEY REGIONS .....		13
3.1	General Profile and Electricity Sector in North Sumatera .....	13
3.2	General Profile and Electrification in South Sumatera.....	16
3.2.1	Medan.....	16
3.2.2	Deli Serdang.....	17
3.2.3	Simalungun .....	17
Chapter IV .....		19
GENERAL FINDINGS .....		19
4.1	Survey Implementation .....	19
4.2	Description Profile of Respondents .....	20
4.2.1	Age of Respondents.....	20
4.2.2	Respondents Education Level .....	20
4.2.3	Number of Household Members .....	21
4.2.4	Household Consumption Expenditure.....	21
4.3	Description of Household Profile as PLN Customers .....	22
4.3.1	PLN Bill Payment System .....	22
4.3.2	Electricity Use.....	23
4.3.3	Electricity Consumption Expenditure .....	24
4.4	Description of Numbers of Mounted Lamps, Light Capacity and Duration of Light Usage.....	25

4.4.1	Number of Mounted Lamps.....	25
4.4.2	Lights Wattage .....	33
4.4.3	Duration of Lights Use .....	35
Chapter V.....		37
RESULTS AND DISCUSSION .....		37
5.1	Output 1 – Average Daily Energy Consumption for Household Lighting .....	37
5.2	Output 2 – Availability of Energy Saving Lamps in the Market.....	38
5.3	Output 3 – Potential Savings from Lighting Replacement Program .....	41
5.4	Output 4 – Investment for Lamp Replacement Program.....	44
5.5	Output 5 – Selection Criteria and Number of Households to Benefit from the Lamp Replacement Program .....	45
5.6	Output 6 – Monitoring and Evaluation Framework for Energy Saving and Cost-Benefit Analysis of the Program .....	47
5.6.1	Monitoring and Evaluation Framework for Energy Saving Program.....	48
5.6.2	Cost-Benefit Analysis of the Program.....	57
Chapter V.....		61
CONCLUSIONS AND RECOMMENDATIONS.....		61
5.1	Conclusion .....	61
5.2	Suggestions.....	63
Appendix A – Household Questionnaire.....		64
	Kuesioner .....	64
	Konsumsi Energi untuk Penerangan di Rumah Tangga .....	64
Appendix B – Market Questionnaire .....		71
	Kuesioner .....	71
	Ketersediaan Lampu di Pasaran .....	71
Appendix C.....		1
Appendix D.....		3

# List of Tables

Table 1 Survey sites selection process.....	7
Table 2 Number of respondents based on electrification class .....	9
Table 3 Number of customers and installed power .....	14
Table 4 GDP and GDP per capita 2013.....	14
Table 5 Distance from each district to the capital of North Sumatera .....	16
Table 6 Area, population, and population density of Medan in 2014.....	16
Table 7 Number of customers, installed power capacity, power sales, and sales revenue in Medan PLN branch .....	17
Table 8 Number of customers, installed power capacity, power sales, and sales revenue in Lubuk Pakam branch .....	17
Table 9 Number of customers, installed power capacity, power sales, and sales revenue in Pematang Siantar branch .....	18
Table 10 Composition of respondents' distribution .....	19
Table 11 Age of respondents .....	20
Table 12 Education level of respondents .....	21
Table 13 Number of household members .....	21
Table 14 Household consumption expenditure .....	22
Table 15 Electricity use .....	23
Table 16 Electricity consumption expenditure.....	24
Table 17 Mann Whitney test result between Medan and Deliserdang in customer class 450 VA .....	29
Table 18 Mann Whitney test result between Medan and Simalungun in customer class 450 VA .....	29
Table 19 Mann Whitney test result between Deliserdang and Simalungun in customer class 450 VA .....	30
<b>Table 20</b> Mann Whitney test result between Medan and Deliserdang in customer class 900 VA .....	30
<b>Table 21</b> Mann Whitney test result between Medan and Simalungun in customer class 900 VA .....	31
<b>Table 22</b> Mann Whitney test result between Deliserdang and Simalungun in customer class 900 VA .....	31
<b>Table 23</b> Mann Whitney test result between Medan and Deliserdang in customer class 1300 VA .....	32
<b>Table 24</b> Mann Whitney test result between Medan and Simalungun in customer class 1300 VA .....	32
<b>Table 25</b> Mann Whitney test result between Deliserdang and Simalungun in customer class 1300 VA...	33
Table 26 Types and price of CFL and LED light bulbs in 30 stores .....	40
Table 27 Price comparison of incandescent light bulb, CFL, and LED lamps for certain wattage.....	41

Table 28 Energy saving potential in household .....	42
Table 29 PLN customer number based of branches and PLN customer class .....	43
Table 30 Energy saving potentials for North Sumatera .....	43
Table 31 Saving of generation capacity in North Sumatera .....	44
Table 32 Investment for light-bulb replacement program .....	45
Table 33 Scoring results for the selection of beneficiaries .....	46
Table 34 Various Payback Period, NPV, and IRR from purchase of saved energy .....	56
Table 35 Calculation of payback period .....	58
Table 36 Potential subsidy saving .....	58
Table 37 Comparison of benefit from using LED lamps .....	59
Table 38 Emissions savings from lamp replacement program.....	60

# List of Figures

Figure 1 General Methodology .....	4
Figure 2 Map of survey sites .....	8
Figure 3 Bill payment system .....	23
Figure 4 Number of mounted lamps in survey regions .....	25
Figure 5 Mounted lamps composition in 450 VA class.....	26
Figure 6 Mounted lamps composition based on region in 450 VA class .....	26
Figure 7 Mounted lamps composition in 900 VA class.....	27
Figure 8 Mounted lamps composition based on region in 450 VA class .....	27
Figure 9 Mounted lamps composition per households in 1300 VA class.....	28
Figure 10 Mounted lamps composition based on region in 450 VA class.....	28
Figure 11 Wattage of lamps used in customer class 450 VA.....	33
Figure 12 Wattage of lamps used in customer class 900 VA.....	34
Figure 13 Wattage of lamps in 1300 VA households .....	34
Figure 14 Lamps duration of use per area in household class 450 VA .....	35
Figure 15 Lamps duration of use per area in household class 900 VA .....	35
Figure 16 Lamps duration of use per area in household class 1300 VA .....	36
Figure 17 Average daily energy consumption for lighting .....	37
Figure 18 Percentage of stores which provide light bulbs .....	38
Figure 19 Percentage and amount of available lightbulbs per area .....	39
Figure 20 The share of light bulb availability .....	39
Figure 21 Monitoring and evaluation framework .....	48
Figure 22 Light bulb replacement program implementation mechanism .....	49
Figure 23 Dissemination Program to regional governments and their staffs.....	50
Figure 24 Mechanism of cooperation with ESCO .....	54
Figure 25 Mechanism of lamp distribution by ESCO .....	57

# Executive Summary

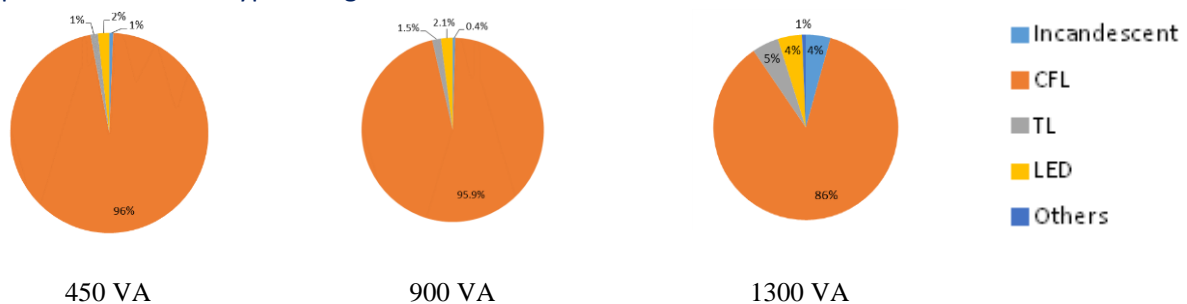
In this assignment, a survey on the electricity consumption characteristics for lighting in household sector for selected areas of North Sumatra Province was conducted by the Ministry of Energy and Mineral Resources (MEMR) directorate of New Renewable Energy and Energy Conservation, Environmental Support Program 3 (ESP3), *Danish* International Development Agency (DANIDA) and Indonesian Institute for Energy Economics (IIEE). Medan, Simalungun, and Deli Serdang were selected as the area for survey sites. Around 400 household comprising 450, 900, and 1,300 VA in each city were surveyed. In addition, this survey also collected the data from 10 lighting appliances shops in each city.

This study covers: (1) average daily energy use of light bulbs, (2) data on price, type and producers of energy saving light bulbs available in the market, (3) potential of energy saving from replacing existing lamps with energy efficient types and data on the amount and types of bulbs required by individual households, (4) Investment needed for a program to replace existing light bulbs with energy efficient lamps, (5) selection criteria that will be appropriate beneficiaries of energy efficient light bulbs replacement program, and (6) monitoring and evaluation framework covering energy savings and cost-benefit of replacement program.

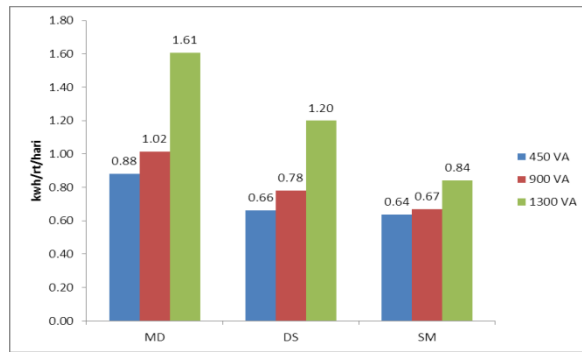
## Average daily energy use of light bulbs

Average daily energy use of light bulb was calculated by averaging the multiplication of: number of lamps per household (lamps/hh), power consumption (W), and the duration of use (h). Results show that numbers of lamps per household were 5.8, 6.7, and 9.2 lamps per household for the consumer group of 450, 900, and 1300 VA, respectively. The composition of types of lamps for each group is presented in the following figures.

Composition of various types of light bulbs in households





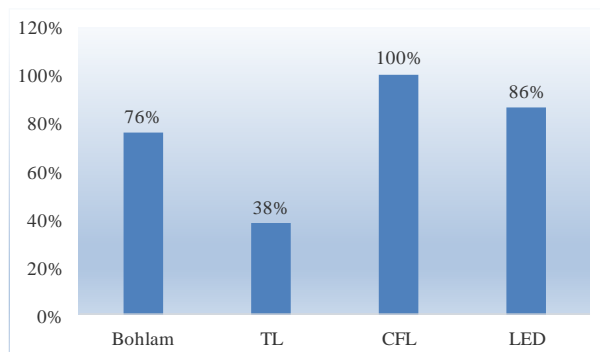


Average daily energy consumption for lighting in various consumer groups and survey locations

Clearly, Compact Fluorescent Lamp (CFL) dominates the ownership of lamps in the surveyed areas. Therefore, the energy efficiency improvement program should be done by focusing on replacing CFL by the more efficient one i.e Light Emitting Diode (LED). This figure also shows that electricity consumption is influenced by economic factors (GRDP/capita), which shows that Medan city has higher electricity consumption for lighting, followed by Deliserdang and Simalungun, respectively.

### Availability and price of lamps in the market

This study found CFL type was the most easily found in the surveyed shops. Number of shops that stock lamps by its type as percentage to the total surveyed shops is presented in the following Figure.



Percentage of shops that stock lamps by its technology

Based on the price of CFL and LED light bulbs most commonly found in the market, the study found that manufacturers of CFL and LED lamps can be grouped into two different market segments (see table below)

#### Price and specifications of LED and CFL lamps

Wattage	CFL Lamp Price (Rp)		LED Lamp Price (Rp)	
	Brand A	Brand B	Brand A	Brand B
3-5	15,000-30,000	16,000-20,000	48,000-59,000	15,000-30,000
6-9	19,000-31,000	16,000-21,000	80,000-100,000	33,000-62,000
10-14	28,000-35,000	17,000-24,000	100,000-126,000	48,000-61,000
15-40	25,000-50,000	23,000-40,000	>126,000	190,000-240,000
Product specification		Energy saving 85%	Energy saving 85%	
		Life span: 15,000 hours	Umur Lampu: 15,000 jam	
		Warranty: 1 year	Warranty: 1 year	

#### Energy saving potential

Energy saving potential was calculated by introducing energy efficiency scenarios i.e. by replacing the existing CFL lamps with LED for the same lumen. Proposed scenarios for the replacement program is presented in the following Table.

#### Lamp replacement program scenario

Area	PLN Customer Class	Lamp replacement			Energy saving (kWh/hh/ year)
		from CFL	to LED	Number of lamps to be replaced	
MD	450 VA	13 watt	6 watt	2	53.90
	900 VA	18 watt	9 watt	2	66.02
	1300 VA	18 watt	9 watt	2	57.98
DS	450 VA	13 watt	6 watt	2	25.92
	900 VA	18 watt	9 watt	2	35.60
	1300 VA	18 watt	9 watt	2	48.03
SM	450 VA	13 watt	6 watt	2	31.31
	900 VA	13 watt	6 watt	2	33.01
	1300 VA	13 watt	6 watt	2	25.15

Of the potential savings per household in the table above, energy saving for the entire region of North Sumatera was estimated by multiplying household energy saving with the total number of customers for each class. In order to be more accurate, potential household saving is used to estimate total energy saving of the regions with the similar characteristics. The areas in North Sumatera were grouped into two GRDP/capita groups, i.e. upper-middle and lower-middle GRDP/capita. Total potential saving for the entire region of North Sumatera can be seen in the following table.

#### Energy Saving Potential in North Sumatera

GRDP/capita	PLN Customer Class	Wattage of CFL to be replaced	Number of Lamps to be Replaced	Energy saving (kWh/hh/year)	Number of customers	Total energy saving (Gwh/year)
Upper-middle	450 VA	13	2	37.38	1,049,728	39.24
	900 VA	18	2	51.76	891,663	46.15
	1300 VA	18	2	55.06	172,966	9.52
Lower-middle	450 VA	13	2	31.31	342,915	10.74
	900 VA	13	2	33.01	126,681	4.18
	1300 VA	13	2	25.15	17,231	0.43
Total energy saving in North Sumatera						110.27

Although 110 GWh of electricity saving could only contribute to 1% of electrical energy production, construction of power plants with capacity of 40.68 MW can be avoided. With current generation capacity of 1889 MW and peak load of 1880 MW, 40.68 MW of savings can potentially reduce peak load or adding the reserve margin to 2.16%.

#### Investment needed

Total Investment required for each GRDP/capita and PLN customer class for the above scenario, as well as total investment for North Sumatera, is as follows:

#### Investment Needed for North Sumatera

GRDP/capita	Customer Class	Number of lamps replaced	Price of equal LED (Rp)	Distribution cost (Rp)	Investment (Rp)
Upper middle	450 VA	2,099,456	35,000	1,750	77,155,008,000
	900 VA	1,783,326	40,000	2,000	74,899,692,000
	1300 VA	345,932	40,000	2,000	14,529,144,000
Lower middle	450 VA	685,830	35,000	1,750	25,204,252,500
	900 VA	253,362	35,000	1,750	9,311,053,500
	1300 VA	34,462	35,000	1,750	1,266,478,500
Total investment					202,365,628,500

#### Selection criteria for replacement program

Criteria of selection for beneficiaries of lamp replacement program is determined by considering the following aspects:

- Saving potentials
- Number of beneficiaries
- Investment costs
- Ease of distribution

Based on the above criteria and a set of assumptions made on the lamp replacement program, the result suggested that PLN branches of Binjai, Medan, and Sibolga are the priority target for the program.

### Cost-benefit of CFL to LED replacement

The lamp replacement program in North Sumatra can potentially save subsidies for customer class 450 and 900 VA

Subsidy saving in North Sumatera

GRDP/capita	Customer class	Energy saving (GWh/year)	Electricity tariff (Rp/kWh)	Subsidized electricity tariff (Rp/ kWh)	Difference (Rp/kWh)	Subsidy saving (Rp/year)
Upper middle	450 VA	39.24	1350.57	415	935.57	36,714,991,323
	900 VA	46.15	1350.57	605	745.57	34,408,337,370
Lower middle	450 VA	10.74	1350.57	415	935.57	10,045,845,398
	900 VA	4.18	1350.57	605	745.57	3,117,568,297
Total subsidy saving in North Sumatera						84,286,742,388

### Implementation mechanism of lamp replacement program

Implementation of the program is simulated in two alternative scenarios. The first is that lamps are given for free by the donor/government, and the second alternative allows implementation of the program through ESCO mechanism with the participation of the community. The distribution of lamps by the government consists of: (i) dissemination program to local government, (ii) media campaign, (iii) preparation for distribution posts, (iv) lamps preparation and provision, and (v) distribution of lamps. Meanwhile, for the ESCO scheme, the implementation of the program will involve several stakeholders such as the Ministry of Energy and Mineral Resources, the Ministry of Finance, PT PLN, and supplier of light bulbs.

### Monitoring and evaluation framework

In general, monitoring and evaluation framework includes determining baseline electricity consumption before and after the program, energy savings, lamp replacement program effectiveness and payback periods. Stages of the activities include a recap of data, monitoring and evaluation.

In general if the lamp replacement program is implemented in North Sumatra, it will be able to save electricity by 110 GWh/year, reduce the peak load by 40.68 MW, add to the reserve margin by 2.6%, and save electricity subsidy by Rp 84.3 billion.

# **Chapter 1**

## **INTRODUCTION**

### **1.1 Background**

Power crisis are recently suffered by some region in Indonesia. Some provinces have suffered prolonged scarcity of power over the past one or two years. This caused the disturbed daily activity of people in these regions due to the regular power cuts. Frequent power cuts also potentially trigger the damage of electric appliances as well as reduced quantity and quality of small and medium scale industry. The power crises have been mostly caused by the State-owned Power Company (PLN)'s failure to fulfill the demand due to the combination of: limited production capacity of generators, damage of generators, repair of generators, insufficient water available in dams, and other causes.

North Sumatra Province is one of the provinces which are currently undergoing electricity crisis. As reported by the Directorate General of Energy and Mineral Resources, there are nine regions in Indonesia who are experiencing a power crisis. The power deficit in the nine regions are; North Sumatra-Aceh (1,788MW), West Sumatra-Riau (1,194MW), South Sumatra: (1,493MW), Bangka (130MW), West Kalimantan (406 MW), Central and South Kalimantan (543 MW), North, Central, and South Sulawesi (520 MW), Maluku 140 MW, and West Nusa Tenggara (260 MW). Based on this data, North Sumatra Province will be selected as the target for this survey.

Generally, there are two ways to address this situation. First is by provision of greater power supply and second is by reducing the use of power through energy efficiency measures. Providing greater power supply means the need to install new power generators, which will take substantial time and big investment.

Lamps are among the common appliances which operated coinciding with the peak load demand. Therefore, replacing energy-inefficient lamps with the high-efficient one such as Compact Fluorescent Lamp (CFL) and Light Emitting Diode (LED) will potentially reduce the use of power. Unfortunately, the data on the consumption characteristics for lighting to estimate potential of power and energy saving are not available. Therefore, survey on the electricity

consumption characteristics for lighting in household needs to be carried out for preparing the intervention program of power and energy reduction.

By knowing the data on the characteristics of electricity consumption for lighting in household, one can calculate not only the power and energy potential saving but also the potential saving of Green House Gasses (GHG) emissions. This will help the local government in implementing the mandate of provincial action plan for GHG emission reduction (RAD-GRK).

## **1.2 Objective**

The objective of the assignment is to determine the potential for electricity savings in North Sumatra Province if existing light bulbs are replaced with energy efficient light bulbs, based on a survey among households and the availability of the light bulbs in the market in selected areas of the province, and on this basis design and determine the cost and benefits of a programme for replacement of light bulbs.

## **1.3 Expected Output**

The expected result of this study is a report which covers:

1. Average daily energy use of light bulbs in selected areas of North Sumatra Province
2. Data on price, type/technical specifications and producer of energy saving light bulbs available at the retail market in selected areas of North Sumatra Province
3. Potential for energy saving from replacing existing lamps with energy efficient types and data on the amount and types of bulbs required by individual households
4. Investment needs and other costs for a program to replace existing light bulbs with energy efficient lamps in a selected area of North Sumatra Province
5. Selection criteria and number of households that will be appropriate beneficiaries of energy efficient light bulbs replacement program
6. Monitoring and evaluation framework covering energy savings and cost-benefit of replacement program.

## **1.4 Benefit of the Survey**

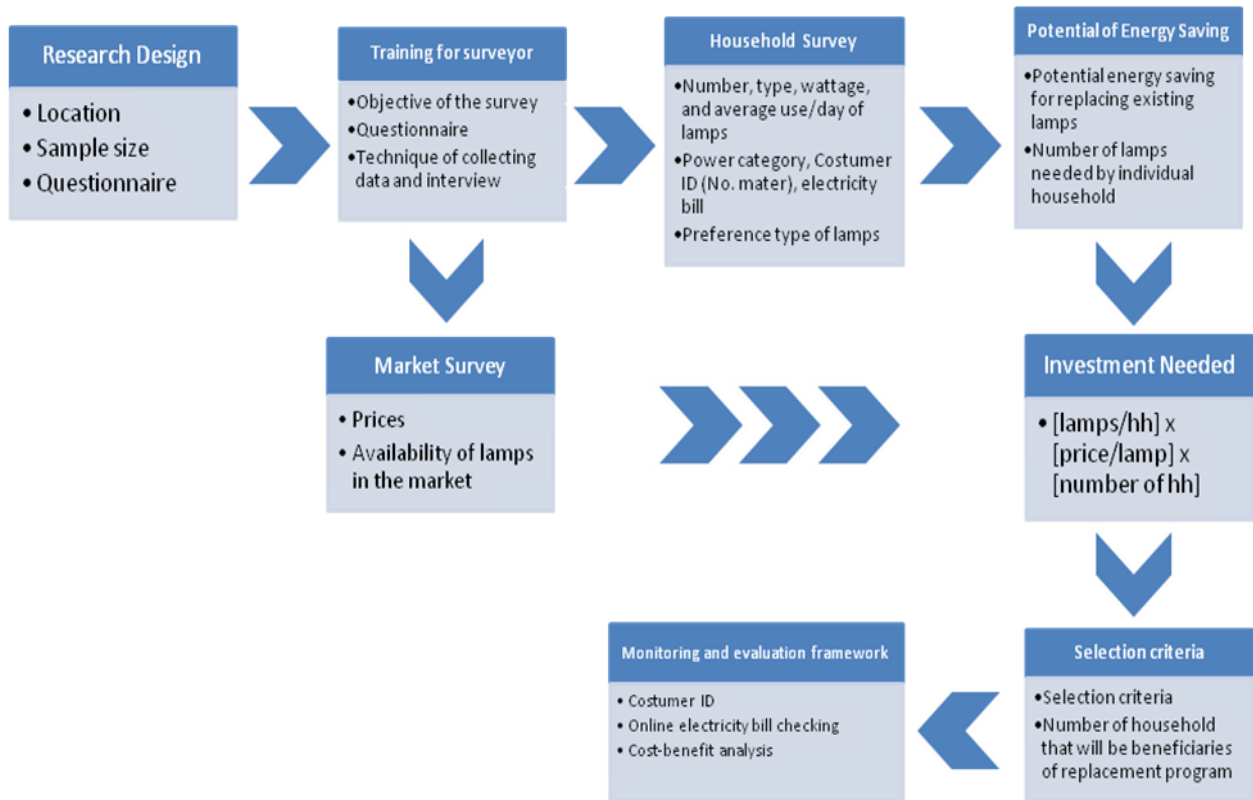
By knowing the data on the characteristics of electricity consumption for lighting in household, this work is expected to give benefit for:

1. Ministry of Energy and Mineral Resources, especially Directorate of New, Renewable Energy and Energy Conservation in terms of providing data for:
  - Calculating the power and energy potential saving of light bulb replacement program in selected areas of North Sumatra Province
  - Calculating the Green House Gasses (GHG) emissions saving of light bulb replacement program in selected areas of North Sumatra Province
  - Developing framework for preparing the intervention program of power energy reduction such as the distribution of efficient light bulbs
2. Decision makers in energy sector and lights bulbs market  
Survey results are expected to help decision makers in determining policies related to energy-saving activities.
3. Public  
The report of this study will provide information to the public regarding potential household savings from reduction of electricity consumption due to the replacement of incandescent light bulbs to energy-efficient light bulbs. This information is expected to raise public awareness for energy efficiency and encourage individual choices to implement energy-efficient light bulbs.
4. Other parties  
Survey results are expected to serve as an additional reference for other surveys relevant to energy efficiency studies.

## Chapter 2

### METHODOLOGY

This chapter describes the research approach and design, survey preparation and data collection, and survey method, which included the geographical area where the study is conducted as well as survey population and sample. Lastly, data analysis and methods implemented to maintain validity are also included in this chapter. General flowchart of the methodology used in this study is shown in **Figure 1**.



**Figure 1** General Methodology

#### 2.1 Research Approach and Design

A quantitative approach is used. Given (2008) define quantitative research as the systematic empirical investigation of observable phenomena via statistical or mathematical techniques. The objective of quantitative research is to develop theories and hypotheses pertaining to the phenomena, as well as examining cause and effect interactions among variables.



A descriptive survey design is used, which aims to provide an accurate and valid representation of the factors or variables that pertain to the research question. A survey is used to collect original data for describing a population too large to observe directly by obtaining information from a sample of people by means of self report through responding to a series of questions posed by the investigator.

## **2.2 Survey Preparation and Data Collection**

In conducting this survey, the Indonesian Institute for Energy Economics (IIEE) funded by the *Environmental Support Programme Phase 3 (ESP3)*, Ministry of Foreign Affairs, Danida Coordinated with the Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumber Daya Mineral - KESDM) and Central Statistics Agency (Badan Pusat Statistik - BPS). Coordination activities with KESDM and BPS are highly necessary because this survey is categorized as KESDM sectoral statistics activity which is done individually by a consultant. The sectoral statistics survey results also aim to support the provision of information in the interest of national development planning to build the national statistics.

In addition to consultation with the KESDM and in order for BPS to recognize and publish this sectoral statistics survey, IIEE also held meetings with a number of BPS team to inform the survey implementation plan and particularly to design the survey questionnaire. Afterwards, IIEE followed up on several recommendations from BPS and applied the procedures for notification plan of survey implementations (i.e. by filling in the notification form for sectoral statistics survey) to meet the administrative requirements.

### **2.2.1 Survey Preparation**

Survey preparation is a series of activities conducted before data collection and analysis. This phase includes constructing a detailed technical plan for data gathering and analyzing to increase time and manpower efficiency. An introductory observation was first conducted to identify the problem and formulate the survey instrument to obtain relevant information, which includes:

1. A literature study on the subject for the planning process
2. Determine the data requires
3. Determine the institutions associated to obtain secondary data

4. Provide administrative requirements for data collection
5. Construct a survey proposal for partners (DANIDA Environmental Support Program and Directorate General of New, Renewable Energy, and Energy Conservation in the Ministry of Energy and Mineral Resources)
6. Coordinate with the Central Statistics Agency (Badan Pusat Statistik – BPS) by filling in the Notification Form of Sectoral Statistics Survey to gain survey recommendations, and to incorporate the survey results into BPS’s Metadata Summary Statistics.
7. Plan the schedule for survey execution and report making.

### **2.2.2 Data Collection Instrument**

A questionnaire was chosen as data collection instrument. A questionnaire is a printed self-report form designed to elicit information that can be obtained through the written responses of the subjects. The questionnaires are carried upon to the respondents by the surveyors using a direct communicative approach. This method is chosen due to its advantages of:

1. They ensured a high response rate as the questionnaires were distributed and collected to respondents personally by the surveyor
2. There was a less opportunity for bias as they were presented in a consistent manner
3. All information was collected straight from the primary source

Apart from the advantages above, questionnaires also have their weaknesses, such as there is a question of validity and accuracy. The subjects might not reflect their true opinions but might answer what they think will please the researcher, and valuable information may be lost as answers are usually brief.

Two questionnaires were used to collect the data, one was for the domestic electricity consumers, and the other one for stores that sells light bulbs. The questionnaires consisted mostly of closed ended questions and a few open ended questions. In the close-ended questions the options are determined by the researchers, whereas open-ended questions require the subjects to respond in writing. Close-ended questions are easier to administer and to analyze, and they are more efficient in the sense that a respondent is able to complete close-ended items than open-ended items in a given period of time. Open-ended questions were included because they allow subjects to respond to questions in their own words and provide more detail.

## 2.3 Survey Method

### 2.3.1 Survey Sites

Sumatera Utara covers 33 regions with 3,037,706 households. The determination of survey region selection considered several criteria:

- Geographical coverage
- Number of household
- Gross Regional Domestic Product (GRDP)
- Customer groups representation

Ideally, survey sites should be representing high, medium, and low GRDP percapita which cover western cost, highland, and eastern coast region. However, due to budget time and budget consideration, it is decided that only regions representing all criteria are chosen as the survey sites. **Table 1** shows the site selection process for each criteria.

**Table 1** Survey sites selection process

Step	Criteria	Basis	Nominated Sites
1	Number of PLN customers and electrification class	PLN branches with highest numbers of customers	Medan, Binjai, Lubuk Pakam, Pematang Siantar
2	Number of Households	One region with the highest household numbers is chosen from the previous selected areas	Medan, Langkat, Deliserdang, Simalungun
3	Gross Regional Domestic Products	Regions with high and medium GRDP are selected	Medan, Deliserdang, Simalungun
4	Distance and Location	Selected regions should be not too far from each other for survey efficiency	Medan, Deliserdang, Simalungun

Therefore, **Medan**, **Simalungun**, and **Deli Serdang** are selected as the area for survey sites. Geographical location of the three sites is shown in **Figure 2**.



**Figure 2** Map of survey sites

### 2.3.2 Sampling Size Determination and Selection of Respondents

The method of stratified random sampling is used in this survey. In stratified random sampling, all members of population in each stratum are categorized into a homogenous group based on their similar characteristics defined by the purpose of samplings. Then samples were randomly selected from each stratum. Parameters considered for the determination of sample size are including the level of confidence and level of precision. In this study, 5% level of precision of estimated values was used, and a level of confidence of 95% was selected for sample sizes. By using the Slovin's formula in Eq. (1), to meet the above mentioned level of confidence (95%) and error estimation (5%), a minimum of 400 household for each city are needed. Therefore, this survey will at least collect the data from 1,200 household. Less than this number will potentially reduce the precision and confidence level mentioned above.

$$n = \frac{N}{(1+N \cdot e^2)} \quad , \quad (1)$$

where,

$n$  : sample size

$N$  : population

$e$  : level of precession (error estimation)

The number of respondents in each city is then proportionally allocated in accordance with the number PLN's customer classes (450 VA, 900 VA, and 1300 VA). In addition, this survey will also collect the data from 10 lighting appliances shops in each city or a total of 30

shops. **Table 2** shows the number of respondents needed for each electrification class in each survey sites.

**Table 2** Number of respondents based on electrification class

Class (VA)	Medan		Deliserdang		Simalungun	
	Customers percentage	Respondents (households)	Customers percentage	Respondents (households)	Customers percentage	Respondents (households)
450	36%	144	51%	206	57%	228
900	46%	186	41%	166	38%	153
1300	18%	70	7%	29	5%	19
Total	100%	400	100%	400	100%	400

## 2.4 Data Analysis Technique

After the data was collected, it was organized and analyzed to produce 6 deliverables or outputs. Methods for each deliverables are elaborated in detail in the subsequent sections.

### 2.4.1 Output 1 - Average daily energy use of light bulbs in selected areas of North Sumatra Province

Average household daily energy use of lamps in the north Sumatra region is calculated by using the formula as expressed in Eq. (2)

$$E_h = P_h \times I_h \times M_h \quad , \quad (2)$$

where,

$E_h$  : average household daily energy use of lamps (kWh/hh/day)

$P_h$  : number of lamps per household (lamps/hh)

$I_h$  : average power per lamps (W/lamp)

$M_h$  : average length time of use per day (hour/day)

Data on  $P$ ,  $I$ , and  $M$  are obtained from the survey.

### 2.4.2 Output 2 - Data on energy saving light bulbs available at the retail market in selected areas of North Sumatra Province

To get the information on price, specification, and producers of energy-efficient lamp available in the market, survey of lighting appliances shops need to be carried out. As mentioned before, this research will conduct the survey for 10 shops in each survey site.

### 2.4.3 Output 3 - Potential for energy saving from replacing existing lamps with energy efficient types

The potential of energy saving can be calculated by creating replacement scenarios of incandescent lamps by high-efficient one. Number of light bulbs could be replaced per household are based on the data obtained from the survey and the replacement scenario mentioned above. This effort will change the value of the average power per lamps ( $I_h$ ). By assuming the number of lamps per household ( $P_h$ ) and average length time of use per day ( $M_h$ ) are constant during the replacement program, energy saving per household can be calculated as:

$$E\_Saving_h = P_h \times (I_h - I'_h) \times M_h \quad , \quad (3)$$

$E\_Saving_h$  : average household daily energy saving of lamps (kWh/hh/day)

$P_h$  : number of lamps per household (lamps/hh)

$I_h$  : average existing power per lamps (W/lamp)

$I'_h$  : average power per lamps after replacement program (W/lamp)

$M_h$  : average length time of use per day (hour/day)

To get the total potential of energy saving in North Sumatra province,  $E\_Saving_h$  in Eq. (3) is then multiplied with the total number of electrified household in North Sumatra province. Number and type of lamps needed by individual household is derived from the replacement scenarios by considering the targeted amount of  $E\_Saving_h$ .

By multiplying  $E\_Saving_h$  as calculated in Eq. (3) and the average emission factor of electricity generated in north Sumatra province, one can calculate the environmental benefit of replacement program

### 2.4.4 Output 4 - Investment needs to replace existing light bulbs with energy efficient lamps in a selected area of North Sumatra Province

The investment needed to replace the existing lamps can be calculated by the formula as expressed in Eq (4)

$$Inv = (NH_{Rep} \times NL_{Rep} \times APL) + O \quad , \quad (4)$$

where,

$Inv$  : investment needed (IDR)

$NH_{Rep}$  : number of household needed for replacement program (household)

$NL_{Rep}$  : number of lamps per household need to be replaced (lamp/household)

*APL* : average price of the lamp for replacement (IDR/lamp)

*O* : Other cost related to the replacement program such as distribution, information campaign, etc

Data of *APL* in Eq. 4 is derived from the market survey.

#### **2.4.5 Output 5 - Selection criteria and number of households that will be appropriate beneficiaries of energy efficient light bulbs replacement program**

Data of Output 1 and output 3 can be used to identify the criteria and number of household that will be beneficiaries of the replacement program. The criteria include:

- The class of household which have relatively high potential of energy saving
- The class of household which will get the economic beneficiaries of replacement program
- Number of household in each household group
- Total targeted amount of energy saving of replacement program

By using those criteria and considering the investment needed, several options of replacement program or phasing-out incentives can be analysed. The options could be the combination of the following factors:

- Number household in each class involved in the program
- Number of light bulbs per household to be replaced
- Incentive for each light bulb

#### **2.4.6 Output 6 - Monitoring and evaluation framework for energy savings and cost-benefit of replacement program.**

The monitoring and evaluation framework of the program will cover:

- Electricity use per household before and after the implementation of light bulb replacement program
- Energy saved of replacement program during the evaluation period
- Cost effectiveness of the replacement program
- Payback period of the replacement program.

As survey collects the information on PLN customer ID of household, the electricity use and bill per household before and after the implementation of light bulb replacement program

can be monitored online through the following link <http://www.pln.co.id/info-rekening/tagihan.php>. By knowing annual energy saved of replacement program and generation cost per kWh of electricity in north Sumatra province, one can calculate the *Annual Avoided Generation Cost* (AAGC) as expressed in Eq. (5). *Payback Period* (PP) of the replacement program can be calculated by dividing the investment needed (Eq. 4) by AAGC (see Eq. 6)

$$AAGC = AE\_Saved \times GC \quad (5)$$

$$PP = \frac{Inv}{AAGC} \quad (6)$$

*AAGC* : Annual Avoided Generation Cost (IDR/year)

*AE\_Saved* : Annual Energy Saved (kWh/year)

*PP* : Payback Period (year)

*Inv* : Investment needed (IDR)

The cost effectiveness of the replacement program can be calculated by comparing the unit investment cost needed to save power in the replacement program (IDR/kW) and the unit investment cost needed to install additional new power generator operated at the peak demand. The replacement program is cost effective if the unit investment cost needed to save power is less than the unit cost for installs the additional power supply.



## **Chapter 3**

### **GENERAL PROFILE AND ELECTRICITY SECTOR IN SURVEY REGIONS**

#### **3.1 General Profile and Electricity Sector in North Sumatera**

North Sumatera Province is bordered by the ocean and two other provinces; north is bordered by Aceh, east is bordered by Malaysia in the straits of Malacca, south is bordered by Riau and West Sumatera provinces, and west is bordered by the Indian Ocean. The province consists of 33 districts, has a land area of 72,981.23 km<sup>2</sup> which is mostly located on the mainland of Sumatera Island and a small portion is located on the island of Nias, Batu Islands, and several smaller islands. Based on the geographical location and natural conditions, the province was divided into 3 groups: West Coast (Pantai Barat), the Highlands (Dataran Tinggi), and East Coast (Pantai Timur) (CBS, 2015). Results of the 2010 population census by BPS shows that North Sumatera has the fourth largest population in Indonesia after West Java, East Java, and Central Java, which is about 11.51 million people.

In terms of electricity supply, the need for electricity in North Sumatera is mostly served by the State Electricity Company (PLN). PLN in North Sumatera Region is divided into eight branches: Medan, Binjai, Siantar, Sibolga, Padang Sidempuan, Rantau Prapat, Lubuhpakam, and Nias. Electrification services throughout 33 districts in North Sumatera are classified according to the branches.

Based on the data from RUPTL PLN 2015-2025, the peak load in North Sumatera Province is about 1,450 MW, supplied by Belawan power plant sectors, Medan power plant sectors, and Pandan Labuhan Angin power plant sectors. Statistical data from PT PLN in North Sumatera 2013 shows that the total PLN customers in North Sumatera is 2,930,584 people or about 4.36% increase from the previous year. Total power connected is 4,038,275 kVA and total energy sold is 7,917,238 MWh. Number one consumer for electricity is the household sector of 3,870.87 MWh (48.89%), followed by business sector of 1,195.41 MWh (15.10%), industrial sector of 2,134.05 MWh (2.98%), public/social sector of 235.56 MWh (1.15%), and public street lighting of 91.18 MWh (4.93%)

As mentioned in Chapter II, survey site selection considers the following criteria:

**a. Number of PLN Customer**

PLN branch in **Medan, Pematang Siantar, Binjai dan Lubuk Pakam** have the highest number of electricity customers and installed power compared to other branches (**Table 3**).

**Table 3** Number of customers and installed power

No	Branch	Number of Household Electricity Consumers	Installed Power (kVA)
1	Medan	498,454	590,139
2	Binjai	478,754	323,637
3	Lubuk Pakam	406,716	303,194
4	Pematang Siantar	488,754	337,380
5	Sibolga	192,354	115,102
6	Padang Sidempuan	214,831	129,182
7	Rantau Prapat	289,522	231,508
8	Nias	64,163	41,527

Based on the table above, the four districts with highest number of PLN customers and installed power are chosen to be considered in the early selection of survey sites.

**b. Number of Households and Gross Regional Domestic Product (GRDP)**

The next criteria to be considered after finding candidates of districts/cities that are potential location for survey sites is the number of households. Based on **Table 4**, from the four chosen PLN branches, four districts/cities with the highest number of household are Medan, Deliserdang, Langkat, and Simalungun in that order.

**Table 4** GDP and GDP per capita 2013

Area	District/City	Population in 2013	Number of Households in 2013	GDP in 2013 in constant value of 2000 (mil. rupiah)	GDP per capita (juta rupiah)	Category of GDP per Capita
West Coast	Kabupaten Nias,	133,388	26,945	545,564	4.09	
	Kabupaten Nias Utara	129,053	27,102	523,869	4.06	
	Kabupaten Nias Barat	82,854	16,715	271,275	3.27	
	Kabupaten Mandailing Natal	413,475	99,116	2,162,577	5.23	
	Kabupaten Tapanuli Selatan	268,824	63,558	1,877,662	6.98	
	Kabupaten Padang Lawas	237,259	56,090	798,255	3.36	

Area	District/City	Population in 2013	Number of Households in 2013	GDP in 2013 in constant value of 2000 (mil. rupiah)	GDP per capita (juta rupiah)	Category of GDP per Capita
	Kabupaten Padang Lawas Utara	232,746	55,386	837,152	3.60	
	Kabupaten Tapanuli Tengah	324,006	71,134	1,273,671	3.93	
	Kabupaten Nias Selatan	295,968	62,863	1,286,516	4.35	
	Kota Padangsidimpuan	204,615	46,911	992,128	4.85	
	Kota Sibolga	85,981	18,858	777,479	9.04	
	Kota Gunungsitoli	129,403	27,025	924,062	7.14	
Highlands	Kabupaten Tapanuli Utara	286,118	67,699	1,703,750	5.95	
	Kabupaten Toba Samosir	175,069	43,946	1,854,522	10.59	
	<b>Kabupaten Simalungun</b>	<b>833,251</b>	<b>217,717</b>	<b>5,894,588</b>	<b>7.07</b>	
	Kabupaten Dairi	276,238	67,821	2,158,858	7.82	
	Kabupaten Karo	363,755	100,606	3,589,130	9.87	
	Kabupaten Humbang Hasundutan	176,429	41,000	1,066,358	6.04	
	Kabupaten Pakpak Bharat	42,144	9,565	174,744	4.15	
	Kabupaten Samosir	121,924	30,142	1,121,617	9.20	
East Coast	Kota Pematangsiantar	237,434	56,753	2,161,591	9.10	
	Kabupaten Labuhanbatu	430,718	99,272	3,448,176	8.01	
	Kabupaten Labuhanbatu Utara	337,404	79,948	3,359,752	9.96	
	Kabupaten Labuhanbatu Selatan	289,655	70,244	3,009,513	10.39	
	Kabupaten Asahan	681,794	162,950	5,679,513	8.33	
	Kabupaten Batu Bara	382,960	89,895	7,772,101	20.29	
	<b>Kabupaten Deli Serdang</b>	<b>1,886,388</b>	<b>452,793</b>	<b>15,389,010</b>	<b>8.16</b>	
	Kabupaten Langkat	978,734	246,276	7,627,545	7.79	
	Kabupaten Serdang Bedagai	605,583	151,164	4,822,988	7.96	
	Kota Tanjungbalai	158,599	34,672	1,468,328	9.26	
	Kota Tebing Tinggi	149,065	36,423	1,243,367	8.34	
	<b>Kota Medan</b>	<b>2,123,210</b>	<b>498,046</b>	<b>38,576,234</b>	<b>18.17</b>	
	Kota Binjai	252,263	59,380	2,147,820	8.51	

Description:

Low GDP

Middle GDP

High GDP



### c. Distance

Selection of survey sites also considers the distance of the location. Medan, Deli Serdang, and Simalungun are chosen due to close proximity easy accessibility to the capital of North Sumatera Province (**Table 5**).

**Table 5** Distance from each district to the capital of North Sumatera

City/District	Capital District	Distance to Capital of North Sumatera
Medan	Medan	0 km
Deli Serdang	Lubuk Pakam	29 km
Simalungun	Raya	155 km

Source: Sumatera Dalam Angka, (BPS 2015)

## 3.2 General Profile and Electrification in South Sumatera

General profile and electrification in the three cities/districts are described briefly as follows

### 3.2.1 Medan

Based on data from the Central Bureau of Statistics (Badan Pusat Statistik – BPS) in 2015, Medan is the most populated city in North Sumatera Province, with population density of 8,268 per km<sup>2</sup>. Medan has 21 sub-districts which borders with Deli Serdang in the north, south, west, and east. Area, population number, and population density of Medan in 2014 is seen in **Table 6**.

**Table 6** Area, population, and population density of Medan in 2014

	Area (km <sup>2</sup> )	Population	Population Density	Number of Household	Average Number of Household Member
Kota Medan	265	2,191,140	8,268	502,735	4.36

Source: Medan dalam Angka 2014 (BPS, 2015)

In terms of electrification, Medan is known to have the highest load center in Sumatera (almost 60% from total electricity demand), with increasing load rate (RUPTL PLN 2015-2024). The city of Medan belongs to PT PLN branch of Medan. The number of customers, installed power capacity, power sales, and sales revenue per customer class of 450 VA, 900 VA, and 1300 VA in 2013 can be seen in **Table 7**.

**Table 7** Number of customers, installed power capacity, power sales, and sales revenue in Medan PLN branch

Customer Class	Number of Customers	Installed Power Capacity (kVA)	Power Sales (MWh)	Sales Revenue (Thousand Rupiah)	Rp/kWh
R-1/TR 450 VA	154,460	69,507	234,820	102,268,517	435.52
R-1/TR 900 VA	199,343	179,409	333,236	192,147,344	576.61
R-1/TR 1300 VA	75,151	97,696	180,661	163,102,011	902.80

Source: PT PLN Wilayah Sumatera Utara (2013)

### 3.2.2 Deli Serdang

District of Deli Serdang has an area of 2,241.68 km<sup>2</sup> with a population of 1,984,598 people and population density of 885 inhabitants/km<sup>2</sup>. This district is located on the eastern coast of North Sumatera province, with Lubuk Pakam as its district capital, and has 22 sub-districts (BPS, Sumatera Utara dalam angka, 2015). Deli Serdang borders Langkat and the Strait of Malacca on the north side, Karo and Simalungun on the south side, Serdang Bedagai on the east side, and Karo and Langkat on the west side.

In terms of electrification, Deli Serdang is a part of Lubuk Pakam and Medan PLN branches. The number of customers, installed power capacity, power sales, and sales revenue per customer class of 450 VA, 900 VA, and 1300 VA in 2013 for Lubuk Pakam can be seen in **Table 8**.

**Table 8** Number of customers, installed power capacity, power sales, and sales revenue in Lubuk Pakam branch

Customer Class	Number of Customers	Installed Power Capacity (kVA)	Power Sales (MWh)	Sales Revenue (Thousand Rupiah)	Rp/kWh
R-1/TR 450 VA	212,304	95,537	262,284	111,693,611	425.85
R-1/TR 900 VA	171,089	153,980	230,400	135,405,706	587.70
R-1/TR 1300 VA	29,759	38,687	65,084	57,019,853	876.09

Source: PT PLN Wilayah Sumatera Utara (2013)

### 3.2.3 Simalungun

Simalungun is the fourth largest district after Langkat, Mandailing Natal, and South Tapanuli, with area of 4,369 km<sup>2</sup>, population number of 844,033 people, and population density of 193 inhabitants/km<sup>2</sup>. Simalungun has 31 sub-districts which capitals in Raya.

Simalungun is a part of Pematang Siantar PLN branch. The number of customers, installed power capacity, power sales, and sales revenue per customer class of 450 VA, 900 VA, and 1300 VA in 2013 for Pematang Siantar can be seen in **Table 9**.

**Table 9** Number of customers, installed power capacity, power sales, and sales revenue in Pematang Siantar branch

Customer Class	Number of Customers	Installed Power Capacity (kVA)	Power Sales (MWh)	Sales Revenue (Thousand Rupiah)	Rp/kWh
R-1/TR 450 VA	282,391	127,076	307,298	132,489,599	431.14
R-1/TR 900 VA	189,141	170,227	218,305	133,274,308	610.50
R-1/TR 1300 VA	23,646	30,740	41,799	37,729,544	902.65

Source: PT PLN Wilayah Sumatera Utara (2013)

## Chapter IV

### GENERAL FINDINGS

#### 4.1 Survey Implementation

There were 1,200 questionnaires being distributed and all were eligible to be processed further. The respondents were distributed in three regencies/cities in North Sumatra Province, namely Medan, Deli Serdang and Simalungun. The composition of respondents' distribution by sub-district and household group is shown on **Table 10**.

**Table 10** Composition of respondents' distribution

Area	No	Sub-District	Class of 450 VA	Class of 900 VA	Class of 1300 VA
Medan	1	Medan Amplas	-	2	-
	2	Medan Area	-	-	2
	3	Medan Barat	1	-	-
	4	Medan Baru	5	14	5
	5	Medan Denai	2	-	3
	6	Medan Helvetia	1	2	2
	7	Medan Johor	61	77	32
	8	Medan Kota Belawan	-	1	-
	9	Medan Perjuangan	28	38	4
	10	Medan Polonia	1	-	1
	11	Medan Selayang	27	41	8
	12	Medan Sunggal	10	6	3
	13	Medan Tembung	1	1	2
	14	Medan Timur	1	1	2
	15	Medan Tuntungan	5	4	6
	<b>Total</b>		<b>143</b>	<b>187</b>	<b>70</b>
	<b>Total Medan</b>		<b>400</b>		
Deli Serdang	1	Batang Kuis	26	17	-
	2	Deli Tua	20	-	2
	3	Kutalimbaru	10	7	1
	4	Lubuk Pakam	18	5	1
	5	Patumbak	62	22	8
	6	Percut Sei Tuan	35	59	9
	7	Sunggal	13	50	6
	8	Tanjung Morawa	22	5	2
	<b>Total</b>		<b>206</b>	<b>165</b>	<b>29</b>
	<b>Total Deli Serdang</b>		<b>400</b>		
Simalungun	1	Bandar	83	25	4

Area	No	Sub-District	Class of 450 VA	Class of 900 VA	Class of 1300 VA
	2	Bosar Maligas	4	31	1
	3	Dolok Batunanggar	23	3	1
	4	Gunung Malela	-	1	-
	5	Gunung Maligas	53	46	6
	6	Panei	14	14	1
	7	Pematang Bandar	23	22	2
	8	Sidamanik	27	12	4
	<b>Total</b>		<b>227</b>	<b>154</b>	<b>19</b>
	<b>Total Simalungun</b>		<b>400</b>		

## 4.2 Description Profile of Respondents

### 4.2.1 Age of Respondents

Age distribution of respondents was divided into five group, those were: (i) < 21 years, (ii) 21-30 years, (iii) 31-40 years, (iv) 41-50 years, dan (v) > 50 years, as shown in **Table 11**.

**Table 11** Age of respondents

Age (years)	450 VA		900 VA		1300 VA	
	Number of Respondents	%	Number of Respondents	%	Number of Respondents	%
<21	37	6.3	34	6.7	18	15.8
21-30	105	17.9	99	19.6	36	31.6
31-40	136	23.2	151	29.8	19	16.7
41-50	163	27.8	143	28.3	32	28.1
>50	145	24.7	79	15.6	9	7.9
TOTAL	586	100	506	100	114	100

### 4.2.2 Respondents Education Level

The education level of respondents was classified into 6 groups: (i) do not have any degrees, (ii) possess an elementary school certificate, (iii) possess a junior high school certificate, (iv) possess a senior high school certificate, (v) possess a diploma certificate, and (vi) possess a university degree (**Table 12**).



**Table 12** Education level of respondents

Education Level of Household Member (latest education certificate)	450 VA		900 VA		1300 VA	
	Number of respondent	%	Number of respondent	%	Number of respondent	%
Have no degrees	268	14.6	168	11.7	31	7.3
Elementary School (SD)	316	17.2	193	13.5	35	8.2
Junior High School (SMP)	448	24.3	261	18.2	55	12.9
Senior High School (SMU)	713	38.7	638	44.5	145	34.0
Diploma	27	1.5	59	4.1	32	7.5
University (PT)	69	3.7	115	8.0	129	30.2
TOTAL	1841	100	1434	100	427	100

#### 4.2.3 Number of Household Members

Number of people per household were classified into 6 groups: (i) 1 up to two people, (ii) 3 to 4 people, (iii) 5 to 6 people, (iv) 7 to 8 people, (v) more than 8 people (**Table 13**).

**Table 13** Number of household members

Number of Households Members	450 VA		900 VA		1300 VA	
	Number of respondent	%	Number of respondent	%	Number of respondent	%
1-2	58	10.1	54	10.7	4	3.4
3-4	310	53.8	274	54.2	44	37.3
5-6	175	30.4	141	27.9	59	50.0
7-8	29	5.0	30	5.9	9	7.6
>8	4	0.7	7	1.4	2	1.7
TOTAL	576	100	506	100	118	100

#### 4.2.4 Household Consumption Expenditure

The total household consumption expenditure per month is classified into six groups: (i) less than Rp 1,000,000; (ii) Rp 1,000,000 up to Rp 2,999,999; (iii) Rp 3,000,000 up to Rp 4,999,999; (iv) Rp 5, 000,000 up to Rp6,999,999; (v) Rp7,000,000 up to Rp 8,999,999; (vi) Rp 9,000,000 up to Rp 10,999,999, (vii) Rp11,000,000 up to Rp12,999,999; (viii) Rp 13,000,000 up with Rp 14,999,999; (ix) Rp15,000,000 up to Rp16,999,999; and (vi) above Rp 17,000,000 (**Table 14**).

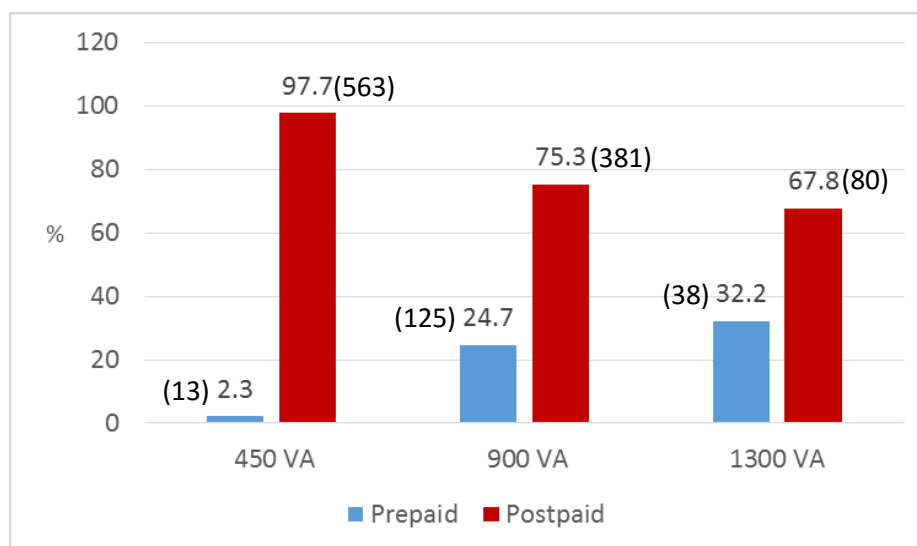
**Table 14** Household consumption expenditure

Household Consumption Expenditure	450 VA		900 VA		1300 VA	
	Number of respondent	%	Number of respondent	%	Number of respondent	%
< Rp1,000,000	141	24.5	65	12.8	9	7.6
Rp1,000,000 - Rp2,999,999	409	71.0	299	59.1	48	40.7
Rp3,000,000 - Rp4,999,999	24	4.2	129	25.5	30	25.4
Rp5,000,000 - Rp6,999,999	2	0.3	10	2.0	19	16.1
Rp7,000,000 - Rp8,999,999			2	0.4	6	5.1
Rp9,000,000 - Rp10,999,999			1	0.2	4	3.4
Rp11,000,000 - Rp12,999,999					1	0.8
Rp13,000,000 - Rp14,999,999						
Rp15,000,000 - Rp16,999,999						
> Rp17,000,000					1	0.8
TOTAL	576	100	506	100	118	100

### 4.3 Description of Household Profile as PLN Customers

#### 4.3.1 PLN Bill Payment System

The bill payment of PLN customer is divided into 2 (two) systems which are pre-paid and post-paid system. The survey results showed there are about 97.7% of 450 VA households that use post-paid bill payment and 2.3% of them used pre-paid system. As for respondents of 900 VA class, about 75.3% of respondents used post-paid system to pay the electricity bill and the remaining of 24.7% used pre-paid system. Meanwhile, about 67.8% of 1300 VA customers were using post-paid system and the remaining of 32.2% was using pre-paid system (**Figure 3**). The survey result implies that the use of pre-paid system was being enthused by public as it allows people to control electricity consumption as needed.



Description: Number in parentheses is the number of respondents

**Figure 3** Bill payment system

#### 4.3.2 Electricity Use

Electricity use by PLN customers is listed based on types of electronic equipment used in households, namely (i) lighting, (ii) air conditioning, (iii) cooking devices, (iv) fans, (v) refrigerators, (vi) television, (vii) computers, (viii) washing machine, (ix) water pump, and (x) other (**Table 15**).

**Table 15** Electricity use

Electricity Use	450 VA		900 VA		1300 VA	
	Number of respondent	% Saturation	Number of respondent	% Saturation	Number of respondent	% Saturation
Lighting	576	100.0	505	99.8	118	100.0
Air Conditioner (AC)	7	1.2	57	11.3	59	50.0
Cooking Devices (electricity stove, <i>rice cooker</i> , etc.)	532	92.4	479	94.7	115	97.5
Fan	442	76.7	442	87.4	112	94.9
Refrigerator	320	55.6	401	79.2	109	92.4
Television	563	97.7	494	97.6	118	100.0
Computer	17	3.0	42	8.3	46	39.0
Wash Machine	79	13.7	213	42.1	81	68.6
Water Pump	320	55.6	299	59.1	67	56.8
Other	14	2.4	11	2.2	12	10.2

### 4.3.3 Electricity Consumption Expenditure

The electricity consumption expenditure is calculated based on the average value of last 3 months electricity bills. The amount of electricity consumption is then classified accordingly with the range of expenditure, namely: (i) less than Rp 200,001; (ii) Rp 200,001 up to Rp 300,000; (iii) Rp300,001 up to Rp 400,000; (iv) Rp 400,001 up to Rp 500,000; (v) Rp 500,001 up to Rp 600,000; (vi) Rp 600,001 up to Rp 700,000; (vii) Rp 700,001 up to Rp 800,000; (viii) Rp 800,001 up to 900, 000; (ix) Rp 900,001 up to Rp 1,000,000; (x) Rp 1,000,001 up to Rp 1,500,000; (xi) Rp 1,500,001 up to Rp 2,000,000; and (xii) more than Rp 2,000,000 (**Tabel 16**).

**Table 16** Electricity consumption expenditure

Pengeluaran Listrik	MD			DS			SM		
	450 VA	900 VA	1300 VA	450 VA	900 VA	1300 VA	450 VA	900 VA	1300 VA
< Rp200.001	97.2	80.7	14.3	99.0	98.2	55.3	100.0	96.7	66.7
Rp200.001 – Rp300.000	2.1	9.6	15.7	1.0	1.8	26.3		3.3	16.7
Rp300.001 – Rp400.000		5.9	28.6			7.9			16.7
Rp400.001 – Rp500.000		1.6	5.7			5.3			
Rp500.001 – Rp600.000	0.7	0.5	12.9			5.3			
Rp600.001 – Rp700.000		0.5	8.6						
Rp700.001 – Rp800.000		0.5	1.4						
Rp800.001 – Rp900.000									
Rp900.001 – Rp1.000.000		0.5	4.3						
Rp1.000.001 – Rp1.500.000			4.3						
Rp1.500.001 – Rp2.000.000			2.9						
> Rp2.000.000			1.4						

MD: Medan

DS: Deliserdang

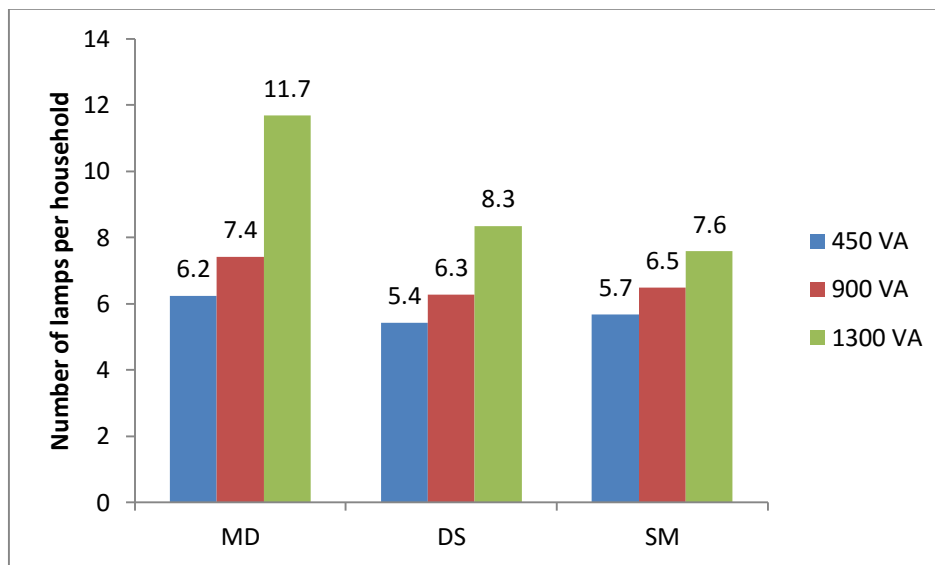
SM: Simalungun

Based on **Table 16**, the majority of respondents in customer class 450 VA and 900 VA in all areas spend under Rp 200,000 for electricity consumption. Whereas for customer class 1300 VA, electricity expenses varies depending on the area. The majority of respondents pay Rp 300,001 – Rp 400,000 in Medan, Rp 201,000 – Rp 300,000 in Deliserdang, dan Rp 301,000 – Rp 400,000 in Simalungun.

#### 4.4 Description of Numbers of Mounted Lamps, Light Capacity and Duration of Light Usage

##### 4.4.1 Number of Mounted Lamps

Of the three regions surveyed, Medan has the highest number of mounted lamps, which are 6.2 lamps per household for customer class 450 VA, 7.4 lamps per household for customer class 900 VA, and 11.7 lamps per household for customer class 1300 VA (**Figure 4**)

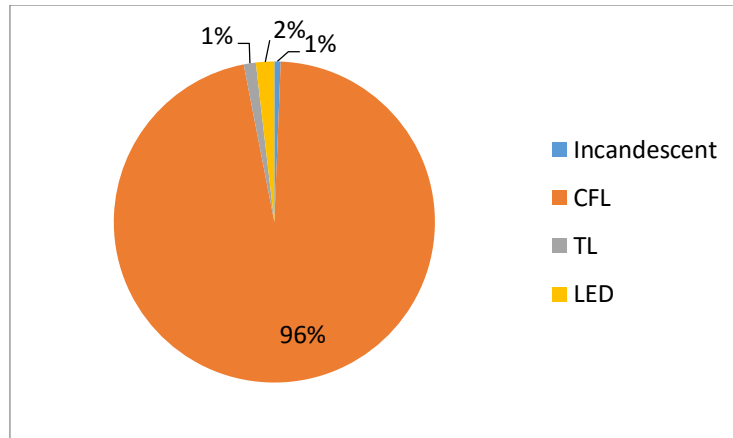


**Figure 4** Number of mounted lamps in survey regions

The survey results from all three regions show that higher customer class leads to higher number of mounted lamps. In Deliserdang, there are 5.4 mounted lamps per household for customer class 450 VA, 6.3 mounted lamps per household for customer class 900 VA, and 8.3 mounted lamps per household for customer class 1300 VA. Whereas in Simalungun, there are 5.7 mounted lamps per household for customer class 450 VA, 6.5 mounted lamps per household for customer class 900 VA, and 7.6 mounted lamps per household for customer class 1300 VA.

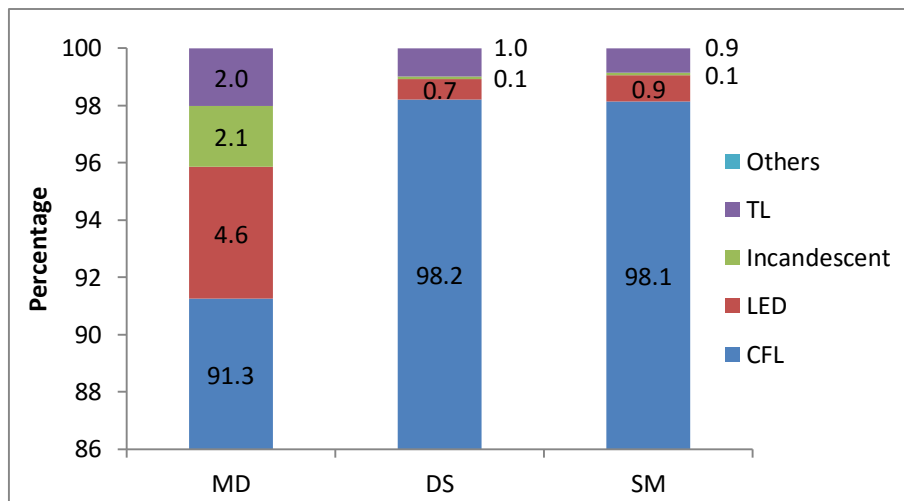
##### *i. 450 VA Class*

In customer class 450 VA, the average household has 5.8 mounted lamps, with CFL as the most widely used light bulb type of 96% (**Figure 5**). The minimum number of mounted lamps found in surveyed households is 2, whereas the highest is 15 lamps.



**Figure 5** Mounted lamps composition in 450 VA class

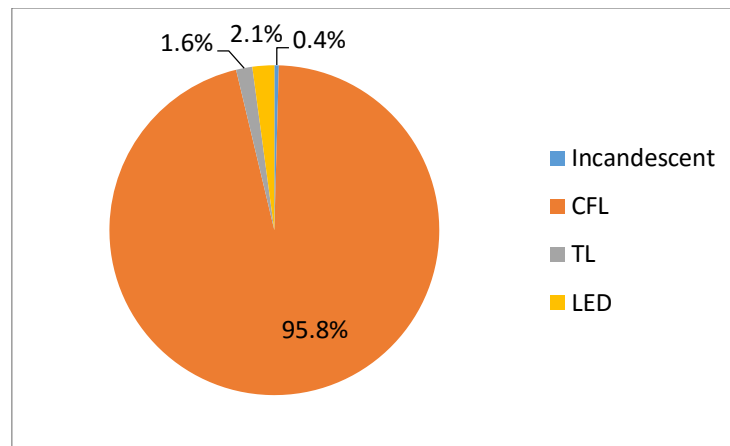
The share of CFL is highest in Deliserdang, which comprises 98.2% of the total number of mounted lamps in the region. LED is most prevalent in Medan with a share of 2.1%. However, the use of incandescent light bulbs is highest in Medan compared to other regions, namely 2% (Figure 6).



**Figure 6** Mounted lamps composition based on region in 450 VA class

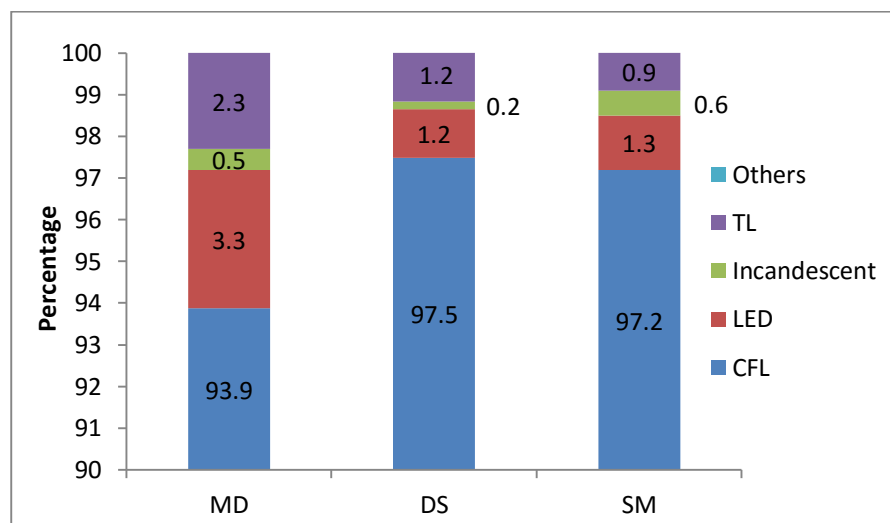
## ii. 900 VA Class

In customer class 900 VA, average number of mounted lamps is 6.7 lamps which mostly comprises of CFL light bulbs (95.9%) as shown in Figure 7. The minimum number of mounted lamps found in surveyed households is 3, whereas the highest is 12 lamps.



**Figure 7** Mounted lamps composition in 900 VA class

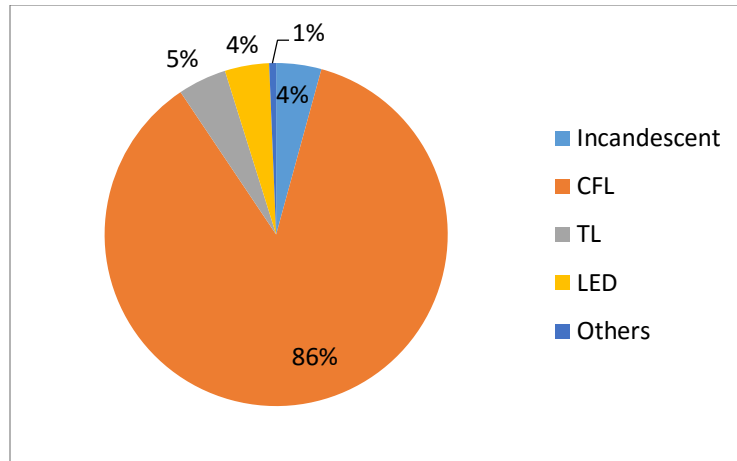
The highest share of CFL light bulbs is in Deliserdang, which reaches 97.5% of the total number of mounted lamps. Whereas LED is most prevalent in Medan with a percentage of 3.3% (**Figure 8**).



**Figure 8** Mounted lamps composition based on region in 450 VA class

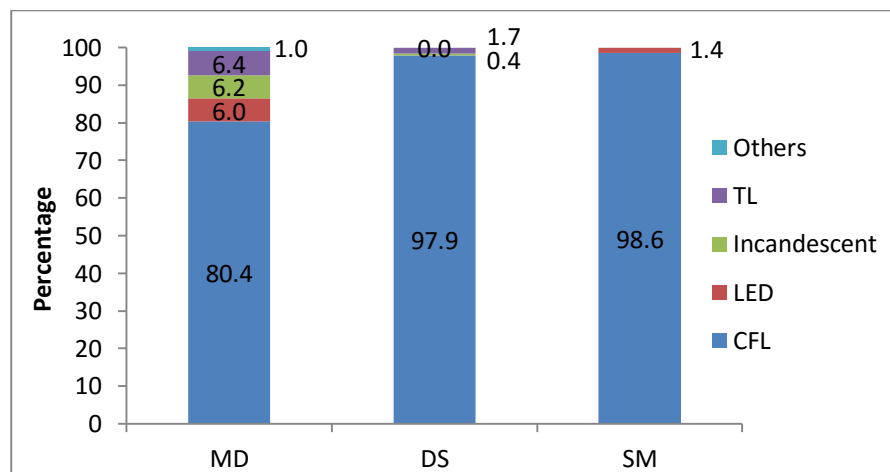
### *iii. 1300 VA Class*

In customer class 1300 VA, the average household has 9.2 mounted lamps, with CFL as the most widely used type (86%) as shown in **Figure 9**. The minimum number of mounted lamps found in surveyed households is 3, whereas the highest is 15 lamps.



**Figure 9** Mounted lamps composition per households in 1300 VA class

The share of CFL lamps is highest in Simalungun, which is 98.6% of the total number of mounted lamps in the region. LED is most prevalent in Medan, with a percentage of 6%. However, the use of incandescent light bulbs is highest in Medan compared to other regions, namely 6.2% (**Figure 10**).



**Figure 10** Mounted lamps composition based on region in 450 VA class

**iv. Test of Significance of Number of Mounted Lamps per Households between 450 VA, 900 VA and 1300 VA households**

Test of Significance was performed to determine whether there are differences in the number of mounted lamps per household by capacity class (450 VA, 900 VA and 1300 VA) and by region (Medan, Deli Serdang, Simalungun). Mann Whitney Test was used because the survey results



were not normally distributed. The test was performed using SPSS statistical applications. The proposed hypothesis ( $H_0$ ) is that there is no difference in the number of mounted lamps per household between two tested variables.

# 1. Test of Significance on number of lamps per household in customer class 450 VA

## a. Medan vs. Deliserdang

According to **Table 17**, the value of Asymp. Sig. is 0,000. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $<0.05$ , the  $H_0$  is rejected. The conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Deliserdang in customer class 450 VA.

**Table 17** Mann Whitney test result between Medan and Deliserdang in customer class 450 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	11168.000
Wilcoxon W	32489.000
Z	-3.976
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kota\_Kab

## b. Medan vs. Simalungun

According to **Table 18**, the value of Asymp. Sig. is 0,006. According to the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $<0.05$ , the  $H_0$  is rejected. The conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Simalungun in customer class 450 VA.

**Table 18** Mann Whitney test result between Medan and Simalungun in customer class 450 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	13546.500
Wilcoxon W	39424.500
Z	-2.744
Asymp. Sig. (2-tailed)	.006

a. Grouping Variable: Kota\_Kab

### c. Deliserdang vs. Simalungun

According to **Table 19**, the value of Asymp. Sig. is 0,270. According to the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $> 0.05$ , the  $H_0$  is accepted. The conclusion indicates **there is no significant difference** in the number of mounted lamps per household between Deliserdang and Simalungun in customer class 450 VA.

**Table 19** Mann Whitney test result between Deliserdang and Simalungun in customer class 450 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	21991.500
Wilcoxon W	43312.500
Z	-1.103
Asymp. Sig. (2-tailed)	.270

a. Grouping Variable: Kota\_Kab

## 2. Test of Significance on number of lamps per household in customer class 900 VA

### a. Medan vs. Deliserdang

According to **Table 20**, the value of Asymp. Sig. is 0,000. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $< 0.05$ , the  $H_0$  is rejected. The conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Deliserdang in customer class 900 VA.

**Table 20** Mann Whitney test result between Medan and Deliserdang in customer class 900 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	10851.500
Wilcoxon W	24546.500
Z	-4.879
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kota\_Kab

### b. Medan vs. Simalungun

According to **Table 21**, the value of Asymp. Sig. is 0,000. From the the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $< 0.05$ , the  $H_0$  is rejected. The conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Simalungun in customer class 900 VA.

**Table 21** Mann Whitney test result between Medan and Simalungun in customer class 900 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	11329.500
Wilcoxon W	23264.500
Z	-3.457
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Kota\_Kab

### c. Deliserdang vs. Simalungun

According to **Table 22**, the value of Asymp. Sig. is 0,141. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $> 0.05$ , the  $H_0$  is accepted. The conclusion indicates **there is no significant difference** in the number of mounted lamps per household between Deliserdang and Simalungun in customer class 900 VA.

**Table 22** Mann Whitney test result between Deliserdang and Simalungun in customer class 900 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	11516.000
Wilcoxon W	25211.000
Z	-1.472
Asymp. Sig. (2-tailed)	.141

a. Grouping Variable: Kota\_Kab

## 3. Test of Significance on number of lamps per household in customer class 1300 VA

### a. Medan vs. Deliserdang

According to **Table 23**, the value of Asymp. Sig. is 0,000. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig  $< 0.05$ , the  $H_0$  is rejected. The

conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Deliserdang in customer class 1300 VA.

**Table 23** Mann Whitney test result between Medan and Deliserdang in customer class 1300 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	370.000
Wilcoxon W	805.000
Z	-5.019
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kota\_Kab

#### b. Medan vs. Simalungun

According to **Table 24**, the value of Asymp. Sig. is 0,000. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig.  $< 0.05$ , the  $H_0$  is rejected. The conclusion indicates a **significant difference** in the number of mounted lamps per household between Medan and Simalungun in customer class 1300 VA.

**Table 24** Mann Whitney test result between Medan and Simalungun in customer class 1300 VA

Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	186.500
Wilcoxon W	376.500
Z	-4.842
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kota\_Kab

#### c. Deliserdang vs. Simalungun

According to **Table 25**, the value of Asymp. Sig. is 0,166. From the basis of decision making in Mann Whitney Test that if the value of Asymp. Sig.  $> 0.05$ , the  $H_0$  is accepted. The conclusion indicates **there is no significant difference** in the number of mounted lamps per household between Deliserdang and Simalungun in customer class 1300 VA.

**Table 25** Mann Whitney test result between Deliserdang and Simalungun in customer class 1300

VA

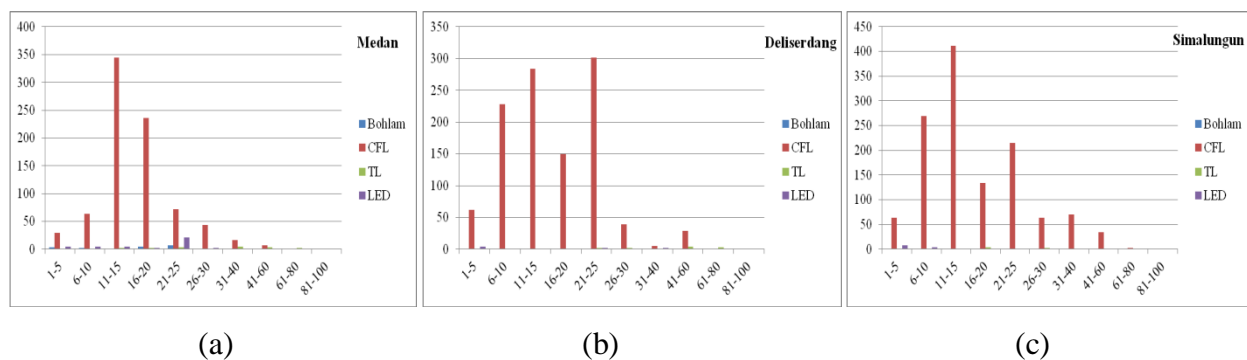
Test Statistics <sup>a</sup>	
	TtkLampu
Mann-Whitney U	211.500
Wilcoxon W	401.500
Z	-1.386
Asymp. Sig. (2-tailed)	.166

a. Grouping Variable: Kota\_Kab

#### 4.4.2 Lights Wattage

##### *i. 450 VA Class*

The number of lamps based on their wattage in customer class 450 VA for all three survey regions can be seen in **Figure 11**.

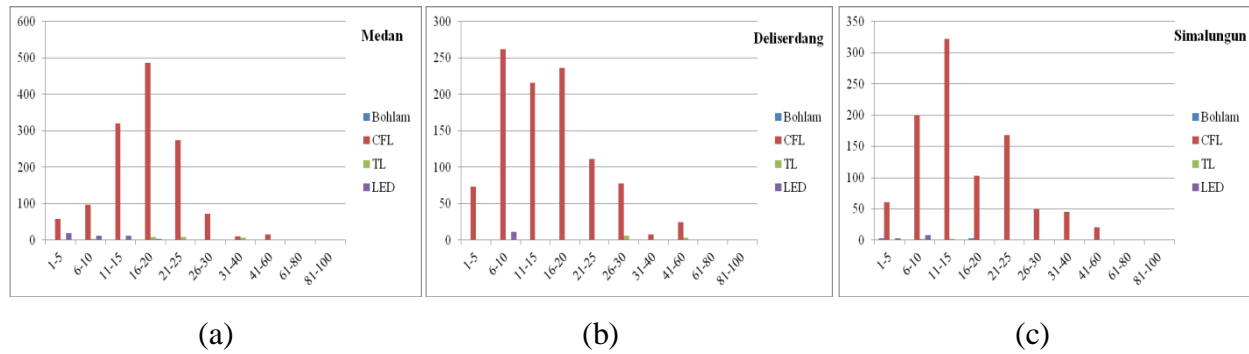


**Figure 11** Wattage of lamps used in customer class 450 VA

In Medan, the most widely used wattage for CFL is 11-15 watts, whereas the most widely used wattage for LED is 21-25 watts (**Figure 11.a**). In Deliserdang, the most widely used wattage for CFL is 21-25 watts, whereas the most widely used wattage for LED is 1-5 watts (**Figure 11.b**). Whereas in Simalungun, the most widely used wattage for CFL is 11-15 watts, whereas the most widely used wattage for LED is 1-5 watts (**Figure 11.c**).

##### *ii. 900 VA Class*

The number of lamps based on their wattage in customer class 900 VA for all three survey regions can be seen in **Figure 12**.

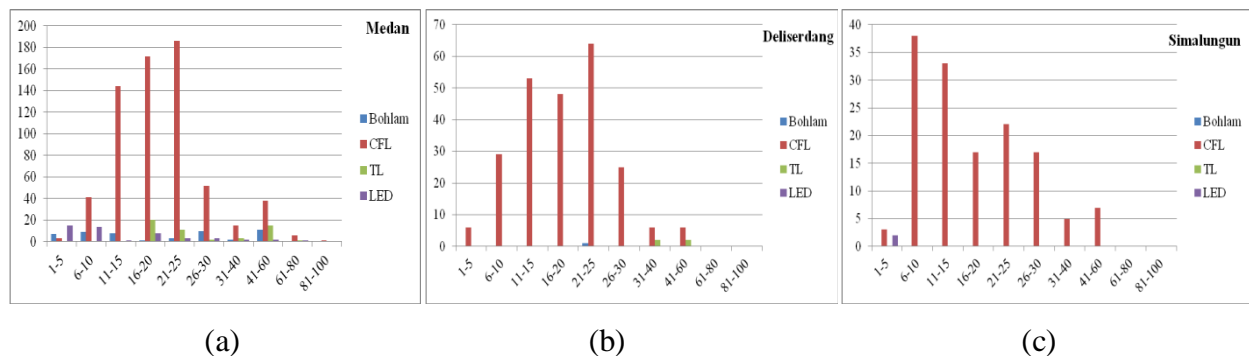


**Figure 12** Wattage of lamps used in customer class 900 VA

In Medan, the most widely used wattage for CFL is 16-20 watts, whereas the most widely used wattage for LED is 1-5 watts (**Figure 12.a**). In Deliserdang, the most widely used wattage for both CFL and LED is 6-10 watts (**Figure 12.b**). Whereas in Simalungun, the most widely used wattage for CFL is 11-15 watts, whereas the most widely used wattage for LED is 6-10 watts (**Figure 12.c**).

### iii. 1300 VA Class

The number of lamps based on their wattage in customer class 1300 VA for all three survey regions can be seen in **Figure 13**.



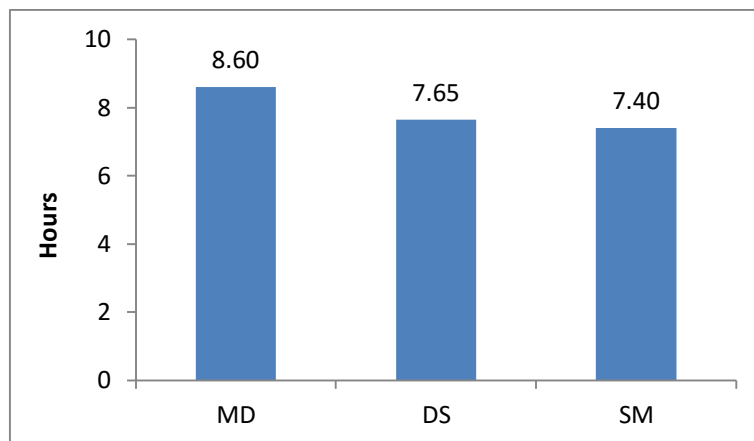
**Figure 13** Wattage of lamps in 1300 VA households

In Medan, the most widely used wattage for CFL is 21-25 watts, whereas the most widely used wattage for LED is 1-5 watts (**Figure 13.a**). In Deliserdang, the most widely used wattage for CFL is 21-25 watts, and none of the surveyed respondents use LED light bulb (**Figure 13.b**). In Simalungun, the most widely used wattage for CFL is 6-10 watts, whereas there are only 2 LED light bulbs used in the range of 1-5 watts (**Figure 12.c**).

#### 4.4.3 Duration of Lights Use

##### *i. 450 VA Class*

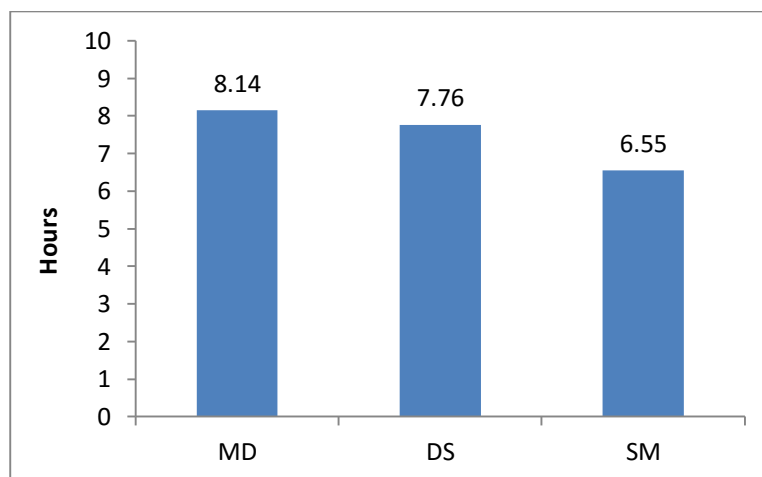
In customer class 450 VA, the highest to lowest average of lamps duration of use are 8.6 hours/day in Medan, 7.65 hours/day in Deliserdang, and 7.4 hours/day in Simalungun (**Figure 14**).



**Figure 14** Lamps duration of use per area in household class 450 VA

##### *ii. 900 VA Class*

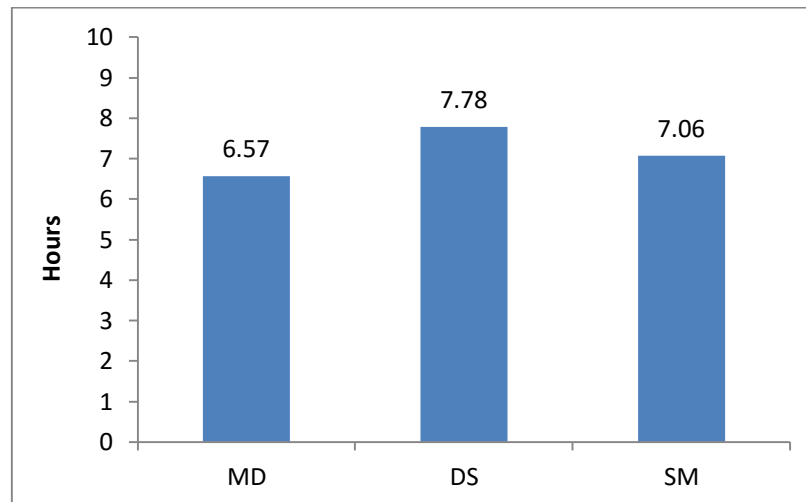
In customer class 900 VA, the highest to lowest average of lamps duration of use are 8.14 hours/day in Medan, 7.76 hours/day in Deliserdang, and 6.55 hours/day in Simalungun (**Figure 15**).



**Figure 15** Lamps duration of use per area in household class 900 VA

**iii. 1300 VA Class**

In customer class 1300 VA, the highest to lowest average of lamps duration of use are 7.78 hours/day in Deliserdang, 7.06 hours/day in Simalungun, and 6.57 hours/day in Medan (**Figure 16**).



**Figure 16** Lamps duration of use per area in household class 1300 VA

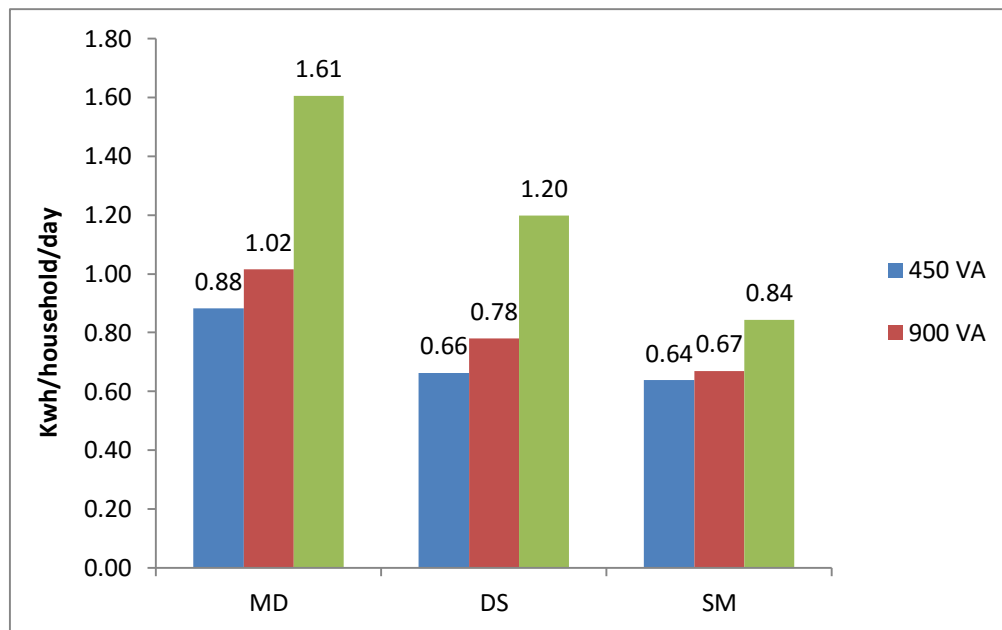


## Chapter V

### RESULTS AND DISCUSSION

#### 5.1 Output 1 – Average Daily Energy Consumption for Household Lighting

The average daily use of energy consumption for lighting can be seen in **Figure 17**. Energy consumption for lighting in Medan is highest compared to the other two areas for all customer classes, which amounted to 0.88 kWh/household/day for customer class 450 VA, 1.02 kWh/household/day for customer class 900 VA, and 1.61 kWh/household/day for customer class 1300 VA.

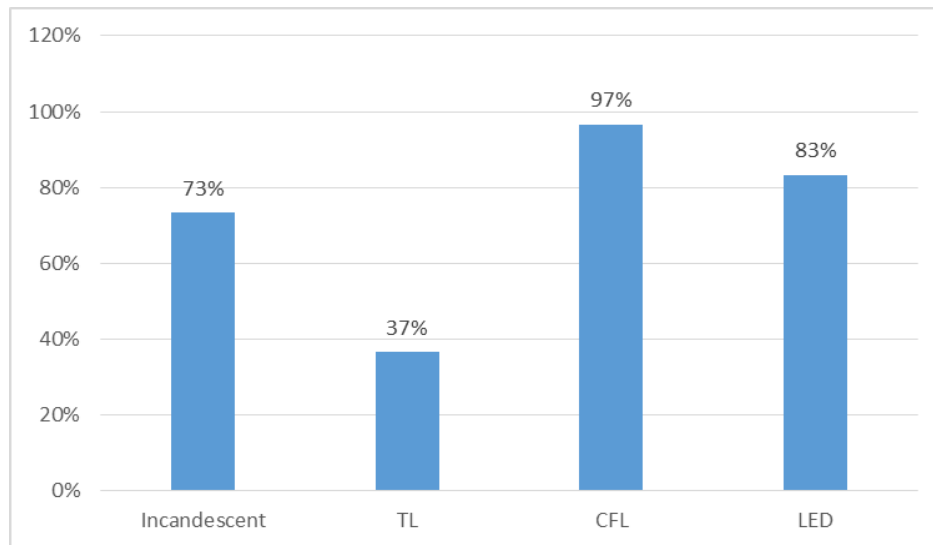


**Figure 17** Average daily energy consumption for lighting

Results from the three surveyed regions show that higher customer class leads to higher energy consumption for lighting. In Deli Serdang, energy consumption for lighting reaches 0.66 kWh/household/day for customer class 450 VA, 0.78 kWh/household/day for customer class 900 VA, and 1.20 kWh/household/day for customer class 1300 VA. Whereas in Simalungung, energy consumption for lighting reaches 0.64 kWh/household/day for customer class 450 VA, 0.67 kWh/household/day for customer class 900 VA, and 0.84 kWh/household/day for customer class 1300 VA.

## 5.2 Output 2 – Availability of Energy Saving Lamps in the Market

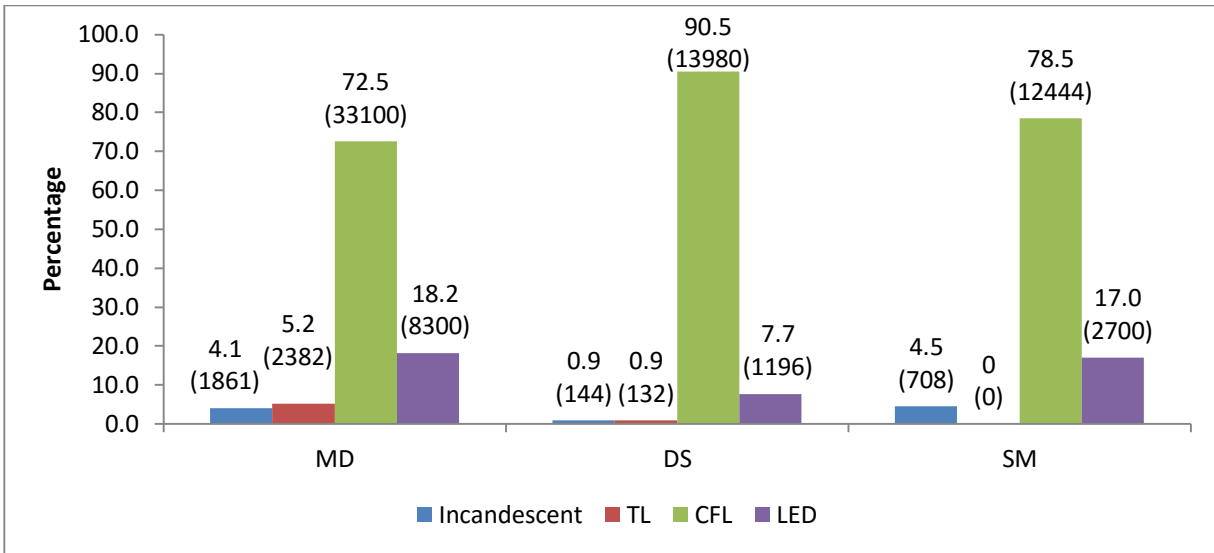
Survey of light bulbs availability is limited to 30 light appliances stores. Based on survey results on 10 stores in each area (Medan, Deli Serdang, and Simalungun), data of stores which provide various types of lamps can be seen in **Figure 18**.



**Figure 18** Percentage of stores which provide light bulbs

**Figure 18** shows that different types of light bulbs are available in the stores, ranging from incandescent light bulbs, TL, CFL, and LED. Out of 30 surveyed stores, the order of largest to smallest saturation of light bulb availability are as follow: (i) 97% of the stores provide CFL lamps, (ii) 83% of the stores provide LED lamps, (iii) 73% of the stores provide incandescent light bulbs, and (iv) only 37% of the stores provide fluorescent lamp.

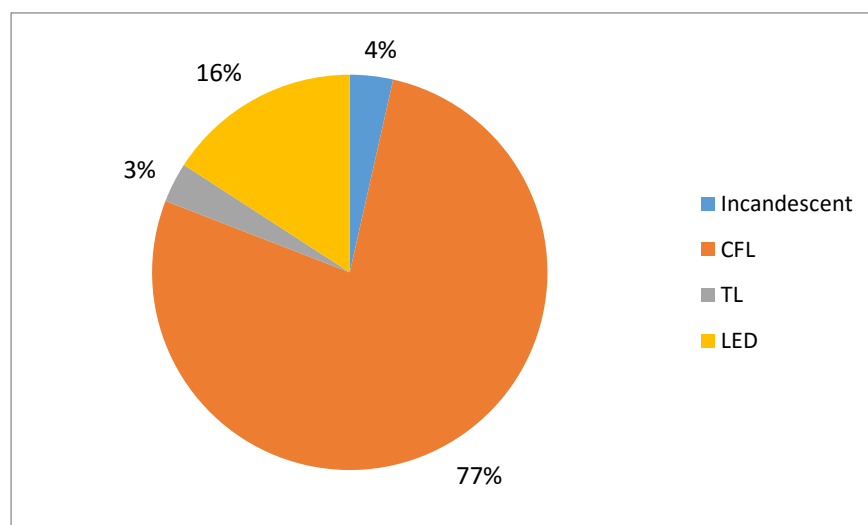
Meanwhile, survey results on the market availability of lightbulbs in each area can be seen in **Figure 19**.



**Figure 19** Percentage and amount of available lightbulbs per area

Out of the 10 stores per survey are, results show that CFL has the highest number of availability. Deli Serdang has the highest percentage of CFL lamps compared to other lamp types, which is 90.5%. However Medan has the highest number of available CFL lightbulb in stores compared to the other two areas, which is 33,100 pieces.

From the total availability of light bulbs in the market in all survey areas, CFL lamps owns the biggest share of 77%. Availability of LED lamps is higher than the other two types of lamp, namely 16% (**Figure 20**).



**Figure 20** The share of light bulb availability

This indicates that the relatively new LED lamp technology has begun to enter the market, which is caused by the growing public awareness for energy saving lamps. Whereas the availability of incandescent light bulbs in the market is only 4% out of the total number of light bulbs, which indicates that it has entered the phase out period. This data shows the market demand for each light bulb type, which correlates to the light bulb availability findings in each household (Figure 5, 7, and 9).

Price of various types of light bulbs depends on the quality of the goods and location of the stores. In a survey in light bulb prices from 30 store respondents, incandescent light bulbs are available starting from 3 to 100 watts with price range from Rp 2,500 to Rp 12,000 and TL light bulbs are available from 8 to 38 watts with price range from Rp 8,000 to Rp 100,000. Whereas the availability of CFL and LED and market price can be seen in **Table 26**. Categorization of Brand A and Brand B is in accordance with field findings for the two brands that are most available in stores. The difference between Brand A and Brand B is generally based on price and branding in the market.

**Table 26** Types and price of CFL and LED light bulbs in 30 stores

Wattage	Price of CFL Lamp (rupiah)		Price of LED Lamp (rupiah)	
	Brand A	Brand B	Brand A	Brand B
3-5	15,000-30,000	16,000-20,000	48,000-59,000	15,000-30,000
6-9	19,000-31,000	16,000-21,000	80,000-100,000	33,000-62,000
10-14	28,000-35,000	17,000-24,000	100,000-126,000	48,000-61,000
15-40	25,000-50,000	23,000-40,000	>126,000	190,000-240,000
Product Specification			Energy saving: 85% Lifetime: 15,000 hours Warranty: 1 year	Energy saving: 85% Lifetime: 15,000 hours Warranty: 1 year

LED light bulbs are the latest technology for energy saving lamps that are used in the household. An example of the price and life span comparison between various types of light bulbs with equal Lumen power can be seen in **Table 27**.

**Table 27** Price comparison of incandescent light bulb, CFL, and LED lamps for certain wattage

Description	Incandescent light bulb	CFL	LED
Wattage	60 watt	13-15 watt	6-8 watt
Price	Rp. 6.500-Rp. 10,000	Rp. 16.000-23.000	Rp. 25,000-Rp. 45,000
Life span (average)	1.200 hours	8.000 hours	30.000-50.000 hours

Explanation:

- b. Wattage in the table are equivalent to the light intensity of 800 lumens
- c. Data comparison of wattage and life span was obtained from <http://www.designrecycleinc.com/led%20comp%20chart.html>
- d. LED prices are obtained from a specific brand in the survey area

Based on the table above, LED light bulbs which used to be expensive nowadays no longer have a significant price differences than CFL light bulbs, which means LED is starting to compete with CFL. This strategy is chosen by the producer of LED lamps by compromising the quality (life span) of LED light bulbs so that the price is not drastically too expensive from CFL light bulbs. Availability of LED lights at a number of stores show that there is already a demand for LED lamps which means the public is already aware of the existence of light saving LED lamps that can provide greater benefits than incandescent lamps.

### 5.3 Output 3 – Potential Savings from Lighting Replacement Program

Since survey results showed that CFL is the most widely used type of light bulb, the light bulb replacement program is focused in replacing CFL with a more energy efficient lamp, which is LED. CFL to LED light bulbs replacement is determined by overlooking which type of wattage is mostly used by the respondents and the largest energy saving potential for each region and class of customer. The number of lamps per household to be replaced is determined by calculating the average number of mounted CFL lamps for certain wattage in all households.

Survey results showed that in all survey locations, 11-15 watts CFL light bulbs are mostly used by customers in PLN class 450 VA and 16-20 watts CFL light bulbs are mostly used by customers in PLN class 900 VA. Meanwhile, for PLN class 1300 VA, 16-20 watts CFL light bulbs are mostly used in Medan and Deliserdang, whereas respondents in Simalungun mostly use 11-15 watts CFL light bulbs.

The wattage determination of CFL to LED replacement is done according to the equal Lumen power; 6 watts LED to replace 11-15 watts CFL and 9 watts LED to replace 16-20 watts CFL lamps. Average potential energy saving for each regions and customer class are then calculated from the light bulb replacement program (**Table 28**). This scenario resulted in the highest energy saving potential compared to other CFL wattage for replacement, because 11-15 watts and 16-20 watts of CFL light bulbs are the most widely used by respondents.

**Table 28** Energy saving potential in household

Region	PLN Customer Class	Light Bulb Replacement			Energy Saving Potential (kWh/hhyear)
		from CFL	to LED	Number of Lamps per Household	
MD	450 VA	13 watt	6 watt	2	53.90
	900 VA	18 watt	9 watt	2	66.02
	1300 VA	18 watt	9 watt	2	57.98
DS	450 VA	13 watt	6 watt	2	25.92
	900 VA	18 watt	9 watt	2	35.60
	1300 VA	18 watt	9 watt	2	48.03
SM	450 VA	13 watt	6 watt	2	31.31
	900 VA	13 watt	6 watt	2	33.01
	1300 VA	13 watt	6 watt	2	25.15

Results of the energy saving potentials for lighting in the three regions were then simulated to estimate total potential energy saving for lighting throughout North Sumatera. The approach used in estimating the potential energy saving is as follows:

1. The three regions surveyed are divided into two categories: upper-middle GRDP/capita and lower-middle GRDP/capita. This is done by sorting all 33 regencies in North Sumatera in the order from the highest to lowest GRDP/capita, and then dividing them into two categories which are upper-middle GRDP/capita and lower-middle GRDP/capita. It was found that Medan and Deliserdang are of upper-middle GRDP/capita whereas Simalungun is within the range of lower-middle GRDP/capita.
2. In accordance with the categorization explained in the first point, identification of GRDP/capita class was done for all eight PLN branches in North Sumatera. This is done to obtain potential energy savings based on the characteristics of each region. As a result,

the division of PLN branches according to GRDP/capita and the total number of customers in every branch and customer class is acquired, as shown in **Table 29**.

**Table 29** PLN customer number based of branches and PLN customer class

GRDP/capita	PLN Branch	Customer Number		
		450 VA	900 VA	1300 VA
Upper-middle	Medan	154,460	199,343	75,151
	Binjai	287,071	175,667	22,946
	P Siantar	282,391	189,141	23,646
	RT Prapat	113,502	156,423	21,464
	Lubuk Pakam	212,304	171,089	29,759
	<b>TOTAL</b>	<b>1,049,728</b>	<b>891,663</b>	<b>172,966</b>
Lower-middle	Sibolga	143,282	45,859	6,963
	P Sidempuan	155,446	63,751	5,378
	Nias	44,187	17,071	4,890
	<b>TOTAL</b>	<b>342,915</b>	<b>126,681</b>	<b>17,231</b>

- After categorization of GRDP/capita for each PLN branch in North Sumatera is done, branch-wide energy saving calculation is done by multiplying the results of energy saving per household by the number of customers in **Table 29**. As final results, energy savings potential from the lamp replacement program in North Sumatera is estimated to be 110.27 GWh/year (**Table 30**).

**Table 30** Energy saving potentials for North Sumatera

GRDP/capita	PLN customer class	CFL wattage to be replaced	Number of lamps for replacement	Energy saving (kWh/hh/year)	Number of customer	Total energy saving (GWh/year)
Upper-middle	450 VA	13	2	37.38	1,049,728	39.24
	900 VA	18	2	51.76	891,663	46.15
	1300 VA	18	2	55.06	172,966	9.52
Lower-middle	450 VA	13	2	31.31	342,915	10.74
	900 VA	13	2	33.01	126,681	4.18
	1300 VA	13	2	25.15	17,231	0.43
Total energy saving in North Sumatera						110.27

Whereas saving of generation capacity from the lamp replacement program in North Sumatera is amounted to 40.68 MW (**Table 31**).

**Table 31** Saving of generation capacity in North Sumatera

GRDP/capita	Customer class	Lightbulb wattage			Number of lamps replaced	Total saving (MW)
		CFL	LED	Wattage difference CFL-LED		
Upper middle	450 VA	13	6	7	2,099,456	14.70
	900 VA	18	9	9	1,783,326	16.05
	1300 VA	18	9	9	345,932	3.11
Lower middle	450 VA	13	6	7	685,830	4.80
	900 VA	13	6	7	253,362	1.77
	1300 VA	13	6	7	34,462	0.24
Total saving in North Sumatera						40.68

According to the Department of Mines and Energy (Dinas Petambangan dan Energi - Distamben) in North Sumatera Province, the current installed generation capacity in North Sumatera is 1889 MW, while peak load of electricity reaches up to 1880 MW. This causes a small reserve margin of only 9 MW or approximately 0.48% from generation capacity, which leads to vulnerability of North Sumatera for electricity blackouts. With the energy-efficient lamp replacement program, peak load of electricity demand is expected to be reduced by 40.68 MW. This will increase reserve margin of generation capacity from 9 MW to 49.68 MW or from 0.48% or 2.6% from installed generation capacity.

#### 5.4 Output 4 – Investment for Lamp Replacement Program

LED lamps are known as energy-saving, environmentally-friendly light bulbs which are more expensive than conventional light bulbs. **Table 32** shows the investment needed for the lamp replacement program in each customer class, and total investment needed for North Sumatera. The scenario used is CFL to LED light bulb replacement of the same Lumen Power for each customer class of 450 VA, 900 VA, and 1300 VA in accordance with their GRDP/capita class. Total number of replaced lamps is derived from number of lamps to be replaced per household multiplied by the number of customers in each PLN class.

The price of LED light bulbs are based on Brand B as seen in Output 2. Brand B is chosen because it is the most used brand by respondents based on observations at the time of the survey. In addition, Brand B LED has equivalent quality with the more expensive brand A, which is



15,000 hours of life span, approximately 90 Lumens/watt of efficacy, and one year warranty after purchase. The price of light bulb in the calculation is the average price of Brand B from survey results, whereas distribution and campaign costs are assumed to be a maximum of 5% of the LED lamp price.

**Table 32** Investment for light-bulb replacement program

GRDP/capita	Class	Number of lamps replaced	Price of LED (Rp/lamp)	Distribution cost (Rp/lamp)	Total investment (Rp)
Upper middle	450 VA	2,099,456	35,000	1,750	77,155,008,000
	900 VA	1,783,326	40,000	2,000	74,899,692,000
	1300 VA	345,932	40,000	2,000	14,529,144,000
Lower middle	450 VA	685,830	35,000	1,750	25,204,252,500
	900 VA	253,362	35,000	1,750	9,311,053,500
	1300 VA	34,462	35,000	1,750	1,266,478,500
Total Investment in NorthSumatera					202,365,628,500

According to PLN Statistics 2014, the average cost of generation for Diesel Power Plant, in which diesel is commonly used during peak load, is Rp 2,064.3 per kWh. In accordance with the amount of total energy savings in lamp replacement program that can be seen in Output 3, if 110.27 million kWh of electricity is needed to be generated by diesel power plant, the investment needed is around 338 billion rupiah. This figure is still higher than the investment needed to reduce energy demand by 110.27 kWh by the light bulb replacement program, which is 202 billion rupiah according to the calculations in **Table 27**. Therefore, it can be concluded that the investment made to save energy through light bulb replacement program is smaller than the investment incurred to build a power plant with similar capacity.

### **5.5 Output 5 – Selection Criteria and Number of Households to Benefit from the Lamp Replacement Program**

Criteria of selection for beneficiaries of lamp replacement program is determined by considering the following aspects:

- Saving potentials
- Number of beneficiaries
- Investment costs
- Ease of distribution

In considering these criteria, some assumptions are made for the program implementation, which are:

- Electricity customer data is based on PLN North Sumatera Branch for household class of 450 VA, 900 VA, and 1300 VA.
- Financing is based on grants
- Cost of the program is set on 10 billion rupiah per PLN branch is North Sumatera
- 2 LED light bulbs with wattage range from 6 watts (class 450 and 900 VA) and 9 watts (class 1300 VA) are distributed per household

A simulation calculation is done (Appendix C) by considering all the different criteria and assumptions mentioned above. The following result is obtained:

**Table 33** Scoring results for the selection of beneficiaries

PLN Branch	Number of beneficiaries	Energy saving (GWh/year)	Cost for lamp replacement program (Rupiah)	Willingness to pay	Ease of distribution	Total scoring
Medan	118,186	5.61	9,975,644,360			
	++	+++++++	+++++	+	++++	20
Pematang Siantar	123,282	5.26	9,979,036,760			
	++++	+++++	+++	+	++++	17
Binjai	123,386	5.25	9,973,821,000			
	+++++	++++	+++++++	+	+++	21
Sibolga	125,215	3.96	9,978,681,240			
	+++++++	+++	++++	+	+++	19
Padang Sidempuan	124,616	3.95	9,974,429,080			
	+++++++	++	+++++	+	++	18
Rantau Prapat	119,317	5.53	9,987,966,780			
	+++	+++++++	+	+	++	14
Lubuk Pakam	122,733	5.30	9,983,121,280			
	+++++	+++++	++	+	++++	18
Nias	66,148	2.08	5,334,967,000			
	+	+	+++++++	+	+	12

Explanation:

- The largest number of beneficiaries is awarded 8 points
- The largest energy saved is awarded 8 points
- Lowest lamp replacement cost is awarded 8 points
- Willingness to pay is assumed to be equal considering this is a grant-based program
- Ease of distribution is divided into four areas:
  - Medan, Lubuk Pakam, Pematang Siantar (4 points)
  - Sibolga, Binjai (3 points)

- Rantau Prapat, Padang Sidempuan (2 points)
- Nias (1 point)

**Table 28** shows that with the program budges of 10 billion rupiah per PLN branch, the three highest score is obtained by PLN branches in Binjai, Medan, and Sibolga respectively. Therefore, the lamp replacement program may be considered to be executed in those three regions. if however, the program is eligible to only be implemented in the branch area of survey sites, then Medan and Lubukpakam PLN branches are the top priority for the program.

## 5.6 Output 6 – Monitoring and Evaluation Framework for Energy Saving and Cost-Benefit Analysis of the Program

In the monitoring and evaluation activities, collection of baseline information needs to be done as a reference to compare changes that occur after the replacement program. Framework for monitoring and evaluation activities can be done by setting performance indicators which include the following assessment

- **Electricity consumption before and after the program.** This needs to be done to determine the baseline for electricity consumption. Energy consumption baseline is set as the average electricity bills for 3 months prior to light bulb replacement. After the light bulb replacement program, electricity consumption of the targeted household can be monitored by filling in the electricity consumer's identity online though the website <http://www.pln.co.id/info-rekening/tagihan.php>.
- **Energy Savings.** Energy savings can be calculated by subtracting the power consumption each month after the program with the baseline electricity consumption before the program.
- **Effectiveness of Light Bulb Replacement Program.** This indicator shows the impact of energy efficiency through the demand side (light bulb replacement program) compared to the supply side. This indicator uses the calculation of Cost of Saved Energy (CSE) as seen in **Equation (8)**.

$$CSE = \frac{Inv}{E_{Saving}} \quad (8)$$

Based on the formula, *Inv* is the investment required for the lamp replacement program (IDR) and *E\_Saving* is the total energy saved from the lamp replacement program (kWh). And then CSE in IDR/kWh is compared to the State Utility Company (Perusahaan Listrik

Nasional – PT PLN) electricity generation cost. If CSE is lower than PT PLN's generation cost, the light bulb replacement program is more effective than energy efficiency efforts from the supply side.

- **Payback period.** Calculation of payback period for the lamp replacement program is as follows:

$$AAGC = AE\_Saved \times GC \quad (9)$$

$$PP = \frac{Inv}{AAGC} \quad (10)$$

in which,

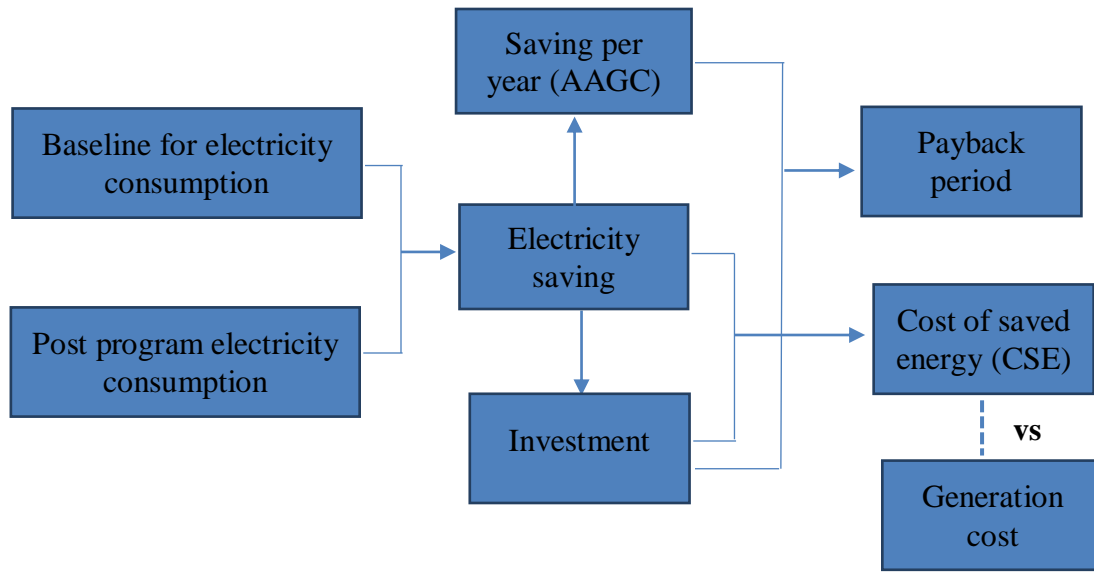
*AAGC* : Annual Avoided Generation Cost (IDR/year)

*AE\_Saved* : Energy saved per year (kWh/year)

*PP* : Payback Period (year)

*Inv* : Investment needed due to the replacement program (IDR)

Illustration of the monitoring and evaluation framework can be seen in **Figure 21**.



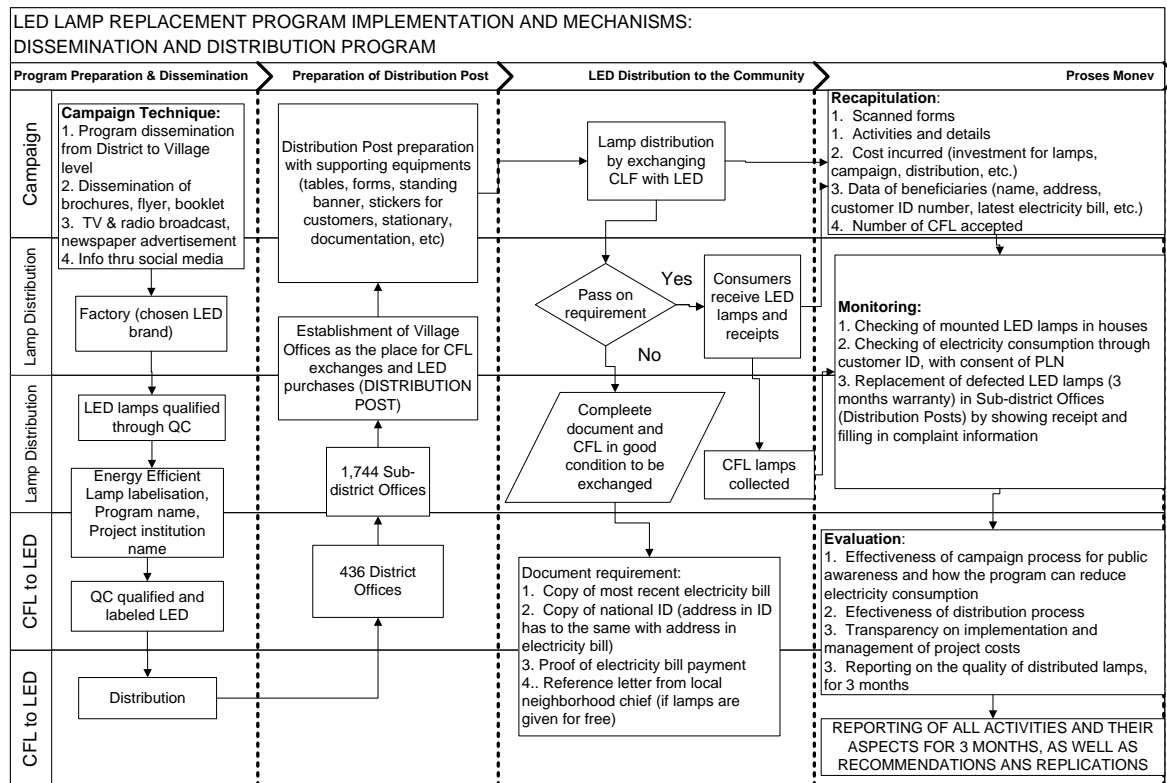
**Figure 21** Monitoring and evaluation framework

### 5.6.1 Monitoring and Evaluation Framework for Energy Saving Program

Implementation of the program is simulated in two alternative schemes: (1) LED light bulbs are provided free from the government or donor, and (2) the program is carried out through the mechanism of ESCO (Energy Saving Companies) with community participation. The mechanism for the two schemes are as follows:

### 5.6.1.1 Mechanism on Program Based on Government or Donor Grants

Implementation of the program is designed in several steps, starting from Program Dissemination to LED Distribution. Proposed distribution mechanism started from the lamp supplier to the process of monitoring and evaluation of the program, as seen in the following chart:



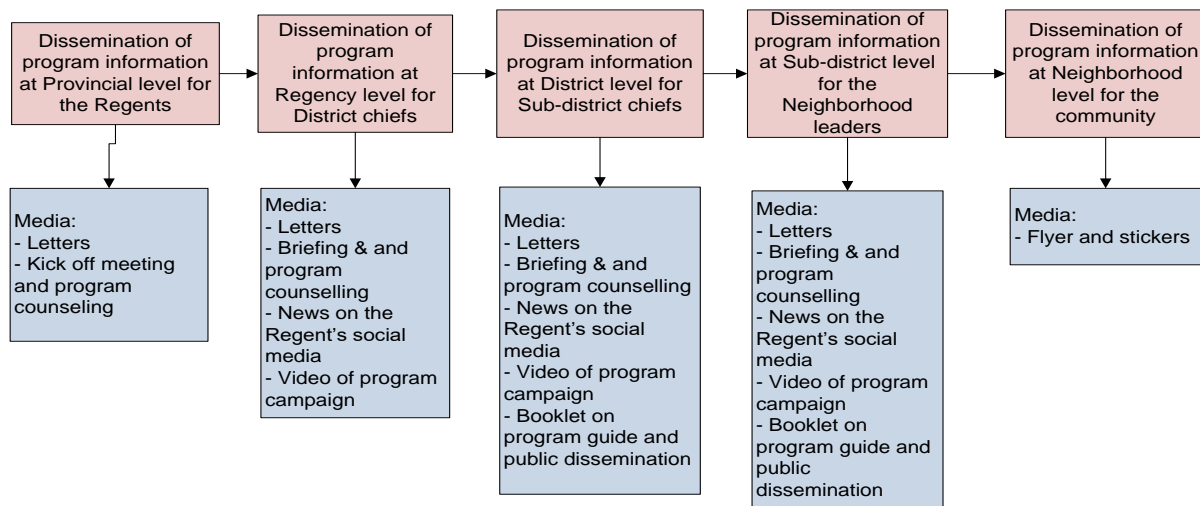
**Figure 22** Light bulb replacement program implementation mechanism

This program can be implemented by the Ministry of Energy and Mineral Resources, especially the Directorate of New Renewable Energy and Energy Conservation, along with other relevant ministries and PLN, with alternative funding sources from the State Budget or donors. There are two main activities in this program, which are the distribution of light bulbs, and monitoring and evaluation activity. Main activities and their components as seen in **Figure 22** are explained in the following description:

## A. Lamp Distribution

### 1. Dissemination program to local government and its apparatus

Dissemination program scheme to local government can be seen in this following chart.



**Figure 23** Dissemination Program to regional governments and their staffs

Target program is PLN's customer amounts to 2,600,000 households spread over 33 regencies and 463 sub-districts.

### 2. Campaign through media channels

Media communication such as television ads, radio ads and newspaper are selected to be a means of disseminating information. Advertisement might appear on television broadcast for two weeks, appear in newspapers 6 times in 2 weeks and through radio broadcasts for 3 weeks.

### 3. Establishment of Distribution Post

Distribution post is set 4 village offices per sub-district with the number of LED lamps per village setting proportional to the number of beneficiary customer. The process of lamp distribution based on completeness requirements with filled out form. The completed form is in the form of paper form that can be scanned for data recapitulation. Data collection is performed by village apparatus.

#### **4. Preparation and Delivery of Lamps**

Before the lamp is distributed, the selected LED lamp is the lamp that has passed the test of QC (Quality Control), and then stamped with "PROJECT NAME" and "YEAR". The packaging of lamp is also equipped with Energy Saving Light Bulb label. The lamps are distributed to 1,744 villages in accordance with the tender agreement on lamps procurement with lamp suppliers.

#### **5. Distribution of Lamps**

PLN's customers can redeem CFL lamp with LED lamp with term and conditions as follows:

- a. Photocopy of the latest electricity bill
- b. Photocopy of the identity card (residence address on the ID card must match the address on the electricity bill)
- c. Proof of electricity bill payment in case arrears of electricity bill happens
- d. A letter from neighbourhood association
- e. Bringing CFL lamp to be redeemed (in good condition)

In addition, the customers are also required to fill out a form in the post and submit it to administrative officer. If the requirements have been fulfilled, customers can receive LED lamp and receipt.

### **B. Monitoring and Evaluation**

Several phases of activities in the monitoring and evaluation are as follows:

#### **1. Data Recapitulation**

Data recapitulation is needed to calculate and to measure the efforts for implementing the activities as well as the basis for monitoring and evaluation of the project objectives achievement. Data recapitulation is performed in the level of village (distribution post) and compiled in the regency and provincial level. Data recapitulation includes:

- a. Scan form
- b. Activities and its details (place and implementation of each activity, implementer, objectives per activity)
- c. Cost for each activity (investment of lamp, campaigns and dissemination program as well as distribution)
- d. Photocopy of customers's identity card and electrical identity number, electricity bill (as initial information for electricity consumption) and letter from neighbourhood

association (as the evidence of neighbourhood association involvement in the program and verification)

- e. Number of CFL lamp collected and means of collecting

## **2. Monitoring**

Monitoring activities including:

- a. Checking into homes that receive LED lamp, whether the LED lamp is installed or not. The checking process will be performed by neighbourhood association and the report submit it to the community association and village office
- b. Village office compiles data from both association above and submit it to sub-district office
- c. Sub-district office compiles data and submit it to regency level
- d. In the provincial level, all the data are compiled and then submit to project implementer (director general of new and renewable energy and donor)

All step a-f are repeated at the end of every month for 3 months since the initial stage of project implementation. The next step is continued with:

- e. Checking power consumption through customers electrical identity number in cooperation with PLN
- f. Providing complaint mechanism for customer and accommodating the damaged LED lamp replacement (in the program period of 3 months) in village office that become distribution post by showing the receipt of LED lamp , damaged lamp and the project label.
- g. Collecting CFL lamps in accordance with an agreed number of CFL lamps

## **3. Evaluation**

- a. Effectiveness of campaign process for public awareness  
Doing an analysis if there are any increase in the purchase of LED lamps (data checking into statistical agency and/or ministry of trade)
- b. Effectiveness of the program to the reduction of power consumption saving  
Performed after measuring changes in power consumption by checking the customer's electrical identity number and doing analysis if the replacement program can overcome the black out or reducing power consumption in the peak hours
- c. Effectiveness of distribution process
- d. Analyzing the effect of the placement of LED lamps only in some village and not across villages to ease the process of distribution and absorption of all LEDs for all target of PLN's customers PLN target
- e. Transparency of project implementation and management of project costs



Analyzing the openness and transparency of distribution process and financial management

- f. Report on the quality of distributed LED lamps performed in the period of 3 months during the program

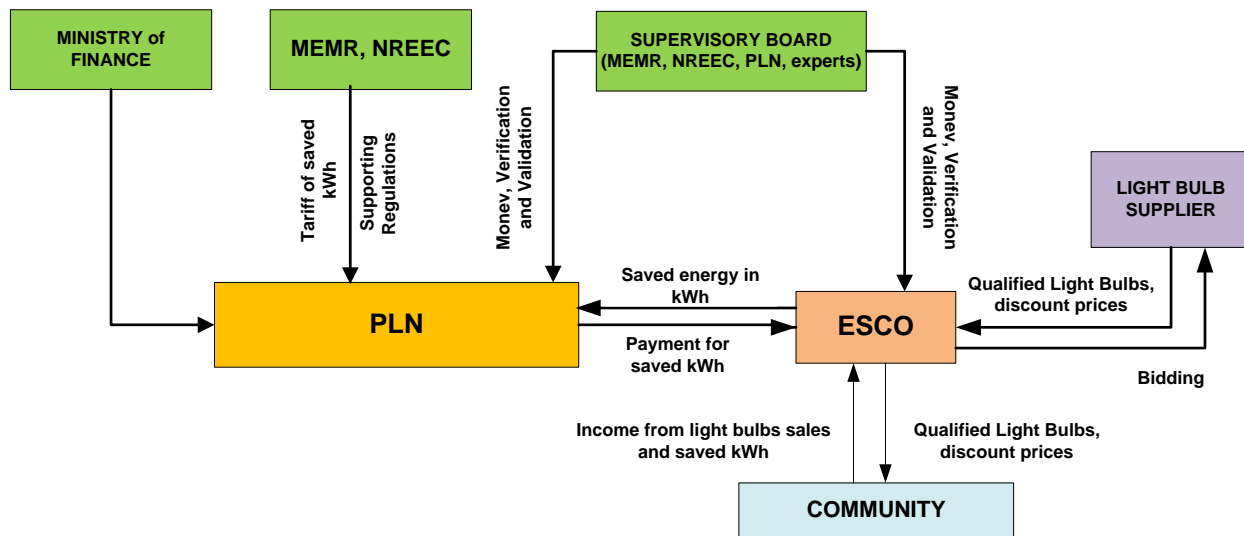
Data are obtained from the complaint mechanism during the monitoring process in order to see the performance of distributed LED lamps and become a reference to evaluate the choosen suppliers of LED lamps

A full report of this activity submitted to the implementer of the main projects to be a reference of recommendation in case the replication of the lamp replacement program will be held.

#### ***5.6.1.2 Mechanism for Program Based on ESCO***

The implementation of the lamp replacement program based on ESCO (Energy Service Company) business model assumes that investment cost is not fully borne by the government, due to: (1) the large amount of costs to be provided, (2) as a tool to foster public awareness on the importance of energy efficient behavior by buying household appliances with high level energy efficiency, and (3) promoting energy efficiency activists or businesses to be involved in the provision of energy efficient technologies.

In this program, exchange mechanism from CFL to LED lamps is not significantly different from the Government/Donor based grant scheme. For the basis of the program, ESCO adopts the model of Demand Side Management (DSM)-based Efficient Lighting Program with Standard Offer Programme (DELP-SOP) which has been implemented in India. In ESCO cooperation scheme, electricity supplier (PLN) is required to buy the saved energy (in kWh) based on a particular type of technology through the establishment of supporting regulations, which is the Energy Efficiency Purchase Agreement (EEPA). This agreement is similar to the agreement between PLN and private power providers through the Power Purchase Agreement (PPA). Proposed ESCO-based program can be seen in the following figure:



**Figure 24** Mechanism of cooperation with ESCO

Description of **Figure 24** is as follows:

- i. The Ministry of Energy and Mineral Resources (MEMR) and the Directorate General of EBTKE act as regulators and policy makers related to the purchase rate on energy saved by a business entity with reference to the avoidance of the cost to build new power plants. In addition to tariff and supporting regulatory framework, MEMR and EBTKE also establish a cooperation mechanism between ESCO, the government, and other relevant ministries/agency with their supporting regulations.
- ii. Supervisory Board is an independent body whose members are MEMR, EBTKE, PLN, and experts. One of the main tasks of this agency is to develop a methodology of supervision, monitoring, evaluation, intervention, and verification of program activities, from implementation to reporting stages. This includes validation of the amount of energy saved and redeemable with the adjusted rates. Verification and validation of calculation results by PLN and ESCO serve as the basis for payment to ESCO.
- iii. PLN acts as a buyer of saved energy as well as one of the members of Supervisory Board to verify on claims made by ESCO, and as an advisor to determine the location of the program. Based on verification by the Supervisory Board, PLN is obliged to pay an amount based on electrical energy saved by ESCO, which is also verified by the Supervisory Board. Additionally, PLN can cooperate with ESCO in terms of payment of the lamps by the public through electricity bills.
- iv. The Ministry of Finance is authorized to oversee the transactions carried out by PLN, especially exchange mechanism for saved energy. This information becomes a basis to determine the amount of subsidy from the government to PLN.
- v. In terms of selection of ESCO, the government (MEMR and EBTKE) can carry out an open bidding for companies to submit proposals as attractive as possible. ESCO is

routinely responsible to implement the purchase of light bulbs by the public during the project.

In terms of program implementation in North Sumatera, the rates stipulated for the purchase of saved energy in replace of construction of energy generation facilities can refer to the CSE value (Cost of Saved Energy). Formulated energy savings in duration of light bulb lifetime can be seen in **Equation (8)**. The life expectancy of LED lamps are 15,000 hours. Assuming that in average, the lamps are turned on 8 hours per day and 365 days a year, lifetime of LED lamps is around 5.14 years. By rounding the lifetime to 5 years, CSE value obtained is Rp 367.04 per kWh.

Further details regarding the ESCO scheme are as follow:

1. In order to motivate people to buy the lamp, the price of LED lamp is set on 1/3 (one third) of market selling price. Buyers can pay all at once or by installments in the form of several months of electricity bills. ESCO obtains an attractive unit price from the supplier through a tender process, as well as income from the beneficiary community. The rest of the investment costs will be recovered through the purchase of saved energy by the PLN in accordance with the rates stipulated in the EEPA.
2. The value of energy savings per kWh is converted to rupiah based on the calculation of CSE as a reference for tariff determination. The agreed rate shall not exceed the applicable economic price of electricity. This approach is intended for PLN to avoid construction costs of a new generator, transmission and distribution system. The difference of lamp replacement program tariff with economic electricity tariff is considered as an opportunity cost for PPLN. As an example, if the purchase of saved energy is set at Rp 367.04/kWh whereas the current economic electricity tariff is Rp 1,350.57/kWh, the difference of Rp 983.53/kWh is considered as opportunity cost. Moreover, tariff composition must consider the profitability of ESCO during the program.
3. The project is implemented in accordance with the lifetime of LED used in the program, which is 5 years. The basis of project duration can be defined by: (i) ESCO's desire to recover the investment within a certain period, and (ii) the ability of the government to buy saved energy up to a certain duration.
4. Other activities and responsibilities of ESCO in this program include:

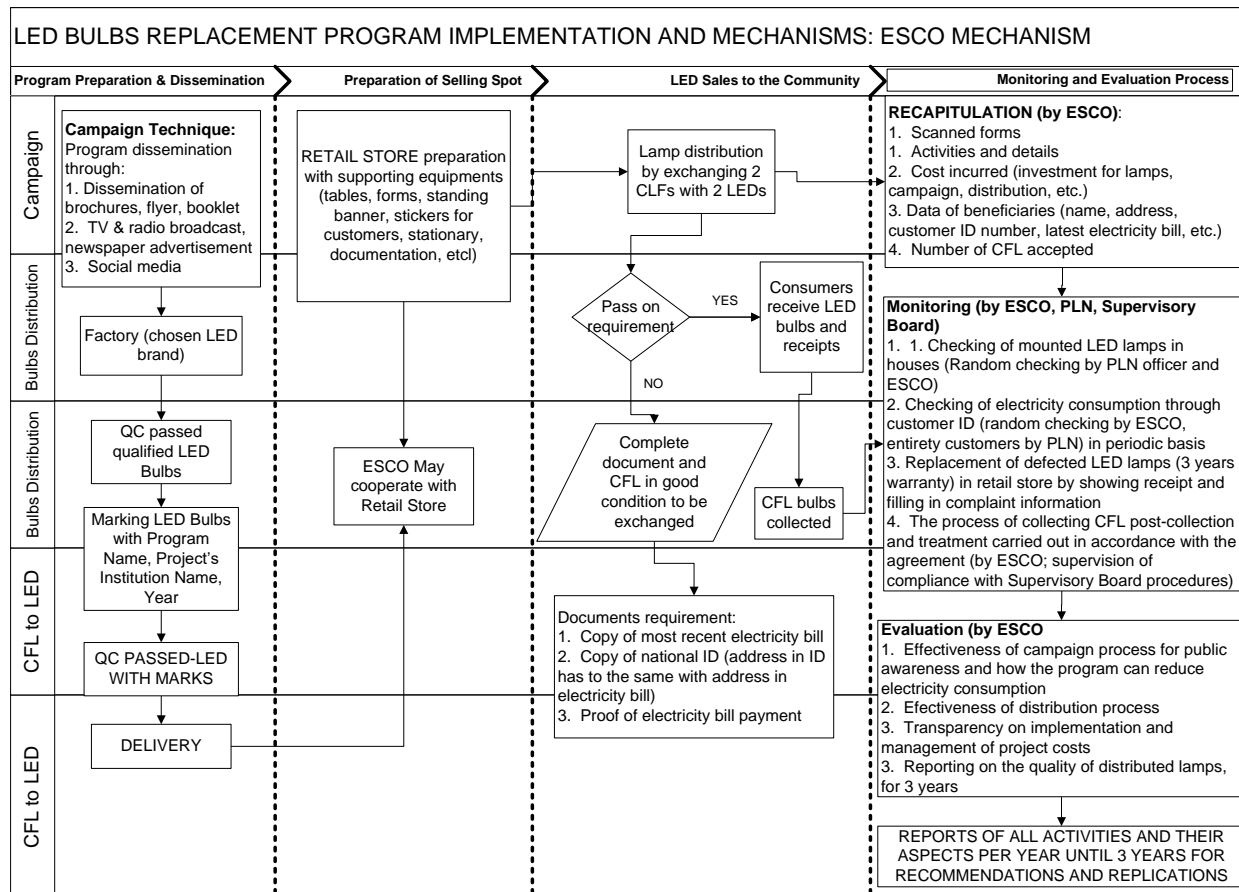
- a. ESCO is responsible for the provision of light bulbs in terms of purchase points and distribution patterns including services, transparent transaction process, and after sales duty for marketed light bulbs (ongoing for 3 years).
  - b. ESCO is responsible for the publication and promotion of the program.
  - c. ESCO will give a special mark or serial number on the LED light bulbs so they will not be resold in the market.
  - d. ESCO is responsible for the collection process and ensures that the exchanged CFL lamps are not sold back to the market.
  - e. ESCO is obliged to record the transaction and customer data to be used as a database by the related K/L.
  - f. ESCO is obliged to implement periodic field monitoring related to the use of light bulbs by the customers, which will be reported to the Supervisory Board.
5. Payment to ESCO is conduction periodically by random field verification using agreed methodologies.

The business model of ESCO will be economically viable if the price of saved energy is set in between the CSE value and the economic electricity tariff. Tariff agreement between the government and ESCO is based on the calculation of economic indicators such as PP (payback period), NPV (net present value) or IRR (interest rate of return) of the program. Here is an example of calculation on various PP, NPV and IRR if the price is stipulated in 3 variations, ie Rp 367.04/kWh, Rp 450/ kWh, and Rp 500/ kWh (the price of electricity generation of coal power plant). The light bulb purchase process is implemented in the first year of the program.

**Table 34** Various Payback Period, NPV, and IRR from purchase of saved energy

Year	Investment (Rupiah)	Lamp purchase by the customers (Rupiah)	Tariff Rp 367.04/kWh		Tariff Rp 450/kWh		Tariff Rp 500/kWh	
			Purchase of saved energy (Rupiah)	Cash flow (Rupiah)	Purchase of saved energy (Rupiah)	Cash flow (Rupiah)	Purchase of saved energy (Rupiah)	Cash flow (Rupiah)
0	202,365,628,500		-202,365,628,500	-202,365,628,50		-202,365,628,50		-202,365,628,50
1		64,243,056,667	38,626,478,300	102,869,534,967	49,621,500,000	113,864,556,667	55,135,000,000	119,378,056,667
2			38,626,478,300	38,626,478,300	49,621,500,000	49,621,500,000	55,135,000,000	55,135,000,000
3			38,626,478,300	38,626,478,300	49,621,500,000	49,621,500,000	55,135,000,000	55,135,000,000
4			38,626,478,300	38,626,478,300	49,621,500,000	49,621,500,000	55,135,000,000	55,135,000,000
5			38,626,478,300	38,626,478,300	49,621,500,000	49,621,500,000	55,135,000,000	55,135,000,000
<b>Payback period</b>			3.58		2.59		2.51	
<b>NPV</b>			(14,242,998,212.19)		12,118,753,212.64		28,006,983,338.50	
<b>IRR</b>			12%		20%		24%	

The program dissemination activities are similar to grant mechanism (lamps are given for free), whereas monitoring and evaluation activities are carried out simultaneously by MEMR's Directorate of Energy Conservation, PLN, and ESCO. Flowchart of ESCO Mechanism is seen in **Figure 25**.



**Figure 25 Mechanism of lamp distribution by ESCO**

## 5.6.2 Cost-Benefit Analysis of the Program

### *Benefit for the Government*

#### i. Payback Period

The calculation of the Payback Period (PP) for each customer class in accordance with the category of GRDP/capita is given in **Table 35**. Total energy savings in kWh/year refers to **Table 30** on Output 3, while the investment cost refers to **Table 32** on Output 4. PLN electricity price for 1300 VA is used. This prices reflected the economic price of electricity which obtained from

the average electricity price for the last 3 months. Calculation of the Annual Avoided Generation Cost (AAGC) is done by multiplying the amount of energy savings with the price of electricity per unit kWh.

**Table 35** Calculation of payback period

GRDP/ capita	Customer class	Total investment	Energy saving (GWh/year)	Electricity tariff for 1300 VA (Rp/kWh)	AAGC (Rp/year)	PP (year)
Upper middle	450 VA	77,155,008,000	39.24	1350.57	53,000,963,632	1.46
	900 VA	74,899,692,000	46.15	1350.57	62,329,191,265	1.20
	1300 VA	14,529,144,000	9.52	1350.57	12,862,721,835	1.13
Lower middle	450 VA	25,204,252,500	10.74	1350.57	14,501,964,114	1.74
	900 VA	9,311,053,500	4.18	1350.57	5,647,337,987	1.65
	1300 VA	1,267,478,500	0.43	1350.57	585,204,373	2.16
Total North Sumatera		202,365,628,500	110.27	1350.57	148,927,383,205	1.30

*Electricity tariff is taken from the average of PLN's Tariff Adjustment in March, April, and May 2016*

**Table 29** shows that there are variations in the payback period for each customer class and each category of the GRDP/capita. The fastest payback period is obtained from the lamp replacement program in customer class 1300 VA in upper-middle GRDP/capita regions, which is 1.13 years. Whereas the longest payback period is obtained from the lamp replacement program in customer class 450 VA in lower-middle GRDP/capita regions. Payback period from North Sumatera if the program is executed simultaneously in all regions, sums up to approximately 1.3 years.

## ii. Saving on Subsidy

If the lamp replacement program is implemented, the electricity savings can help the government avoid spending subsidies on 450 VA and 900 VA households. Potential saving on subsidy in North Sumatera for customer class 450 VA and 900 VA can be seen in **Table 36**.

**Table 36** Potential subsidy saving

GRDP/capita	Customer class	Energy saved (GWh/year)	Electricity tariff (Rp/kWh)	Subsidized electricity tariff (Rp/kWh)	Tariff difference (Rp/kWh)	Subsidy saving (Rp/year)
Upper middle	450 VA	39.24	1350,57	415	935,57	36.714.991.323
	900 VA	46.15	1350,57	605	745,57	34.408.337.370
Lower middle	450 VA	10.74	1350,57	415	935,57	10.045.845.398
	900 VA	4.18	1350,57	605	745,57	3.117.568.297
Total subsidy saving in in North Sumatera						84.286.742.388

**Table 36** shows that the lamp replacement program for sutomer class 450 and 900 VA can help the government to reduce subsidies by 84 billion rupiah per year.

### ***Benefit for public***

Intervention program to replace CFL lamps with LED light bulbs also show cheaper investment cost, based on comparison of ligh bulb wattage, lifetime, and energy consumption (**Table 37**).

**Table 37** Comparison of benefit from using LED lamps

	CFL	LED	Explanation
Light bulb wattage	18	9	The brightness of 18 watt CFL is equal to 9 watt LED (900 lumens)
Lifetime (hours)	8,000	15,000	
Energy consumption (kWh)	270	135	Wattage multiplied by lifetime
Average electricity tariff (Rp/kWh)	1,350.57	1,350.57	
Electricity cost (Rp)	364,654	182,327	Electricity cost for LED is cheaper than CFL for the same usage (15,000 hours)
Lamp price (Rp)	Rp. 31,500 x 2 lamps = Rp. 63,000	Rp. 40,000	For a lifetime of 15,000 hours, CFL lamps need to be replaced 2 times, whereas LED only 1 time
Total cost	427,654	222,327	The total cost of using CFL in more expensive than LED

*Price on LED lamp is based on a certain brand*

**Table 37** shows that the use of LED lamps over CFL has several benefits such as: the wattage of LED is half of CFL for the same brightness, lamp lifetime is twice longer, and energy consumption is only half of CFL, which result in cheaper investment cost if people either purchase their own LED lamps or through a grant program.

### ***Benefit for the Environment***

The benefit from the lamp replacement program in North Sumatera can also be reviewed by calculating the emissions (in carbon dioxide equivalent) mitigated by the program. The calculation of carbon emission is done by multiplying the energy savings by the diesel power

plant emission factor. This is based on the consideration that the energy saving generated by the program is coincide with the peak load demand supplied by diesel power plant. The lamp replacement program in North Sumatera could mitigate approximately 2.2 tons of CO<sub>2</sub> equivalents per year (**Table 37**)

**Table 38** Emissions savings from lamp replacement program

GRDP/capita	Customer class	Emission saved (kg/year)					
		CO <sub>2</sub>	Methane		Nitrous oxide		Total (CO <sub>2</sub> eq)
			NH <sub>4</sub>	CO <sub>2</sub> eq	N <sub>2</sub> O	CO <sub>2</sub> eq	
Upper-middle	450 VA	808.4043	0.11773	0.004709	0.00654578	0.00002197	808.41
	900 VA	950.6843	0.138451	0.005538	0.00769785	0.00002583	950.69
	1300 VA	196.1904	0.028572	0.001143	0.00158859	0.00000533	196.19
Lower-middle	450 VA	221.1931	0.032213	0.001289	0.00179104	0.00000601	221.19
	900 VA	86.13678	0.012544	0.000502	0.00069746	0.00000234	86.14
	1300 VA	8.925908	0.0013	5.2E-05	7.2275E-05	0.00000024	8.93
Total emission saved in North Sumatera							2271.55



## **Chapter V**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1 Conclusion**

Some important findings in this study are as follows:

- Average mounted lights of each customer class 450 VA, 900 and 1300 VA are 5.8, 6.7, and 9.2 light bulbs per household respectively.
- For all customer class of 450 VA, 900, and 1300 VA, CFL light bulbs dominate the possession of lamps in households with a share of 86-96%. Meanwhile, incandescent bulbs stands as the least used type of light bulbs with a share of <1% for 450 and 900 VA and 4% for 1300 VA.
- LED light bulb has already entered the household market with a share of 2-5% for all customer classes. The share was greater in higher customer class.
- With the least type of light bulb found in the household, it can be concluded that the incandescent lamp technology has undergone a phase-out. This is presumably due to the affordable price of CFLs. The same tendency in the future is expected to occur also to CFLs since currently there is a strategy applied by lighting manufacturers to lower LED quality and prices by reducing LED life span, therefore LED will be more affordable.
- Given the three types of lighting (incandescent bulbs, CFLs, and LEDs) are easy to be found in the market, the concluded main factor of bulbs selection by customer is due to its price.
- The market demand profile of light bulbs type obtained from the availability of each type of light bulbs of the surveyed stores, indicates conformity with the profile of the type of lamps ownership per household, which is dominated by CFL's followed by LED lamps, TL, and incandescent bulbs.
- Although the number of mounted lamps per household in higher class of customers is greater than the lower class, they tend to use light in shorter duration. The survey showed the duration use of lights in 450, 900, and 1300 are respectively 7.7, 7.6, and 7.2 hours per day
- As estimated, the higher capacity of households, the higher would be the electricity consumption per household for lighting. Data result showed the electricity consumption of

0.88, 1.02, and 1.61 kWh/household/day for customer class of 450, 900, and 1300 VA respectively in Medan, 0.66, 0.78, and 1.20 kWh/household/day for customer class of 450, 900, and 1300 VA respectively in Deliserdang, and 0.64, 0.67, and 0.84 kWh/household/day for each customer class of 450, 900, dan 1300 VA in Simalungun.

- Through several proposed scenarios of replacing CFL with LED in all PLN customer class, it is concluded that the highest potential savings will be gained by replacing 11-15 watts CFL in customer class 450 VA and 16-20 watts CFL in customer classes 900 and 1300 in upper-middle GRDP/capita regions. As for areas with middle-lower GRDP/capita, 11-15 watts CFL are to be replaced in all customer class.
- If using the optimistic scenario, namely by replacing 2 CFL light bulbs with LED in each household, the potential savings for the entire North Sumatera province will be 110.27 Gwh/year.
- The light bulb replacement program can also potentially reduce peak load in North Sumatera, which is equivalent to saving of generation capacity by 40.68, adding the reserve margin to 2.6% of the installed capacity throughout North Sumatra (according to 2013 data).
- Analysis of the cost-benefit program demonstrates the benefits for the government, communities, and the environment. For the government, payback period of 1.3 years is gained if the program is conducted throughout North Sumatera. If the program is implemented only in specific customer class and specific GRDP/capita class, the fastest payback period will be obtained in customer class 900 VA in upper middle category of GRDP/capita.
- Implementation of the program can also reduce government subsidy on electricity by Rp 84.28 billion per year and the avoidance of having to build coal power plant which will cost approximately Rp 813,16 billion.
- For the household, using LED lamps will cut electricity bills by half as CFL, with longer lifetime. This applies to both secenarios of whether the customers buy their own lamps, or through a grant program.
- If the program is done by ESCO, with lamp selling price to the public by a third of the market price, the value of payback period, NPV, and IRR based on saved energy buying rate of Rp 450/kWh and Rp 500/kWh are 2.59 years; Rp 12.12 billion; 20% and 2.51 tahun; Rp 28 billion; 24%.

- Emission savings from the lamp replacement program in North Sumatera is approximately 2.27 tons of CO<sub>2</sub> equivalent per year.

## **5.2 Suggestions**

Based on several important findings through this study, several recommendations are made as follows:

- For the reason that CFL bulbs already dominated the use of lighting devices in households, therefore when there will be a replacement of lighting devices program to reduce electricity demand in overcoming power crisis, the most recommended program will be the replacement of CFLs to LEDs lamps.
- In lower-middle PDRB/capita regions, it is recommended to switch 11-15 watts CFL bulbs to LEDs for household classes of 450, 900, and 1300 VA as it will provide the highest potential savings and the least payback period.
- While for upper-middle PDRB/capita regions, the recommended CFL bulbs to be replaced are the 11-15 watts for household class 450 VA, and 16-20 watts for household classes of 900 and 1300 VA, as it will provide the highest potential savings and the least payback period.

## Appendix A – Household Questionnaire

### Kuesioner

### Konsumsi Energi untuk Penerangan di Rumah Tangga

#### 1. Informasi Umum

Keterangan Tempat							
1.a	Provinsi	_____ [Kode] <input type="text"/>					
	Kabupaten/Kota	_____ [Kode] <input type="text"/>					
	Kecamatan	_____ [Kode] <input type="text"/>					
	Kelurahan/Desa	_____ [Kode] <input type="text"/>					
1.b	Alamat	.....					
Keterangan Anggota Rumah Tangga							
1.c	Nama Kepala rumah tangga: .....						
1.d	Nama responden: .....						
1.e	Usia responden: <input type="text"/> <input type="text"/> th			Jenis kelamin responden: <input type="radio"/> L <input type="radio"/> P			
1.f	Hubungan dengan Kepala rumah tangga	<input type="radio"/> Diri sendiri	<input type="radio"/> Pasangan	<input type="radio"/> Anak	<input type="radio"/> Lainnya		
1.g	Jumlah anggota rumah tangga: <input type="text"/> <input type="text"/> Orang <i>(Rumah tangga merupakan seorang/sekelompok orang yang mendiam di sebagian/seluruh bangunan fisik/sensus dan biasanya tinggal bersama serta makan bersama dari satu dapur)</i>						
1.h	Ijazah/STTB tertinggi yang dimiliki						
	Kepala rumah tangga	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	Pasangan	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	Anak	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	Anak	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	Anak	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	.....	<input type="radio"/> Tidak memiliki ijazah	<input type="radio"/> SD	<input type="radio"/> SMP	<input type="radio"/> SMU	<input type="radio"/> Diploma	<input type="radio"/> PT
	.....	Tidak memiliki ijazah	<input type="radio"/> SD	SMP	SMU	Diploma	PT
.....	Tidak memiliki ijazah	<input type="radio"/> SD	SMP	SMU	Diploma	PT	
<u>Keterangan</u> SD dan sederajat : SD, SDLB, M. Ibtidaiyah SMP dan sederajat : SMP, SMPLB, M. Tsanawiyah SMA dan sederajat : SMA, SMLB, M. Aliyah Diploma : D1, D2, D3							

		Perguruan Tinggi : S1, S2, S3	
1.i	Total pengeluaran konsumsi rumah tangga per bulan		
	<input type="radio"/> < Rp 1.000.000	<input type="radio"/> Rp 7.000.000 – Rp 8.999.999	<input type="radio"/> Rp 15.000.000 – Rp 16.999.999
	<input type="radio"/> Rp 1.000.000 – Rp 2.999.999	<input type="radio"/> Rp 9.000.000 – Rp 10.999.999	<input type="radio"/> > 17.000.000
	<input type="radio"/> Rp 3.000.000 – Rp 4.999.999	<input type="radio"/> Rp 11.000.000 – Rp 12.999.999	
	<input type="radio"/> Rp 5.000.000 – Rp 6.999.999	<input type="radio"/> Rp 13.000.000 – Rp 14.999.999	

## 2. Profil Rumah Tangga Pelanggan PLN

2.a	Satu meteran digunakan untuk berapa rumah tangga?	<input type="text"/>
2.b	Batas daya listrik yang terpasang saat ini	
	<input type="radio"/> 450 VA	<input type="radio"/> 900 VA <input type="radio"/> 1300 VA
2.c	Sistem pembayaran tagihan	
	<input type="radio"/> Pra bayar	<input type="radio"/> Pasca bayar
2.d	No. Pelanggan	
	No. meter : _____	IDPEL: _____
2.e	Penggunaan listrik	
	Penerangan	<input type="radio"/> Ya <input type="radio"/> Tidak
	Pendingin Ruangan (AC)	<input type="radio"/> Ya <input type="radio"/> Tidak
	Keperluan Memasak (kompor listrik, <i>rice cooker</i> , dll.)	<input type="radio"/> Ya <input type="radio"/> Tidak
	Kipas Angin	<input type="radio"/> Ya <input type="radio"/> Tidak
	Kulkas	<input type="radio"/> Ya <input type="radio"/> Tidak
	TV	Ya Tidak
	Komputer	Ya Tidak
	Mesin cuci	<input type="radio"/> Ya <input type="radio"/> Tidak
	Pompa air	<input type="radio"/> Ya <input type="radio"/> Tidak
	Lainnya (sebutkan .....)	<input type="radio"/> Ya <input type="radio"/> Tidak

## 3. Pengeluaran untuk konsumsi listrik

3.a	Rata-rata pembayaran listrik setiap bulan	Rp ____	
3.b	Tagihan rekening listrik 3 bulan terakhir		
	Pasca bayar		Prabayar
	Bulan	Tagihan listrik	Jumlah isi ulang pulsa listrik
		Rp ____	Rp ____
			Jangka waktu pemakaian pulsa listrik sampai pulsa habis
			____ hari

	Rp ____	Rp ____	____ hari
	Rp ____	Rp ____	____ hari

#### 4. Konsumsi energi listrik untuk penerangan

4.a	Deskripsi titik lampu								
	Titik Lampu	Jenis dan Daya Lampu					Lama pemakaian (jam/hari)	Jangka waktu pemakaian (dari jam... s/d jam...)	
	Lampu -1	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -2	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -3	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -4	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -5	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -6	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -7	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
	Lampu -8	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __
		Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10						
Lampu -9	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -10	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -11	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -12	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -13	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -14	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -15	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -16	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10							
Lampu -17	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5					--	__ : __ s/d __ : __	

	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -18	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -19	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -20	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -21	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -22	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -23	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -24	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -25	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -26	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -27	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -28	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -29	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
Lampu -30	Jenis	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5	--	__ : __ s/d __ : __
	Daya	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/> 9 <input type="radio"/> 10		
<b>Keterangan Jenis Lampu</b> 1. Bohlam      2. CFL      3. TL      4. LED      5. Lainnya  <b>Keterangan Range Daya Lampu</b> 01 – 1 s/d 5 watt      05 – 21 s/d 25 watt      09 – 61 s/d 80 watt 02 – 6 s/d 10 watt      06 – 26 s/d 30 watt      10 – 81 s/d 100 watt 03 – 11 s/d 15 watt      07 – 31 s/d 40 watt 04 – 16 s/d 20 watt      08 – 41 s/d 60 watt				
4.b	Dimana Anda biasanya membeli/memperoleh lampu?			
	<input type="radio"/> Warung klontong	<input type="radio"/> Minimarket/Supermarket	<input type="radio"/> Toko Listrik	<input type="radio"/> Lainnya
4.c	Apakah yang menjadi pertimbangan utama dalam memilih jenis lampu?			
	<input type="radio"/> Garansi	<input type="radio"/> Merk	<input type="radio"/> Harga	<input type="radio"/> Lainnya

## 5. Persepsi tentang lampu hemat energy

5.a	Apakah Bapak/Ibu/saudara pernah mendengar atau mengetahui tentang lampu hemat energi?	
	<input type="radio"/> Ya	<input type="radio"/> Tidak

	Jika <b>Tidak</b> , surveior menunjukkan contoh bentuk lampu hemat energi (CFL dan LED)
--	---

5.b	Apakah Bapak/Ibu/saudara saat ini menggunakan lampu hemat energi (CFL/LED) di rumah?	
	<div><input type="radio"/> Ya</div> <div>Jika <b>Ya</b>, lanjut ke pertanyaan [5.c] dan [5.d]</div>	<div><input type="radio"/> Tidak</div> <div>Jika <b>Tidak</b>, surveior menjelaskan tentang perbedaan konsumsi listrik dan harga antara Bohlam, CFL, dan LED, kemudian lanjut ke pertanyaan [5.e]</div>

5.c	Jika ya, apa alasan utama anda menggunakan lampu hemat energi?
	<input type="radio"/> Hemat listrik dan hemat biaya <input type="radio"/> Mengikuti anjuran pemerintah, teman, tetangga, dll <input type="radio"/> Membaca, mendengar, dan melihat iklan tentang lampu hemat energi <input type="radio"/> Agar dapat membantu masalah krisis listrik di Sumatera Utara <input type="radio"/> Kualitasnya lebih baik Lainnya: .....
5.d	Bagaimana pengalaman anda setelah menggunakan lampu hemat energi, terkait dengan tagihan listrik?
	<input type="radio"/> Lebih murah <input type="radio"/> Sama saja <input type="radio"/> Tidak pernah dihitung <input type="radio"/> Lainnya: .....
Pertanyaan selesai.	

5.e	Setelah mengetahui informasi bahwa CFL dan LED dapat menghemat energi, apakah Bapak/Ibu/Saudara berencana mengganti lampu yang sudah ada menjadi lampu hemat energi (CFL dan LED)?	
	<input type="radio"/> Ya Jika <b>Ya</b> , pertanyaan selesai.	<input type="radio"/> Tidak Jika <b>Tidak</b> , lanjut ke poin <b>[5.f]</b>

5.f	Jika <b>Tidak</b> berencana mengganti dengan lampu hemat energi, apa alasan utama Anda?
	<input type="radio"/> Harganya mahal <input type="radio"/> Sulit didapat di pasaran <input type="radio"/> Kualitasnya tidak sesuai dengan yang dijanjikan <input type="radio"/> Lainnya: .....



## Appendix B – Market Questionnaire

### Kuesioner Ketersediaan Lampu di Pasaran

#### 1. Informasi Umum

Keterangan Tempat		
1.a	Provinsi	_____ [Kode] <input type="text"/> <input type="text"/>
	Kabupaten/Kota	_____ [Kode] <input type="text"/> <input type="text"/>
	Kecamatan	_____ [Kode] <input type="text"/> <input type="text"/> <input type="text"/>
	Kelurahan/Desa	_____ [Kode] <input type="text"/> <input type="text"/> <input type="text"/>
1.b	Nama Toko/Minimart/Supermarket	.....
1.c	Nama Responden	.....

#### 2. Ketersediaan Lampu di Toko

2.a	Jenis lampu yang Dijual	Daya (Watt)	Harga (Rp/lampu)
	Bohlam		
	Bohlam		
	Bohlam		
	Bohlam		
	Bohlam		
	Lampu TL		
	Lampu TL		
	Lampu TL		
	Lampu TL		
	CFL		

	CFL		
	CFL		
	CFL		
	LED		
	LED		
	LED		
	LED		
	LED		
	LED		

	Persediaan Lampu						
<b>2.b</b>	Jenis Lampu	Bohlam	Lampu TL	CFL	LED	Lainnya	Total
	Jumlah/tahun						

	Jumlah Penjualan Lampu						
<b>2.c</b>	Jenis Lampu	Bohlam	Lampu TL	CFL	LED	Lainnya	Total
	Jumlah penjualan lampu/tahun						

## Appendix C

PLN Cabang	Kelas Pelanggan	Total Pelanggan PLN	Sasaran Program	Total Pelanggan Sasaran	Penghematan Energi (kWh/RT/thn)	Penghematan Energi (kWh/thn)	Penghematan Energi (GWh/thn)	Jumlah Lampu/ RT	Total Harga Lampu	Total Biaya Penggantian Lampu (Rupiah)
Medan	450	154,460	25%	38,615	37.38	1,443,593	1.44	2	77,000	2,973,355,000
	900	199,343	32%	63,790	51.76	3,301,593	3.30	2	88,000	5,613,498,880
	1300	75,151	21%	15,782	55.06	868,976	0.87	2	88,000	1,388,790,480
<b>Total</b>		<b>428,954</b>		<b>118,186</b>			<b>5.61</b>			<b>9,975,644,360</b>
Pematang Siantar	450	282,391	28%	79,069	37.38	2,955,954	2.96	2	77,000	6,088,349,960
	900	189,141	21%	39,720	51.76	2,055,784	2.06	2	88,000	3,495,325,680
	1300	23,646	19%	4,493	55.06	247,380	0.25	2	88,000	395,361,120
<b>Total</b>		<b>495,178</b>		<b>123,282</b>			<b>5.26</b>			<b>9,979,036,760</b>
Binjai	450	287,071	28%	80,380	37.38	3,004,943	3.00	2	77,000	6,189,250,760
	900	175,667	22%	38,647	51.76	2,000,255	2.00	2	88,000	3,400,913,120
	1300	22,946	19%	4,360	55.06	240,057	0.24	2	88,000	383,657,120
<b>Total</b>		<b>485,684</b>		<b>123,386</b>			<b>5.25</b>			<b>9,973,821,000</b>
Sibolga	450	143,282	66%	94,566	31.31	2,961,132	2.96	2	77,000	7,281,591,240
	900	45,859	60%	27,515	33.01	908,218	0.91	2	88,000	2,421,355,200
	1300	6,963	45%	3,133	28.11	88,063	0.09	2	88,000	275,734,800
<b>Total</b>		<b>196,104</b>					<b>3.96</b>			

PLN Cabang	Kelas Pelanggan	Total Pelanggan PLN	Sasaran Program	Total Pelanggan Sasaran	Penghematan Energi (kWh/RT/thn)	Penghematan Energi (kWh/thn)	Penghematan Energi (GWh/thn)	Jumlah Lampu/ RT	Total Harga Lampu	Total Biaya Penggantian Lampu (Rupiah)
				<b>125,215</b>						<b>9,978,681,240</b>
<b>Padang Sidempuan</b>	450	155,446	58%	90,159	31.31	2,823,122	2.82	2	77,000	6,942,218,360
	900	63,751	50%	31,876	33.01	1,052,134	1.05	2	88,000	2,805,044,000
	1300	5,378	48%	2,581	28.11	72,551	0.07	2	88,000	227,166,720
<b>Total</b>		<b>224,575</b>		<b>124,616</b>			<b>3.95</b>			<b>9,974,429,080</b>
<b>Rantau Prapat</b>	450	113,502	41%	46,536	37.38	1,739,707	1.74	2	77,000	3,583,258,140
	900	156,423	42%	65,698	51.76	3,400,341	3.40	2	88,000	5,781,394,080
	1300	21,464	33%	7,083	55.06	390,013	0.39	2	88,000	623,314,560
<b>Total</b>		<b>291,389</b>		<b>119,317</b>			<b>5.53</b>			<b>9,987,966,780</b>
<b>Lubuk Pakam</b>	450	212,304	35%	74,306	37.38	2,777,890	2.78	2	77,000	5,721,592,800
	900	171,089	25%	42,772	51.76	2,213,781	2.21	2	88,000	3,763,958,000
	1300	29,759	19%	5,654	55.06	311,334	0.31	2	88,000	497,570,480
<b>Total</b>		<b>413,152</b>		<b>122,733</b>			<b>5.30</b>			<b>9,983,121,280</b>
<b>Nias</b>	450	44,187	100%	44,187	31.31	1,383,620	1.38	2	77,000	3,402,399,000
	900	17,071	100%	17,071	33.01	563,473	0.56	2	88,000	1,502,248,000
	1300	4,890	100%	4,890	28.11	137,433	0.14	2	88,000	430,320,000
<b>Total</b>		<b>66,148</b>		<b>66,148</b>			<b>2.08</b>			<b>5,334,967,000</b>

## Appendix D

PLN Cabang	Kelas Pelanggan	Total Pelanggan PLN	Sasaran Program	Total Pelanggan Sasaran	Penghematan Energi (kWh/RT/thn)	Penghematan Energi (kWh/thn)	Penghematan Energi (GWh/thn)	Jumlah Lampu/RT	Total Harga Lampu	Total Biaya Penggantian Lampu seluruh RT (Rp)
Medan	450	154,460	50%	77,230	37.38	2,887,187	2.89	2	77,000	5,946,710,000
	900	199,343	40%	79,737	51.76	4,126,991	4.13	2	88,000	7,016,873,600
	1300	75,151	30%	22,545	55.06	1,241,395	1.24	2	88,000	1,983,986,400
Total Medan		<b>428,954</b>		<b>179,513</b>			<b>8.26</b>			<b>14,947,570,000</b>
Pematang Siantar	450	282,391	50%	141,196	37.38	5,278,490	5.28	2	77,000	10,872,053,500
	900	189,141	40%	75,656	51.76	3,915,780	3.92	2	88,000	6,657,763,200
	1300	23,646	30%	7,094	55.06	390,601	0.39	2	88,000	624,254,400
Total P. Siantar		<b>495,178</b>		<b>223,946</b>			<b>9.58</b>			<b>18,154,071,100</b>
Binjai	450	287,071	50%	143,536	37.38	5,365,969	5.37	2	77,000	11,052,233,500
	900	175,667	40%	70,267	51.76	3,636,828	3.64	2	88,000	6,183,478,400
	1300	22,946	30%	6,884	55.06	379,038	0.38	2	88,000	605,774,400
Total Binjai		<b>485,684</b>		<b>220,686</b>			<b>9.38</b>			<b>17,841,486,300</b>
Sibolga	450	143,282	50%	71,641	31.31	2,243,282	2.24	2	77,000	5,516,357,000
	900	45,859	40%	18,344	33.01	605,478	0.61	2	88,000	1,614,236,800
	1300	6,963	30%	2,089	28.11	58,709	0.06	2	88,000	183,823,200
Total Sibolga		<b>196,104</b>		<b>92,074</b>			<b>2.91</b>			<b>7,314,417,000</b>
Padang Sidempuan	450	155,446	50%	77,723	31.31	2,433,726	2.43	2	77,000	5,984,671,000
	900	63,751	40%	25,500	33.01	841,707	0.84	2	88,000	2,244,035,200
	1300	5,378	30%	1,613	28.11	45,345	0.05	2	88,000	141,979,200
Total. P. Sidempuan		<b>224,575</b>		<b>104,837</b>			<b>3.32</b>			<b>8,370,685,400</b>
Rantau Prapat	450	113,502	50%	56,751	37.38	2,121,594	2.12	2	77,000	4,369,827,000
	900	156,423	40%	62,569	51.76	3,238,420	3.24	2	88,000	5,506,089,600
	1300	21,464	30%	6,439	55.06	354,557	0.35	2	88,000	566,649,600
Total R. Prapat		<b>291,389</b>		<b>125,759</b>			<b>5.71</b>			<b>10,442,566,200</b>
Lubuk Pakam	450	212,304	50%	106,152	37.38	3,968,414	3.97	2	77,000	8,173,704,000
	900	171,089	40%	68,436	51.76	3,542,050	3.54	2	88,000	6,022,332,800
	1300	29,759	30%	8,928	55.06	491,579	0.49	2	88,000	785,637,600
Total Lubuk Pakam		<b>413,152</b>		<b>183,515</b>			<b>8.00</b>			<b>14,981,674,400</b>
Nias	450	44,187	50%	22,094	31.31	691,810	0.69	2	77,000	1,701,199,500
	900	17,071	40%	6,828	33.01	225,389	0.23	2	88,000	600,899,200
	1300	4,890	30%	1,467	28.11	41,230	0.04	2	88,000	129,096,000
Total Nias		<b>66,148</b>		<b>30,389</b>			<b>0.96</b>			<b>2,431,194,700</b>