Optimization of Advanced Metering Infrastructure (AMI) Customer Ecosystem by Using Analytic Hierarchy Process Method

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***Abstract*—The industrial revolution 4.0 is marked by the commencement of the digitalization era of the business sector. This condition requires all industrial sectors to transform through the digitalization of business processes. Advanced Metering Infrastructure (AMI) is a representation of the digital transformation of equipment technology and customer service delivered by utility companies in the electricity industry and is at the same time the core of the Smart Grid system. With the start of the commercialization phase of AMI infrastructure to customers in Jakarta, the State Electricity Company or PT PLN (a limited liability company) as the company managing the electricity supply business in Indonesia has successfully built an AMI infrastructure ecosystem in 2021. The commercialization of AMI infrastructures takes place in stages in accordance with the company's targets and funding capabilities. The right method is needed in the development phase of the AMI ecosystem so that PT PLN and customers can maximize the features and benefits of AMI technology in the future. Therefore, it is necessary to cluster PLN customers to build an optimal AMI customer ecosystem. By using Analytic Hierarchy Process (AHP) method, the customer clustering method has been found by prioritizing several things. For the Jakarta area specifically, based on expert judgment with a total overall inconsistency value of 0.03 it is known that Jakarta's PLN Distribution Main Unit must prioritize five subcategories are theft losses chance (C12) with 11,2%, customer density (C54) with 7,8%, corporation's bad debt problems (C13) with 7,5%, number of customers per substation (C53) with 6,9%, and the distance of LV distribution network to smart meter (C53) with 6,5% to make optimization of Advanced Metering Infrastructure (AMI) customer ecosystem.**

***Keywords*— Advanced Metering Infrastructure, Customer, Clustering, PLN, Analytic Hierarchy Process**

I. INTRODUCTION

The industrial revolution 4.0 has had a significant impact on various industrial sectors in the past few years. This phenomenon is closely related to the start of the digitalization era which triggers technological disruption, which has necessitated the transformation of the industrial paradigm in order to maintain business continuity by opening up space for innovation and sustainable business development. The electricity business, specifically the electric energy utility firm, is one of the industries that is affected.

Based on that fact, an industrial digitalization model that focuses on equipment technology and customer service is required. optimizing the electricity network accommodates the function of regulating and managing customer loads through an equipment/device that can be monitored in real time, as well as integrating customer service through digital service products that can be enjoyed related to the management of the energy they use through the implementation of the Smart Grid system [1,2]. This is very important considering that electric utility companies in developing countries such as Indonesia face a variety of challenges, not only of traditional electricity issues such as public access to electricity, increasing demand for energy, or ensuring the continuity of electrical energy distribution, but also the most recent global-scale issues such as distributed generation trends, environmental impacts from fossil generators, greenhouse gas emissions, customer satisfaction, and the security of technological systems.

PT PLN (Persero) is a state-owned company as well as the only electric utility company that has a legal license and entrusted to conduct electricity supply business in Indonesia [3]. PLN has established itself as the sole contributor in the electric power market, with the largest assets, all of which are utilized to optimize the performance of electricity distribution to 82 million customers across Indonesia's islands [4]. The ongoing digitalization era in the industrial revolution 4.0 encourages PLN to carry out transformations to face the phase of technological disruption that occurs. The PLN transformation program, which started in the second quarter of 2020, focuses on the four pillars of the PLN 2024 aspirations: Green, Innovative, Lean, and Customer Focused. The implementation of the AMI system as a representation of the Lean and Customer Focus pillars aimed at optimizing service quality by ensuring reliable and efficient electricity availability to ensure customer satisfaction through the Smart Grid concept is one of the strategic programs in PLN's transformation.

Smart Grids (SG) is the development of a conventional electrical network system that has successfully modernized and optimized the function by use of information technology to maximize system efficiency and reliability [5-7]. Through SG, energy utility companies are also able to control and monitor data/information on equipment that works from the control center to consumers so that the electrical system can be more effective, efficient and sustainable[8-11]. Advanced Metering Infrastructure (AMI) is a major part that cannot be separated from the Smart Grid system because it functions as a basic building component of the SG system itself [12-20]. Therefore, the application of AMI technology is a must for PLN to start digitizing device technology and customer service.

As a new technology for electricity companies in Indonesia, PLN's implementation of AMI is considered slow when compared to other countries in the Asia Pacific region such as China, Japan, South Korea and India. These three countries are the largest markets for this technology in the Asia Pacific region due to the massive commercialization of AMI technology in their countries. The slow implementation of this technology can be seen with no aggressive market for AMI technology until 2020 for Indonesia, Malaysia, the Philippines, Singapore and Thailand [7,21]

Even though PLN is considered slow in terms of market aggressiveness of AMI technology in Indonesia, PLN's consistency in promoting and adopting Smart Grid technology has been going on for the last five years through pilot projects for developing AMI systems that have been carried out to test the effectiveness and performance of AMI infrastructure in several cities in Indonesia. Referring to the PLN pilot project that has been carried out, several studies have been carried out including those related to performance studies and the types of communication media that can be selected in the AMI technology commercialization program by PLN [22-27], the development of an AMI data processing center by PLN [28] to the most possible funding aspect of AMI technology development in Indonesia [27] considering that one of PLN's biggest challenges that resulted in the slow adoption of Smart Grid technology in Indonesia is the funding problem itself [7].

Currently, PLN is in the process of commercializing AMI technology by constructing AMI infrastructure, with the aim of getting 150,000 consumers into the Smart Grid ecosystem. DKI Jakarta is one of three cities in Indonesia that will begin the commercialization phase of the AMI ecosystem development at the end of 2021. The process of implementing the AMI infrastructure development by PLN is carried out in stages (partial) with Jakarta's PLN Distribution Main Unit (PLN UID Jaya) being the unit with the target of the largest number of AMI customers in Indonesia at the first opportunity. There are approximately 21,000 customers out of a total of 4.9 million PLN Jakarta customers who will be mobilized to the AMI customer ecosystem. When referring to previous studies [22-28], there has been no study on the target of implementing AMI technology for PLN customers in the initial, advanced, or mass commercialization phase in the end. A method is needed to make priority scale of customers who will be transferred to the AMI customer ecosystem considering that the number of AMI ecosystems to be formed is only a small part of the total number of Jakarta customers. This phenomenon will also occur in all PLN units in Indonesia considering the amount of AMI infrastructure that will be formed is directly proportional to the company's funding capacity.

Based on the facts above, this study will discuss the priority scale for selecting areas through the customer clustering stage where the AMI installation will be carried out so that the gradual commercialization process of the AMI system is right on target so that there is value obtained before and after the AMI is implemented either by PLN or customers in particular.

II. MAKING A SUCCESS OF COMMERCIALIZATION OF THE AMI PROGRAM IN INDONESIA

A. *Indonesian Future Technology of Measurement*

Advanced metering infrastructure (AMI) is an integrated system built from smart meters, communication networks, and data management systems that allow a utility company to carry out two-way communication with customers [22]. All data and information on the customer's energy usage measured on the electricity meter will be sent to the electric utility manager and an instruction signal from the utility will be sent to the electricity meter in the customer's building [29-30]. The AMI system presents the latest electrical energy measurement system method that promises accuracy of data so that transparency in the use of electrical energy used by customers can be ensured as well as guarantees utility income [28].

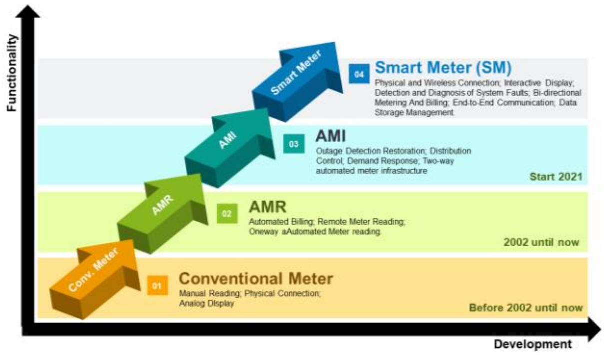


Fig 1. Meter Evolution and Feature Development in PLN [24]

Technological advancements have brought changes to the electricity meter reading system. Initially, a conventional electricity meter (static) was used where the customer's energy consumption mechanism was measured through a booth meter that was read manually. In recent years, utility companies have transformed from using their Automated Meter Reading (AMR) technology to Advanced Metering Infrastructure (AMI) [23,28]. In AMR technology, the meter reading for the current period can be accessed by the utility owner by sending an order to the meter in the customer's building. This process is a one-way communication process, i.e., the energy meter responds to the device, but the device cannot respond back to the energy meter. In contrast, AMI enables two-way communication processes between utility and the meter at the customer's side. While using AMR, consumers are unaware of their energy consumption patterns, so between billing periods, most of the time, energy wastage exceeds unexpected levels.

As the basic component of the Smart Grid system [12-20], AMI integrates several technologies to optimize its functionality. Fig. 2 is a block diagram of the AMI infrastructure built from smart meters, communication networks, and data management systems.

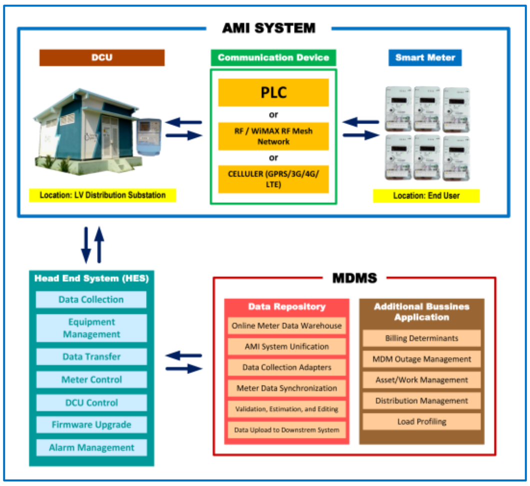


Fig. 2 AMI Architecture at PLN, Indonesia

- Smart Meter (SM) is a main component in the AMI infrastructure. This device accommodates a number of functions, including measuring electrical energy consumption (with reading intervals of 5, 15, 30, or 60 minutes).

- Communication standards have a crucial role in the AMI infrastructure. Many utilities use a common communication platform to support multiple devices in the AMI infrastructure including SM. In the AMI Commercialization Process in Indonesia, Power Line Carrier (PLC) and Radio Frequency technology are chosen as AMI communication modules.

- Head-End System (HES) is also known as meter control system. HES works together with the Data Concentrator Unit (DCU) where the data that have been collected from each SM located at at the end user is then transferred to the MDMS to be managed.

As a modern infrastructure, AMI offers solutions to solve the challenges of modern electrical systems, so that this technology undoubtedly has become a trend in the energy industry over the last few years [13,31-32]. The following are the various advantages of implementing AMI technology in the electric power distribution network.

- Telemetering, Tele-signaling, and Tele-controlling capabilities

- Basic power system planning, load forecasting, and taking control measures to balance electricity supply and demand [41].

- Customers can manage the amount of energy they use, costs, and bills [22,33]

- Speeding up Recovery Time during power outages and sending a more effective repair team to the fault location makes the ENS (Energy Not Supplied) value [22]

- Accommodates remote service disconnection

- Saving on operation and maintenance (O&M) costs of remote billing and measurement services is a key benefit for the AMI business case.

- Able to detect damage and theft

- Supports better integration of Distributed Power Generation [7]

B. *Challenges in AMI's Commercialization Stage*

PLN realizes that the most significant challenge in developing AMI in Indonesia is related to funding. PLN's investment capability for smart grids lags far behind other electric utility companies such as TNB which is able to spend 4% of its CAPEX for implementing smart grids, while PLN can only spend less than 1% [7]. The utility's level of experience in AMI system development, technical implementations that only run partially, geographical conditions of the utility, affordability, and education level of the customers have also proven to influence the size of the AMI project funding [22]. These aspects need to be considered because the realization of the project currently being carried out in Jakarta is only 0.04% of all postpaid service users.

The implementation of AMI infrastructure development by PLN is carried out in stages (partially) with Jakarta becoming the area with the highest number of AMI target customers in Indonesia at the first phase. Considering the company's strength in terms of funding, the partial commercialization process of AMI technology must be carried out optimally considering that the total investment spent by the utility company is not small.

C. *AMI Ecosystem Development Site Selection Method*

Decision making is the act of choosing between alternatives to prioritize some of the alternatives found through an evaluation. The activity of evaluating by providing weighting from alternatives so that planners can prioritize priorities can be addressed with the use of Multiple Criteria Decision Making (MCDM) [42].

The selection of AMI ecosystem development locations is closely related to planning design activities as a decision-making process, it is very appropriate when MCDM techniques are used to make alternative location choices by maximizing the quality of design. Methods in MCDM have been widely used in selection, including Analytic Hierarchy Process (AHP) [43].

Various problems with diverse goals can be solved by applying this technique, one of which is related to problems that arise in sustainable development efforts. The use of MCDM techniques in relation to sustainable development efforts is further described in Table I

Based on information obtained through Table I, it is known that in general, the MCDM methods applied to various selection scopes are Analytical Hierarchy Process (AHP),, Analytical Network Process (ANP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

TABLE I. MCDM TECHNIQUES IN SUSTAINABLE DEVELOPMENT

Ref.	**Selection Scope**	**Method 1**	**Method 2**
[44]	Smart Grid Project	AHP	
[45]	Location of Solar Farm	AHP	TOPSIS
[46]	Selection of Environmentally Friendly Technology	AHP	
[47]	Location of Solar Farm	AHP	
[48]	Wind Farm Location	AHP	TOPSIS
[49]	Location and Type of Solar Powe Plant	AHP	FAHP
[42]	Smart Cities in the World	ANP	TOPSIS
[50]	Home Energy Management System (HEMS)	BMW	ANP
[51]	RE Policy	AHP	
[52]	Adoption of Electric Power Sitem technology	AHP	
[53]	Urban Water infrastructure development area	AHP	
[54]	New-Teknologi Smart City	SWOT-FAHP	

D. *Analytical Hierarchy Process (AHP) Method*

AHP is one of the methods in MCDM that is done by arranging complex problems in hierarchical order by assessing all criteria relevant to decision making [55,56]. AHP is used as a decision analysis tool, and is a mathematical technique for multi-criterion decision making [57]. The technique was developed by Saaty in 1977 to analyze complex decisions that require many criteria [57] and accepted by the international scientific community as a powerful and flexible multi-criterion decision-making tool for dealing with complex decision-making issues [58].

Overall, the approach to the AHP method serves to help decompose a large problem into smaller sub-problems so that each sub-problem can be analyzed in depth and detail through a hierarchical form in the form of deconstruction of the problem into several homogeneous and hierarchically arranged elements [59]

Of the many MCDM methods, AHP is a widely applied technique in solving various problems, and allows people to choose the best option among the many criteria among which are applications related to energy planning and the carrying capacity of renewable energy facilities [60-62]. This method generally has three steps, first is the arrangement of the hierarchy between criteria and alternatives, then synthesize the comparison matrix in pairs, and finally, namely calculating the weight value of criteria and alternative performance scores. [46]

To be able to rank these alternatives against different criteria of interest, individual weighting factors must be established. It requires the creation of a paired comparison matrix [63]. Paired comparisons are made between criteria that mark their relative importance (preferability). Each paired comparison result is divided by the number of columns it has. The same row element is added and the number is divided by the number of sub-criteria. Therefore, each element of this matrix is normalized, resulting in a weight coefficient. This procedure is followed for all grades [64]. Alternatives are compared in pairs, and the results are ranked on a scale of 1–9, with 1 being the least important (value 1) and 9 being the most important (value 9) [63]. Furthermore, the results of such calculations give weight to each criterion. In addition, it is necessary to calculate the Consistency Ratio (CR) for each matrix comparison. CR indicates the probability of the value obtained from the paired comparison matrix [65].

To facilitate the process of understanding this method, here is the flow mechanism for using the AHP method [66-70]:

- Establish a hierarchy of decisions by considering the objectives of the research and determining criteria and sub-criteria.
- Compile a series of assessments in the comparison matrix where the elements are compared using a comparison scale. If the number of criteria considered is “n” then the matrix is A_k, as shown in (1)

$$A_k = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

- Fill in the weights on the matrix in (1) using the relative importance scale of 1 to 9 (Saaty's 9-point scale) displayed in Table II, then the experts reveal their relative individual preferences for each criterion for obtaining a priority scale

TABLE II. RELATIVE IMPORTANCE SCALE

Relative Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak (moderate) importance	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practices.
9	Extreme important Intermediate values	The evidence of favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

- Determine the level of relative importance of factors by calculating the eigen vector against the maximum eigenvalue of the comparison
- Check the consistency of the assessment of the Consistency Index (CI) and consistency ratio (CR) specified as in (2)

$$CI = \frac{\lambda \max - n}{n-1} \quad (2)$$

where λ_{max} is the Eigen value according to the paired comparison matrix and n is the number of elements compared in (3)

$$CR = \frac{CI}{RCI} \quad (3)$$

where RCI is the random consistency index value specified by referring to Table III

TABLE III. CONSISTENCY RANDOM INDEX VALUES (RCI)

Number of Criteria (n)	RCI
1	0
2	0
3	0,58
4	0,90
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49

In AHP it is possible to have inconsistencies in comparison, because in judgment people tend to be difficult to be consistent because they cannot accurately estimate the measurement value [71], therefore a consistency ratio is needed. CR values less than 0.1 are generally acceptable, if they cannot meet the requirements of the CR value limit, then the pair comparison must be revised.

E. Indicator of AMI Ecosystem Development Selection

Literature studies from previous studies mention different indicators. These indicators then became a reference, there were additional indicators that are in accordance with the existing regulatory restrictions in Indonesia, namely of course related to the conditions in PLN as an electric utility company. There are several indicators / criteria that are used as selection variables presented in Table IV.

TABLE IV. AMI DEVELOPMENT LOCATION SELECTION VARIABLES

Criterion	Indicator	Reference
Function	Customer Complaints Issues	[22]
	Theft Losses Problems	[72], [78]
	Corporation's bad debt Problems	[22]
	High Load Demand Issues	[44], [22]
Environment	Geographical Conditions	[51], [72]
	Potential Natural Disasters (Annual Flood Areas)	This Study
	Geometry of Buildings	[72]
	Infrastructure Growth	[72]
Company	Customer Contract Power (Volt Ampere Connected)	This Study
	Types of Customer Tariffs (Subsidies/Non-Subsidies)	This Study
	Energy Consumption	[39], [78]
	Priority Customer (Premium)	This Study
	PV Rooftop Customers	This Study
	Industrial Sector Customers	[39], [29]
	Commercial Sector Customers	[39], [29]
	Household Sector Customers	[39], [29]
	Customer Growth	[51], [54]
	Electricity Energy Sales Growth	[73], [78]
Social	Local Government Support	[39]
	Information Affordability	[80]
	Acceptance of New Technologies	[77], [39], [54], [76]
	Permit	[51], [29]
	Consumer Mindset and Awareness	[72]
	Customer Education Level	[39], [51], [54], [72], [73]
Technical	Geometry of Buildings Against Meter Locations	[39], [74]
	Consumer Service Type (Prepaid / Postpaid)	This Study
	Number of customers Per Substation	[22]
	Density of Number of Customers	[7], [39], [38], [74]
	Customer Mapping GIS Accuracy	[39]
	Availability of Field Area Network (FAN)	[39]
	Home Area Network (HAN) Availability	[81]
	Communication Infrastructure and Accessibility	[80]
	LV Distribution Network Infrastructure Conditions	[51], [44]
	Network Length up to kWh Meter	[79]
Technology	Penetration Of Distributed Generation (PV)	[7],[73],[75], [76]
	Home Energy Management System (HEMS) Development	[44]
	Electrical Vehicle Ownership Development	[50]

III. METHODS

This study raises the topic of choosing the best location related to the development of the AMI ecosystem in the first commercialization stage in Jakarta as a representation of smart cities in Indonesia through customer clustering based on qualitative research methods. The literature study based on Table IV is then evaluated through the assessment of experts to provide priority dislodging before entering the AHP method stage. Weighting is carried out to formulate the suitability of sub-criteria with problems in Jakarta, especially in terms of PLN business processes. This process is the initial stage where three experts analyze sub-criteria based on the criteria presented through the form asked by the interview. The three selected experts are figures who have full knowledge related to AMI technology and have been adjusted to the criteria required in [82].

IV. RESULTS & DISCUSSIONS

Table V is a hierarchy of criteria and sub-criteria for the selection of AMI ecosystem locations in Jakarta as a result of the conformity assessment of Table IV. There appears to be a downsizing of sub-criteria so as to add specifics to the selected criteria. Through Table V then a hierarchical chart is created with each criterion denoted by the notation C_1 to C_n, and the sub-criteria is notated with C_{11} - C_{1n} to C_n - C_{nn} as Fig. 3.

TABLE V. HIERARCHY OF CRITERIA AND SUB-CRITERIA

Indicator	Notation
Customer Complaints Issues	C11
Theft Losses Problems	C12
Corporation's Bad Debt Problems	C13
Geographical Conditions	C21
Infrastructure Growth	C22
Energy Consumption	C31
Priority Customer (Premium)	C32
Industrial Sector Customers	C33
Commercial Sector Customers	C34
Household Customers	C35
Customer Growth	C36
Energy Sales Growth	C37
Local Government Support	C41
Information Affordability	C42
Acceptance of New Technologies	C43
Permit	C44
Consumer Mindset and Awareness	C45
Geometry of Buildings Against Meter Locations	C51
Customer Service Type (Prepaid / Postpaid)	C52
Number of customers Per Substation	C53
Customers Density	C54
Customer Mapping GIS Accuracy	C55
Availability of Field Area Network (FAN)	C56
Network Length up to kWh Meter (Distance)	C57
Penetration Of Distributed Generation (PV)	C61
Home Energy Management System (HEMS) Development	C62
Electrical Vehicle Ownership Development	C63

A. *Analytic Hierarchy Process (AHP) Data Processing*

Data processing in the Analytic Hierarchy Process (AHP) method in this study used Expert Choice 11 software to obtain paired comparison results from all respondents, where the value of paired comparisons in all respondents was obtained from geometric average results on the value of each respondent's paired comparison, then ensured the consistency ratio of the comparison.

Based on the results of the weighting simulation entered, the weight of combined criteria are obtained based on the results of the assessment of 3 experts, the Company (C3) has the largest weight, which is 0.228 or 22.8% then followed by Technical criteria (C5) of 0.221 or 22.1%, Function criteria (C1) are 0.212 or 21.2%, Social criteria (C4) are 0.126% or 12.6%, Technology criteria (C6) are 0.118% or 11.8% and the smallest weight is obtained by environmental criteria (C2) by 0.0963% or 9.6%.

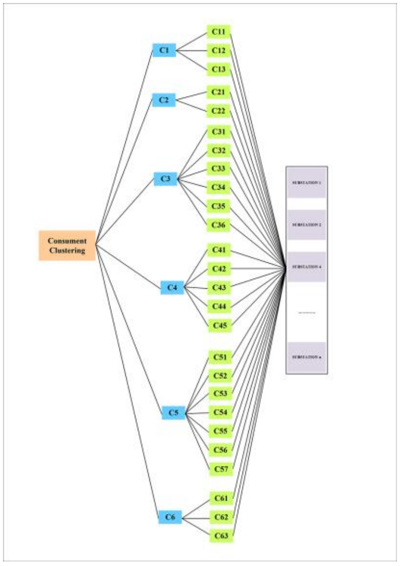
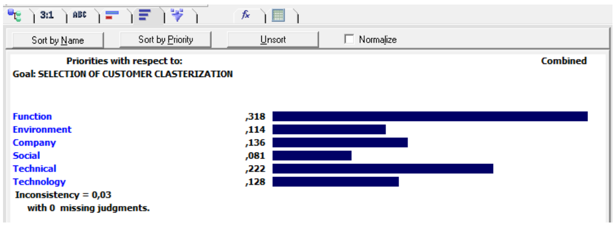


Fig. 3 Layers of criteria for AMI ecosystem locations in Jakarta

The priority weight of the results of pairwise comparisons between criteria along with the consistency ratio is shown in Fig. 4. The value of the number of variables (n) is 6 (C1-C6), with a consistency ratio of 0.03 so that the comparison results can be accepted.



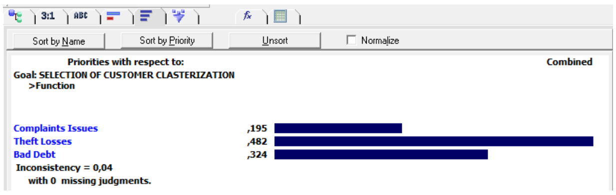
Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION

Function	,318
Environment	,114
Company	,136
Social	,081
Technical	,222
Technology	,128

Inconsistency = 0,03
with 0 missing judgments.

Fig. 4. The Weight of Criteria Priority

Based on the simulation results of the function criteria weighting, Theft Losses (C12) has the largest weight, which is 0.482 or 48.2%, followed by the Receivable Problems (Bad Debt) (C13) criteria of 0.324 or 32.4%, and the smallest weight is obtained by the Customer Complications criteria. Issues (C11) of 0.195% or 19.5%. The priority weight of the results of pairwise comparisons between criteria along with the consistency ratio is shown in Fig5. The value of the number of variables (n) is 3 (C11-C13), with a consistency ratio of 0.04 so that the comparison results can be accepted.



Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Function

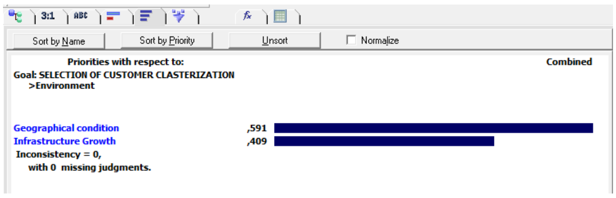
Complaints Issues	,195
Theft Losses	,482
Bad Debt	,324

Inconsistency = 0,04
with 0 missing judgments.

Fig. 5. The Weight of Function Sub-Criterion

By referring to the weighting simulation of function criterion, it can be recommended to PLN for the AMI commercialization program in Jakarta, location with the highest theft loss level in PLN Jakarta can be choose as customer clasterization. Data related to the distribution of Theft Losses is needed so that the distribution of materials to Jakarta area units is right on target.

The simulation of environmental criterion show that geographical conditions (C21) have the largest weight, namely 0.591 or 59.1%, then followed by infrastructure growth (C22) criterion of 0.409 or 40.9%. referring to Fig.4, environmental conditions do not seem to have much effect on the development of AMI ecosystem in Jakarta. Of all the measured criteria, it is proven that environmental conditions occupy the lowest weight.



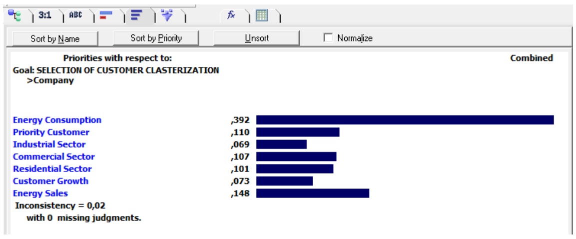
Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Environment

Geographical condition	,591
Infrastructure Growth	,409

Inconsistency = 0,
with 0 missing judgments.

Fig. 6. The Weight of Environment Sub-Criterion

the weight of the company's review sub-criterion show that total customer energy consumption (C31) has the largest weight, which is 0.392 or 39.2% then followed by Energy Sales (C37) criteria of 0.148 or 14.8%, Priority Customer (C32) of 0.11 or 11 %, Commercial Sector Customers (C34) 0.107 or 10.7%, Residential Sector Customers (C35) 0.101 or 10.1%, Customer Growth (C36) 0.073 or 7.3%, and Industrial Sector Customers (C33) 0.069 or 6.9%. By using this priority, it is easy to map customer clusters based on their total monthly energy consumption. it can be seen that the industrial sector is considered by experts to be the last priority of all sub-criteria. This can be referenced if the development of AMI technology in Jakarta does not necessarily eliminate the AMR technology that has been used by PLN for industrial tariff customers.



Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Company

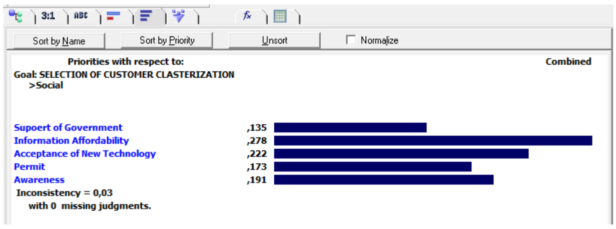
Energy Consumption	,392
Priority Customer	,110
Industrial Sector	,069
Commercial Sector	,107
Residential Sector	,101
Customer Growth	,073
Energy Sales	,148

Inconsistency = 0,02
with 0 missing judgments.

Fig. 7. The Weight of Company’s Review Sub-Criterion

The weighting of social aspects sub-criterion of the Jakarta citizen shows that the affordability of public information is an important point in the AMI development program in Jakarta. Information Affordability (C42) has the largest weight, which is 0.278 or 27.8% then followed by Acceptance of New Technologies (C43) criteria of 0.222 or 22.2%, Consumer Mindset and Awareness (C45) of 0.191 or 19.1%, Working Permit (C44) is 0.173 or 17.3%, and the smallest is Support of Government agencies (C41) is 0.135 or 13.5%.

For the technical aspects sub-criterion, shows that Customers Density (C54) has the largest weight, which is 0.201 or 20.1% then followed by the Number of customers Per Substation (C53) criteria of 0.178 or 17.8%, Network Length up to kWh Meter (C57) of 0.166 or 16.6%, Customer Mapping GIS Accuracy (C55) of 0.148 or 14.8%, Availability of Field Area Network (FAN) (C56) of 0.137 or 13.7%, Customer and the smallest Geometry of Buildings Against Meter Locations (C51) of 0.59 or 5.9 %.

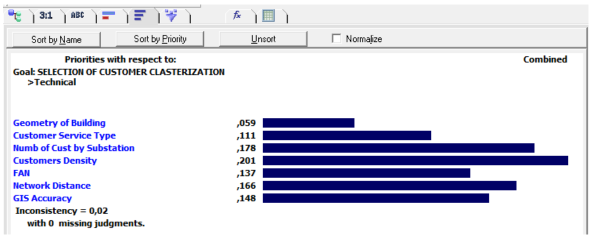


Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Social

Supoert of Government	,135
Information Affordability	,278
Acceptance of New Technology	,222
Permit	,173
Awareness	,191

Inconsistency = 0,03
with 0 missing judgments.

Fig. 8. The Weight of Social Aspect Sub-Criterion



Priorities with respect to: Combined
Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Technical

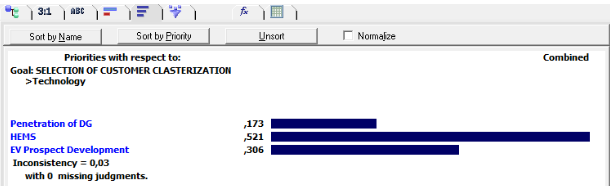
Geometry of Building	,059
Customer Service Type	,111
Numb of Cust by Substation	,178
Customers Density	,201
FAN	,137
Network Distance	,166
GIS Accuracy	,148

Inconsistency = 0,02
with 0 missing judgments.

Fig. 9. The Weight of Technical Sub-Criterion

for the last one, the availability of HEMS in an area is very important to support a perfect AMI ecosystem. Home Energy Management System (HEMS) Development (C62) is given a weight of 0.521 or 52.1% followed by Electric Vehicle

Ownership Prospect Development (C63) and Penetration of Distributed Generation from Prosumer in Jakarta (C61) respectively with a value of 0.306 or 30, 6% and 0.173 or 17.3%



Priorities with respect to: Combined

Goal: SELECTION OF CUSTOMER CLASTERIZATION
>Technology

Penetration of DG ,173
HEMS ,521
EV Prospect Development ,306

Inconsistency = 0,03
with 0 missing judgments.

Fig. 10. The Weight of Technology Sub-Criterion

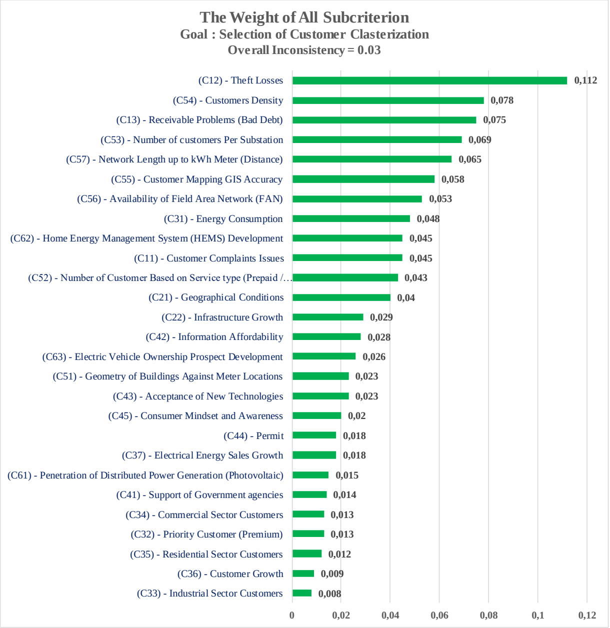


Fig. 11. The Weight of All Sub-Criterion as Clasterization Priority

In the category selection stage, determining location of the AMI ecosystem development can be done by considering the alternative sub-criteria with the greatest weight. The greater of the weight obtained, the sub-criteria are the best alternative choice. Figure 11 displays all the priority values of all sub-criteria in the category. Previously, through Figure 4, it was known that the determination of the location of the AMI ecosystem development in Jakarta would be more optimal if it was implemented by considering the function of technology.

With an overall (combined) inconsistency value of 0.03 from the experts, it is known that there are five sub-criteria that are the most optimal to be used as a priority scale for AMI development in the Jakarta's PLN Distribution Main Unit working area which includes reaching the entire Jakarta Capital Region. The five subcategories are theft losses chance (C12) with 11,2%, customer density (C54) with 7,8%, corporation's bad debt problems (C13) with 7,5%, number of customers per substation (C53) with 6,9%, and the distance of LV distribution network to smart meter (C53) with 6,5%

Furthermore, by knowing these five priority scales, each implementing unit under the auspices of Jakarta's PLN Distribution Main Unit can use it as a benchmark for choosing which distribution substations in the unit concerned will build the AMI ecosystem. Since there are hundreds or even thousands of distribution substations under one implementing unit in Jakarta, the next weighting method can also be carried out using Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), of course, each expert in each unit will correctly assess which substation will be the target for the development of the AMI ecosystem. the most suitable.

V. CONCLUSION

The Advanced Metering Infrastructure (AMI) commercialization program in Jakarta is ongoing and will continue until all customers in Jakarta are fully successful in using this technology. In the AMI technology development phase, it is necessary to select an appropriate location by making the customer clustering as optimal as possible so that PLN as the electricity utility company in Indonesia can still optimize the functions and advantages of AMI technology. By using Analytic Hierarchy Process (AHP) method, the customer clustering method has been found by prioritizing several things. For the Jakarta area specifically, based on expert judgment with a total overall inconsistency value of 0.03 it is known that Jakarta's PLN Distribution Main Unit must prioritize five subcategories are theft losses chance (C12) with 11,2%, customer density (C54) with 7,8%, corporation's bad debt problems (C13) with 7,5%, number of customers per substation (C53) with 6,9%, and the distance of LV distribution network to smart meter (C53) with 6,5% to make optimization of Advanced Metering Infrastructure (AMI) customer ecosystem.

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