Implementation of Clustering K-Means Algorithm classification of the need of Electricity power for each region at PT Lhokseumawe

Muhammad Sadli[1], Wahyu Fuadi[2] Fajriana[3], Ermatita[4], Iwan Pahendra[5]

[1] Teknik Elektro, Universitas Malikussaleh, Lhokseumawe, Indonesia. msadli@unimal.ac.id
[2]Teknik Informatika, Universitas Malikussaleh, Lhokseumawe, Indonesia. Fajriana16@yahoo.co.id
[3]Teknik Informatika, Universitas Malikussaleh, Lhokseumawe, Indonesia. wahyu.fuadi@ unimal.ac.id
[4]Sistem Informasi, Universitas Sriwijaya, Palembang, Indonesia. ermatitaz@yahoo.com
[5]Teknik Elektro, Universitas Sriwijaya, Palembang, Indonesia. iwanpahendra@unsri.ac.id

Abstract. PLN (State Electricity Company) is in charge of providing stock of needs for the grouping of electrical power and classification for each region in Lhokseumawe City. The area that were grouped based on the amount of power consists of the four subdistricts, namely Banda Sakti, Blang Mangat, Muara Dua and Muara Satu, each of which is sourced from the village. The importance of clusters is to separate each data between data in the villages that will be input into sub-district data. Furthermore, the K-Means Clustering Classification was used in determining the grouping of electrical power needs in each region in the Lhokseumawe City where this system classify the electricity stock needs in each region categorized into a cluster. In this study, Clustering Classification of K-Means variables include job (V1), overall income (V2), house area (V3), number of rooms (V4), number of electronic equipment (V5) and total of power usage (V6). Results of grouping of C1 system = Subsidy R-1/450 VA, C2 = Subsidy R-1/900 VA, C3 = Non Subsidy R-1/900, C4 = Non Subsidy R-1/1300, C5 = Non Subsidy R- 1/2200 VA. The purpose of this study is to be able to predict the classification of each electric power requirement for each region based on the input data per district. This has an impact on the community and PLN's stock of electricity needs in order to remain stable. It is found out from the Clustering K-Means Classification that there is a new cluster for Banda Sakti. The last step in determining Clustering K- Means stopped at the the iteration 3 until the cluster is optimal. The results of this study are in the form of grouping of PLN Customers from each region displayed in the system in the form of classification of electrical power in each subdistrictdistrict. Furthermore, the grouping can be recommended to predict the power needs of each sub-district and belong to the cluster provided by the PLN.
Keywords: Clustering, K-Means, Electricity Needs

1. Background

Development in an area is very important for the electrical energy needs of the power that will be provided by PT PLN in each region. The regional development will increase the consumption of electricity for each region and be grouped according to the power needs of each region. For the area with high electrical power needs, the energy consumption level will be prioritized. Whereas for areas with little electricity consumption, the PLN of Lhokseumawe adjust the power supply based on the level of needs of each region.

The sustainable development with rapid technological advances and improvement in living standards can cause the consumption of electrical energy to continue to increase. The availability of electricity is the subject of discussion in a region for the distribution of clusters in the community is based on the level of power used.

To avoid the occurrence of electrical energy and supply crisis, a classification model is needed as the development of the system model in the power requirements that will be supplied to each region. Furthermore, this system can also estimate the amount of electricity demand in the coming years. This is related to the amount of additional electricity supply that is used for each region.

The grouping in the application of electrical power clustering for each region in the working area of PLN lhokseumawe has variable value consisting of job (V1), overall

income (V2), house area (V3), number of rooms (V4), number of equipment electronic (V5) and the amount of usage power (V6), each of which can be grouped into clustering classification to be able to calculate the power requirements of each sub-district or region grouping of lhokseumawe city. Furthermore, these variables were included in the process of k-means clustering in determining the amount of power in each region and the system to be built can predict the total amount of power installed from each grouping region.

2. Literature Review

(Tampubolon and Reinhardt, 2014), The use of electricity is expected to increase every year. This is due to the growing needs of the community that must be met. Many factors affect the level of electrical energy needs, such as economic, population, territorial, and other factors. According to the level of electrical energy needs are influenced by the following factors: Economic factors that affect the level of electricity demand is the growth of GRDP (Gross Regional Domestic Product). In general, GRDP can be divided into 3 sectors, namely the GRDP of the commercial (business) sector, the industrial sector and the public sector. Economic activities categorized as commercial or business sectors are electricity, gas and clean water, building and construction, trade and transportation and communication.

Load requirements from an area depend on the conditions of the region, the population and the standard of life, the current and future development plans, power prices and so on. Consumers expect to receive continuous service. Consumer demand that power must be supplied at any time makes electricity companies must provide facilities for their maximum needs, electricity reserves may be needed. Consumers should not be allowed to wait (Sheng *et al.*, 2013) which includes:

1. Load Type In general, the distribution of expenses (type - type of load) is divided: domestic, commercial and industrial. The division of this load area is based on the nature and load characteristics of each of the load areas mentioned above, where the load conditions are very different in nature and characteristics.
2. Domestic Load Distributed in residential areas. Electrical equipment consists of lamps, lighting, fans, irons, household appliances such as heaters, refrigerators, air conditioners, stirrers, customer appliances, electric stoves and small motors for pumps, and tools - small appliances for other households.
3. Commercial Load Distributed to trading areas located in the city center. Electrical equipment consists of lighting for cities and billboards and so on, fans, air conditioners, heaters and other electrical equipment used in shops, restaurants, markets and so on..
4. Industrial Load Distributed to industrial areas or factories located on the outskirts of the city. Equipment such as electric motors as a driving force, electricity generators as a backup of electrical power if the supply of the nets is disturbed.

Clustering is the process of dividing data in a set into several groups whose similarity in data in a group is greater than the similarity of the data with other group data. The potential of clustering is that it can be used to determine the structure in the data that can be used further in various external applications such as classification, image processing, and pattern recognition. (Ipmawati, Kusrini and Luthfi, 2017).

K-Means algorithm is one of the non-hierarchical data clustering methods that try to partition existing data into one or more clusters / groups. This method partition data into clusters / groups so that data that has the same characteristics are grouped into the same cluster. According to (Vaswani *et al.*, 2013) the K-Means algorithm is one of the most frequently used data grouping techniques. K-Means groups similar objects in the same cluster.

Clustering is the process of dividing data in a set into several groups whose similarity in data in a group is greater than the similarity of the data with other group data. Potential clustering of various external applications such as classification, image processing, and pattern recognition. Clustering analysis is an attempt to identify groups of similar objects and help find patterns of distribution and patterns of large data sets. (Ipmawati, Kusrini and Luthfi, 2017).

According to (Shang, 2011) Clustering is the activity of grouping objects into a cluster, so that objects in a cluster have a great resemblance to other objects on the same cluster and are different from objects in other clusters. Several methods can be used in developing the K-Means Clustering clustering method. Clustering described by (II, 2009) is

defined by dividing data objects (forms, entities, examples, obedience, units) of a number of groups (groups, sections or categories).

(Ula *et al.*, 2017) Search method uses a forward chaining while deficiencies to deal with the uncertainties arising used method of application Mycin certainty factor. To facilitate the users, the system is made by using mobile technology. Based on testing performed to the expert can be proved that the expert system built able to diagnose the deficiency of vitamins and minerals with a value of 100% accuracy the truth. By knowing deficiency that occurs then the handling and prevention can be done in a timely fashion.

(Hendriana and Hardi, 2017) The presence of mobile phone or mobile phone that has been known and used by many people, who are able to communicate wherever they are, without being limited by space and range of cable lengths could be a solution for the needs of remote objects as described above. One of the most popular mobile phone function is to send and receive SMS. SMS is suitable for the control system of wireless real time because the speed of data delivery, efficiency and breadth of coverage, but the excess mobile phone with SMS facility of its still needs to be connected to a control device to be able to control on / off devices electric remotely.

(Hardi, 2015) Likewise, this system should be protected by viruses. Through antivirus development based on client servers, users can easily find out the behavior of viruses and worms, knowing what parts of an operating system are attacked by viruses and worms, creating their own network-based antivirus development. client server and can also be relied upon as a fast and reliable engine scanner for recognizing viruses and saving in memory management. thus the system can be run as expected.

The K-Means algorithm is one method in clustering or grouping functions. Clustering refers to grouping data, observations or cases based on the similarity of the object under study. A cluster is a collection of data similar to others or data inequality in other groups (Larose and D'Auteuil, 2006).

The steps in the K-Means algorithm are as follows:

1. Determine the K where K is the many clusters you want to form.
2. Select K data at random from the data as the initial group center ().
3. This 3rd step is done:

a. Determine the distance of each data with each centroid. Here you will see the data will become a member of the kth cluster.

$$D_{L2}(X_2, X_1) = \sqrt{\sum_{J=1}^{P} (X_{2j} - X_{1j})^2} \quad \text{..... (2.1)}$$

Information:

D_{L2} = The shortest distance between and where is the data and is the centroid

X_{2j} = Value of data to -j and X_{1j} = Centroid value to -j

b. Calculate BCV (Between Cluster Variation)

$$BCV = d(m_{i,j}) \quad \text{..... (2.2)}$$

Information : BCV= Distance between clusters and $d(m_{i,j})$= Distance between clusters to clusters

c. Calculate WCV(Within cluster Variation)

WCV is the minimum number of squares the center distance of each cluster.

$$WCV = \sum_{i=1}^{k} \sum a_{ik}\, d(x_k, m_i)^2 \quad \text{..... (2.3)}$$

Information:

WCV = Distance between members in Cluster and k = Number of data and i = number of clusters

a_{ik} = Membership of data to-k to cluster I and x_k= Data to-k; m_i= Centroid value to -i

d. Calculate ratio

$$r = \frac{BCV}{WCV} \quad \text{..... (2.4)}$$

Description: r = Ratio

WCV = Distance between members in Cluster and BCV = Distance between clusters

4. Update group centers

$$m_i = \frac{\sum C_i}{n_i}$$ …….…… ……..... (2.5)

Information :

m_i = *Centroid* to-I and n_i = The amount of data per cluster to -I and $\sum C_i$= Number of cluster values to-i

3. RESULTS AND DISCUSSION

Analysis of Discussion

The high population growth has led to the high demand for electricity in the city of Lhokseumawe which in 2020 is expected to increase to 15%. Based on the results of the data prediction, PT PLN Lhokseumawe must be able to predict the patterns of grouping from each sub district in lhokseumawe area. The K-Means clustering algorithm model can classify electrical power needs and can predict the number of stock requests of each region which is seen from the customer data in each village and sub-district. This will be useful for PLN in monitoring the supply of electric power so that the distribution of electrical energy remains stable and not much power is wasted.

The availability of electricity has now become the main discussion in the community along with the increasing socio-economic growth of the community. To avoid the occurrence of the electricity energy crisis, a classification model is needed as an initial step in the development of the electricity system by making an estimate of the amount of electricity demand in the coming years.

3.1 Manual Model K-Means Clustering

Variable value data that determines the size of the electricity load required. The variable entered based on the case is:

V 1=work, V2= overall income, V3= spacious house, V4= number of rooms, V5 = the amount of electronic equipment, V 6 = the amount of power consumption, The values of these variables will be grouped into four groups (K = 4) namely,

C1 = Subsidi R-1/450 VA, C2 = Subsidi R-1/900 VA, C3 = Non Subsidi R-1/900, C4 = Non Subsidi R-1/1300

Table 3.1. Customer data

Number	Customer's name	V1	V2	V3	V4	V5	V6
1	Anismar	7	4	3	1	1	4
2	Budi susia	6	3	4	1	5	7
3	renardiani	4	6	2	2	3	5
4	Dian eka satria	3	5	1	3	6	1
5	Eko satria	2	4	6	5	8	8
6	Fitria Eri	7	6	7	8	7	9
7	Rendi Artanegara	7	8	9	6	9	8
8	Heri Prasetya	6	6	4	6	5	9
9	Lusia prania	8	1	3	4	3	7
10	Junaidi	9	1	9	8	4	9

The initial process of the k-means method is to determine the center of the cluster (centroid) arbitrarily, based on the table above any cluster center that can be determined, among others: C1 = (2), C2 = (9), C3 = (4), C4 = (7). Then calculate the distance of each data to each cluster center.

The first data distance (A) with the first cluster center:

$$PA_1 = \sqrt{(P_1A - P_1c_1)^2 + (P_2A - P_2c_1)^2 + (P_3A - P_3c_1)^2 + (P_4A - P_4c_1)^2 + (P_5A - P_5c_1)^2 + (}$$
$$= \sqrt{(7-2)^2 + (4-2)^2 + (3-2)^2 + (1-2)^2 + (1-2)^2 + (4-2)^2}$$
$$= 6{,}000$$

Second data distance (B) with the first cluster center:

$$PB_1 = \sqrt{(P_1B - P_1c_1)^2 + (P_2B - P_2c_1)^2 + (P_3B - P_3c_1)^2 + (P_4B - P_4c_1)^2 + (P_5B - P_5c_1)^2 + (}$$
$$= 7{,}483$$

Third data distance (C) with the first cluster center:

$$PC_1 =$$
$$\sqrt{(P_1C - P_1c_1)^2 + (P_2C - P_2c_1)^2 + (P_3C - P_3c_1)^2 + (P_4C - P_4c_1)^2 + (P_5C - P_5c_1)^2 + (}$$
$$= \sqrt{(4-2)^2 + (6-2)^2 + (2-2)^2 + (2-2)^2 + (3-2)^2 + (5-2)^2}$$
$$= 5{,}477$$

Fourth data distance (D) with the first cluster center:

$$PD_1 =$$
$$\sqrt{(P_1D - P_1c_1)^2 + (P_2D - P_2c_1)^2 + (P_3D - P_3c_1)^2 + (P_4D - P_4c_1)^2 + (P_5D - P_5c_1)^2 +}$$
$$= \sqrt{(3-2)^2 + (5-2)^2 + (1-2)^2 + (3-2)^2 + (6-2)^2 + (1-2)^2}$$
$$= 5{,}385$$

The search results for the distance between the data and the cluster center are then entered into the following table. A data will be a member of a cluster that has the smallest distance from the center of the cluster. For example for the first data (A), the smallest distance is obtained in the third cluster (C3), so the first data will become a member of the third cluster.

Table 2. Data distance to the initial cluster

Num	Customer's name	Distance			MIN	Cluster member
		C1	C2	C3		
1	Anismar	6.08276253	7.41619848	11.3578166	6.08276253	C1
2	Budi susia	7.14142842	4.58257569	9	4.58257569	C2
3	renardiani	5.91607978	5.19615242	10.0498756	5.19615242	C2
4	Dian eka satria	6.16441400	7.61577310	12	6.16441400	C1
5	Eko satria	9.38083152	4.47213595	7.48331477	4.47213595	C2
6	Fitria Eri	11.9582607	5.3851648	1.73205080	1.73205080	C3
7	Rendi Artanegara	13.8564064	6.1644140	4.47213595	4.47213595	C3
8	Heri Prasetya	9.32737905	3.3166247	4.12310562	3.31662479	C2
9	Lusia prania	6.55743852	6.8556546	9	6.55743852	C1
10	Junaidi	11.8743420	9	7.41619848	7.41619848	C3

The search results for the distance between the data and the cluster center are then entered into the following table. A data will be a member of a cluster that has the smallest distance from the center of the cluster. Furthermore, it will be fixed on the distance of data to the new cluster 1 as follows:

Table 3. Distance Search Results

Num	Customer's name	Distance			MIN	Cluster member
		C1	C2	C3		
1	Anismar	3.1797973	6.53356717	11.1305385	3.17979733	C1
2	Budi susia	4.1766546	3.41869858	8.43932593	3.41869858	C2
3	renardiani	3.5746017	4.26468052	10.4827901	3.57460176	C1
4	Dian eka satria	5.4569018	7.15454401	12.3917535	5.45690184	C1
5	Eko satria	8.5505035	4.60298816	6.79869268	4.60298816	C2
6	Fitria Eri	9.8375697	6.57171971	1.97202659	1.97202659	C3
7	Rendi Artanegara	11.244751	7.91754381	4.18993503	4.18993503	C3
8	Heri Prasetya	6.9841089	3.63145976	5.21749194	3.63145976	C2
9	Lusia prania	4.5582647	5.71729831	8.47873156	4.55826477	C1
10	Junaidi	10.619688	9.17537465	5.088112507	5.0881125	C3

Next, determine the new cluster center of each data by looking for the average of the values of the variables included in a cluster in seeing the results of the k-means classification for clusters are as follows:

Table 4. New Cluster Distance Search Results

NEW CLUSTER 1						
Cluster	V1	V2	V3	V4	V5	V6
C1	6	3.3333	2.333333	2.6666666	3.3333333	4
C2	4.5	4.75	4	3.5	5.25	7.25
C3	7.6666667	5	8.3333333	7.3333333	6.6666666	8.66666666

Next, determine the new cluster center of each data by looking for the average of the values of the variables included in a cluster in seeing the optimal results of the k-means classification for the cluster and the results are as follows:

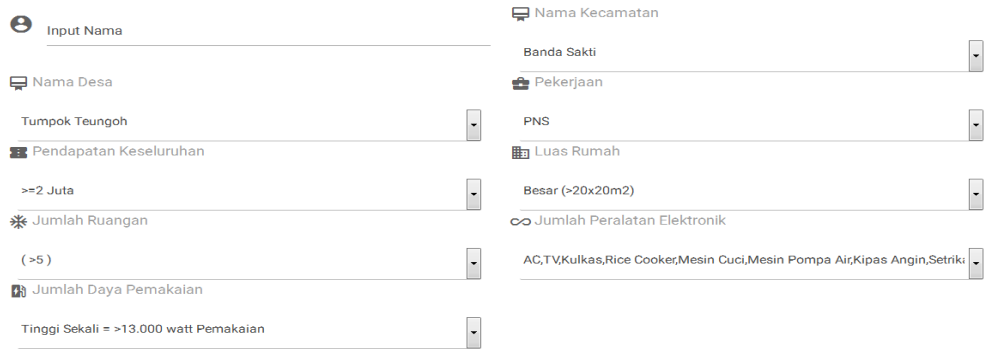
Table 5. Optimal New Cluster Distance Search Results

NEW CLUSTER2						
Cluster	V1	V2	V3	V4	V5	V6
C1	5.5	4	2.25	2.5	3.25	4.25
C2	4.666667	4.3333333	4.666667	4	6	8
C3	7.666667	5	8.333333	7.333333	6.66666667	8.6666667

3.1 Implementasi Program Model K-Means Clustering

A. Customer Data Input

The customer input data consisting of, inputting the customer's name, input the name of the village, input sub-district data and input data variables, the following are as follows:



Picture 3.1 Customer Data Input

B. Customer data

The customer data consisting of, customer ID, customer name, village name, sub-district data and variable data name, the following are as follows:

No	ID_Pel	Nama Pel	Kecamatan	Desa	Pekerjaan	Pendapatan Keseluruhan	Luas Rumah	Jumlah Ruangan	Jumlah Peralatan Elektronik	Jumlah Daya Pemakaian
1	K001	Fadil	Banda Sakti	Batu Phat Barat	2	3	3	1	1	4
2	K002	Fauzan	Blang Mangat	Blang Punteut	5	1	4	3	3	3
3	K003	M. Ali	Muara Satu	Cot Trieng	1	5	2	1	1	5
4	K004	Sonia	Muara Dua	Paloh Batee	3	1	4	3	1	3
5	K005	Fauzil	Muara Dua	Keude Cunda	3	1	5	5	5	1
6	K006	Ferdi	Banda Sakti	Lancang Garam	1	3	3	3	1	5
7	K007	Sofian	Blang Mangat	Kumbang Punteut	2	5	3	1	1	3
8	K008	Djalil	Muara Satu	Meuria Paloh	5	3	4	5	1	3

Gambar 3.2 Customer data

B. Customer Data for each Cluster

The customer data that consists of, the customer's name, the name of the village, subdistrict of data center and cluster centroid, the following views are as follows: and cluster consisting of C1 = Subsidi R-1/450 VA, C2 = Subsidi R-1/900 VA, C3 = Non Subsidi R-1/900, C4 = Non Subsidi R-1/1300, C5= Non Subsidi R-1/2200 VA. The customer data consists of, customer name, village name, sub-district data and center of the centroid cluster, the following are as follows:

No	Nama	Kecamatan	Desa	Centroid 1	Centroid 2	Centroid 3	Centroid 4	Centroid 5	C1	C2	C3	C4
1	Lela	Banda Sakti	Blang Panyang	5	4.5825756949558	8.0622577482985	6.0827625302982	8.0622577482985	0	1	0	0
2	Fatimah	Muara Dua	Meunasah Mee	7.6157731058639	4.2426406871193	5.0990195135928	4	5.0990195135928	0	0	0	1
3	Ronald	Muara Satu	Padang Sakti	4.1231056256177	2.2360679774998	6.4031242374328	4.1231056256177	6.4031242374328	0	1	0	0
4	Totok	Banda Sakti	Blang Crum	5.6568542494924	4.8989794855664	8	6.164414002969	8	0	1	0	0
5	Sony	Banda Sakti	Blang Pohroh	5.8309518948453	1.4142135623731	4.2426406871193	2	4.2426406871193	0	1	0	0
6	Zubir	Muara Dua	Meunasah Mee	4.6904157598234	2.4494897427832	6.164414002969	4	6.164414002969	0	1	0	0
7	alex	Muara Dua	Meunasah Mee	5.56776436283	3.3166247903554	6.2449979983984	4.3588989435407	6.2449979983984	0	1	0	0

Picture 3.3 Customer Data in each cluster center cluster 1

D. The results of the K-Means Algorithm for optimal centroids

The customer data consists of, customer name, village name, sub-district data and center of the centroid 2 cluster and the iteration is stopped because the cluser centroid center has been optimized, the following display is as follows:

8	Della Puspita	Muara Dua	Meunasah Mesjid	6.9282032302755	2.5061149704069	6.9282032302755	3.6968455021365	6.9282032302755	0	1	0	0
9	Firiani	Muara Dua	Meunasah Mee	6.4031242374328	1.9987240828047	6.4031242374328	2.9439202887759	6.4031242374328	0	1	0	0
10	Nurdin	Muara Dua	Meunasah Manyang	7.8740078740118	4.3746719993665	7.8740078740118	3.2145502536643	7.8740078740118	0	0	0	1
11	Jufrizal	Muara Dua	Meunasah Mesjid	8.3066238629181	2.8275250589842	8.3066238629181	2.7080128015453	8.3066238629181	0	0	0	1
12	Rial Fauza	Blang Mangat	Blang Cut	6.3245553203368	3.2063393839234	6.3245553203368	1	6.3245553203368	0	0	0	1
13	Sadikin	Blang Mangat	Blang Teue	5.744562646538	3.1159563015982	5.744562646538	1.1547005383793	5.744562646538	0	0	0	1
14	Alfiadi	Blang Mangat	Jambo Mesjid	8	3.2942435878858	8	5.8594652770823	8	0	1	0	0
15	Mahdi	Blang Mangat	Blang Buloh	7	1.066656037362	7	2.7080128015453	7	0	1	0	0
16	tata surya	Muara Dua	Meunasah Manyang	8	2.8275250589842	8	3.1091263510296	8	0	1	0	0
17	M.Palino	Muara Satu	Blang Panyang	7.2801098892805	2.2027348493013	7.2801098892805	2.4494897427832	7.2801098892805	0	1	0	0

Picture 3.3 Customer data on each cluster cluster is optimal

D. Grafik Graph of grouping will need electric power requirements for each regional cluster.

Graph of grouping will need electric power requirements for each regional cluster. The data of the electrical power requirements for each sub-district data and the center of the centroid 2 cluster, the following display is as follows:

Proses iterasi berakhir pada iterasi ke- 5

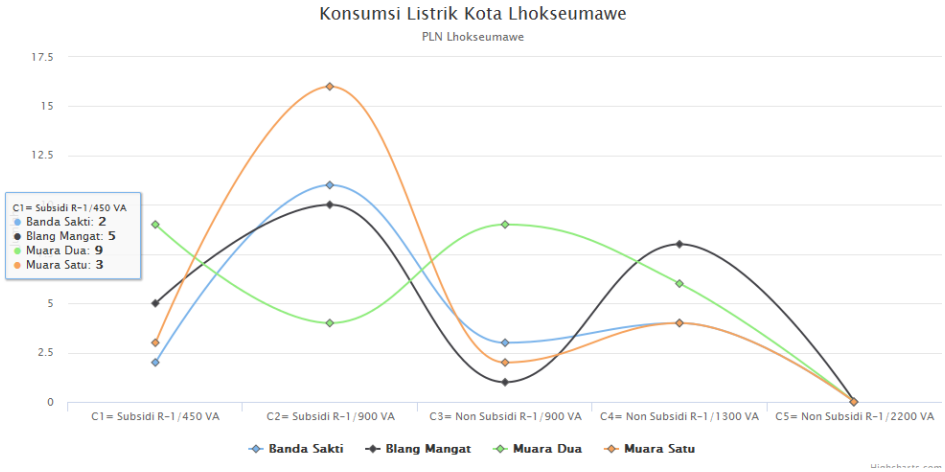


Figure 3.4 Chart Electricity Needs in each district

4. Conclusion

1. To facilitate PT. PLN Lhokseumawe in predicting the power needs for each sub-district namely Banda Sakti, Blang Mangat, Muara Dua and Muara Dua.

Furthermore, it can be used as an evaluation tool for PT PLN in the amount of power needed so that the electricity used for each region can be sufficient and there no power wasted.

2. The results of the system application can be directly seen in the grouping of new customers, so that the system built can determine the classification of each customer, for example Muhammad Palin, Muara Satu sub-district as new customer with a total income of 2 million, with data on the number of buildings (> 2) number of rooms: 2, work as labor, house size is small (5x6m), and has few of electronic equipment. So the value of centroid 1 is 5.7445, the optimal centroid value is 2,236. then the result of clustering is in cluster C2.
3. Facilitate PLN in predicting the fulfillment of electric power needs in each region as seen from the current demand of each sub-district and the demand for electricity stock in the future.

5. **Suggestions**
   1. It is better to use a combain method in predicting Electric Stock Needs Fulfillment in Lhokseumawe City so that it can know the shortcomings and advantages of each method.
   2. There needs to be further development using other methods such as automatic clustering and optimization of the best results.

6. Reference

[1] Antonov, B. M., Baranov, N. N. and Kryukov, K. V. (2015) 'A direct current converter for power supply systems with alternative energy sources', *Russian Electrical Engineering*. doi: 10.3103/S1068371215070020.

[2] Hardi, R. (2015) 'Client Server Based Antivirus Development', *Telematika*.

[3] Hendriana, Y. and Hardi, R. (2017) 'Remote control system as serial communications mobile using a microcontroller', in *2016 International Conference on Information Technology Systems and Innovation, ICITSI 2016 - Proceedings*. doi: 10.1109/ICITSI.2016.7858212.

[4] II, R. X. and D. C. W. (2009) *Clustering, Computational Intelligence*. doi: 10.1002/9780470382776.

[5] Ipmawati, J., Kusrini and Luthfi, E. T. (2017) 'Komparasi Teknik Klasifikasi Teks Mining Pada Analisis Sentimen', *ijns.org Indonesian Journal on Networking and Security*.

[6] Larose, G. L. and D'Auteuil, A. (2006) 'On the Reynolds number sensitivity of the aerodynamics of bluff bodies with sharp edges', *Journal of Wind Engineering and Industrial Aerodynamics*. doi: 10.1016/j.jweia.2006.01.011.

[7] Shang, L. H. (2011) 'ftsa : An R Package for Analyzing Functional Time Series', *The R Journal Vol*.

[8] Sheng, J. *et al.* (2013) 'PT-symmetric optical potentials in a coherent atomic medium', *Physical Review A - Atomic, Molecular, and Optical Physics*. doi: 10.1103/PhysRevA.88.041803.

[9] Tampubolon, W. and Reinhardt, W. (2014) 'UAV data processing for large scale topographical mapping', in *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*. doi: 10.5194/isprsarchives-XL-5-565-2014.

[10] Ula, M. *et al.* (2017) 'An expert system for early diagnose of vitamins and minerals deficiency on the body', in *2016 International Conference on Information Technology Systems and Innovation, ICITSI 2016 - Proceedings*. doi: 10.1109/ICITSI.2016.7858225.

[11] Vaswani, A. *et al.* (2013) 'Decoding with Large-Scale Neural Language Models Improves Translation', *Proceedings of the 2013 Conference on Empirical Methods in Natural Language Processing (EMNLP 2013)*. doi: 10.1.1.637.2567.