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Analysis Location Public Electric Vehicle Battery Exchange Stations (SPBKLU) For Battery *Swap* in Developing the Electric Vehicle Ecosystem

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Abstract

Rapid growth in the transport sector in Surabaya, especially in the use of electric vehicles, has increased the need for efficient supporting infrastructure. With the increasing number of electric vehicles, the government is facing challenges in providing charging stations (SPBKLU) to reduce user concern regarding the limitations of charging facilities. The optimization results identify 14 strategic locations in East Surabaya that can serve the needs of electric vehicle users effectively. These locations are selected based on coverage and capacity criteria, ensuring that every area with high demand gets adequate access to a common electric vehicle charging station (SPBKLU). The results showed that 14 optimal locations in East Surabaya could cover the needs of electric vehicle users effectively. 14 points are in Barata Jaya village, gubeng, gunung anyar, gunung anyar tambak, keputih, klampisngasem, semolowaru, pacar kembang, rangangan, dukuh sutorejo, Kedung Baruk, medokan ayu, wonorejo. These locations have been selected to ensure even distribution and easy access for users. This study provides practical guidance for the development of electric vehicle infrastructure in Surabaya, as well as offers models That can be applied by other cities that face similar challenges in improving facility distribution efficiency and adoption of electric vehicles.

Keywords
Electric vehicle infrastructure, charging station, Set Covering Problem, location planning

1. Introduction
The rapid development of transportation has become an important part in the dynamics of urban growth in various regions, including Surabaya. Based on data from the Central Statistics Agency (BPS), the period from 2020 to 2024 showed a significant increase in transportation sector in Surabaya. This increase is seen from the increasing number of private and public vehicles and the growing infrastructure supporting transportation. Among these developments, electric vehicles experienced a growth of 15% per year, reflecting efforts towards more sustainable transport amid rapid urbanization (Bercuson & Carling, 1995).

However, the growth of the transport sector also brings a negative impact, especially on the quality of the environment. One of the main problems is the increasing air pollution derived from vehicle emissions. IQ Air data shows that air quality in Surabaya is in a moderate category with an air quality index of 60, indicating air quality that needs to be vigilant (Tajik & Hoque, n.d.) In addition, dependence on fossil fuels is also a crucial issue, encouraging governments to seek more environmentally friendly alternatives.

As part of its global commitment to reduce carbon emissions, the Indonesian government, including Surabaya, has encouraged the use of electric vehicles as an alternative to conventional vehicles. The ministry of energy and mineral resources (esdm) targets a 29% reduction in carbon emissions by 2030 through increased use of clean energy and sustainable transport (FACTORS INFLUENCING URBAN HEAT ISLAND IN SURABAYA, INDONESIA, n.d.). However, adoption of electric vehicles in the community is still facing challenges, especially related to insufficient charging infrastructure, where 52% of respondents in the survey expressed their concern about the availability of common electric vehicle battery exchange stations (Chandra Prasetyo et al., 2022)

To answer these challenges, the development of adequate infrastructure, such as spbklu, is a priority for the adoption of electric vehicles to increase significantly. Determination of the optimal location of spbklu is critical to meeting the growing demand. Previous research has proven the effectiveness of set covering problem method in determining the optimal location for various public facilities, such as fire stations and bus stops, which can be applied in the development charging station in Surabaya. Therefore, this study aims to obtain models and generate optimal location points to build a public charging station in Surabaya. (Fadhila Permana et al., 2022)

Linear programming is particularly effective for solving facility location problems, where multiple constraints—such as distance, accessibility, and resource availability—must be considered simultaneously. By using algorithms like the simplex method or integer programming, decision-makers can determine optimal solutions that balance competing priorities, such as minimizing costs while maximizing coverage and accessibility. In the context of SPBKLU development in Surabaya, linear programming can assist in identifying strategic locations that maximize user convenience while ensuring economic feasibility and environmental sustainability. This method provides a structured and data-driven approach to addressing the challenges posed by the rapid growth of electric vehicle adoption and the need for supporting infrastructure (Hussain et al., 2023).

2. Literature Review
2.1 Charging Station (SPBKLU)
The Charging Station (SPBKLU) is a facility that allows electric bicycle users to exchange batteries quickly and efficiently, thereby reducing vehicle downtime (Sulistyawati et al., 2021). According to the Minister of Energy and Mineral Resources Regulation of the Republic of Indonesia No. 1 year 2023, charging station should be placed in locations that are easily accessible to the owner of battery-based vehicles and do not interfere with traffic. To speed up the program, charging stations are also recommended to be placed at public refueling stations, government offices, shopping centers, and public parking on the roadside.

2.2 Electric Vehicle
Electric Motorcycle is one type of vehicle that uses alternative fuel, utilizing electric power converted into motion energy to operate (Istiqomah et al., 2022). In accordance with Presidential Regulation No. 55 of 2019 on accelerating battery-based electric motor vehicle program, the government seeks to accelerate the development of electric vehicle component industry in the country (Suranto et al., 2023). In Indonesia, there are several types of electric vehicles, namely:

1. **Battery Electric Vehicle (BEV)**
   This vehicle is fully driven by electricity without the need for fuel, as it has no internal combustion engine, so it produces no gas emissions and is very environmentally friendly.

2. **Hybrid Electric Vehicle (HEV)**
   These vehicles still need fuel to run an internal combust ion engine, which also serves as a generator to charge the vehicle's batteries.
3. **Plug-in Hybrid Vehicle (PHEV)**
   The vehicle uses an electric motor as the main driver but still has an engine that serves as a battery charger generator, this providing higher fuel efficiency and lower e missions.

Although HEV and PHEV still use fuel, Bev is a completely emission-free vehicle, making it the most environmentally friendly option (Das et al., 2020).

2.3 *Swap* Battery

Electric vehicles are environmentally friendly vehicles because the source of power used does not come from fossil fuels from batteries to drive electric vehicles (Figure 1- Figure 2). With a swap battery in an electric vehicle is an important component in an electric vehicle as an energy storage area(Suranto et al., 2023).

1. *Big Swap Station*

Figure 1. *Big Swap Station*

Power	: 5600 watt
Battery Slot	: 8
Dimension	: 1800 x 644 x 749 mm
Sertifikasi	: IP54,CE & IEC 62840

2. Battery Dimension

Figure 2. Battery Swap

Based on Figure 2 is a picture of battery swap used for electric bicycle vehicles (Sutopo et al., 2018). Dimensions of removable and exchangeable batteries for electric vehicles voltage 72v battery capacity 1,44 kWh this battery requires a charging time of 4 hours with a mileage of 50 km/1 battery (Sun et al., 2019).

2.4 Set Covering Problem

Set Covering Problem (SCP) is a model used to determine the number of facility location points Minimal service but able to serve all demand points. Up to the purpose function from the Set Covering Problem model is minimizing the total point of location of the service facility. Whereas its functionality is the location of the service should be able to meet all points of demand (Christofides & Korman, 1975). Process optimal location determination for charging station (spbklu) involves several important steps using the set covering problem (SCP) method.

1. Determining the demand point the first step is to identify the requested location which includes gas stations, spbg, government offices, shopping malls, and public parking lots.
2. Determine the candidate point of spbklu after the request point is determined, the next step is to select a location that meets the criteria as a candidate for the spbklu establishment.
3. Measure distance measure the distance between spbklu candidate s and request points with the help of Google Maps to ensure optimal coverage.
4. Determining the location and the number of spbklu final stage is to determine the optimal location and number of spbklu using the SCP model, so that all request points in Surabaya have decent access to the nearest charging station.

2.5 Sensitivity analysis

is a method used to evaluate the extent to which variations or changes in a variable or parameter can affect the outcome or output of a model or system. Sensitivity analysis is done by giving treatment, which is changing an input variable in a certain unit and maintaining the value of other variables in the base case value to generate a value of Output desired. Sensitivity analysis is called sensitivity analysis. Sensitivity analysis can be said an activity to re-analyze a project to see if what will happen to the project if a project does not go according to plan.

2.6 *GAMS*

General Algebraic Modeling System (GAMS) is a common algebra modeling system used to solve optimization problems. GAMS is designed to help model and complete optimization. GAMS was developed to facilitate the modeling and resolution of complex optimization problems in a variety of areas, including economics, engineering, logistics, and management (Chen et al., 1996). One major advantage of GAMS is it ability to handle large-scale models and integrate different types of mathematical programming. With its broad capabilities and flexibility in modelling, GAMS is often used in academic and p oject industry to resolve issues such as resource al location, scheduling, and facility locating. (Hutabarat et al., n.d.)

3. Methods

The method used in this research is quantitative method, which aims to measure and analyze the data obtained numerically and using a statistical approach. This quantitative approach enables researchers to identify the relationship between variables examined through systematic and structured data collection. In this study, data collected are related to the number of conventional vehicles and electricity in Surabaya city, the distribution of residents in each village, as well as the average distance between the village Surabaya in Sura baya. The data is then processed using a set covering problem (SCP) method, which is an optimization technique used to determine the location of the optimal electric vehicle battery exchange station in Surabaya. (ReVelle et al., 1976)

This study involves using software such as Microsoft Word, Excel, PowerPoint, and gams to support the processing process and data analysis. The purpose of this study was to determine the location of a charging station. The model verification and validation process is carried out to ensure that the developed mode l is in accordance with real conditions and is reliable in decisi on making. Verification is done by checking the conformity of the final result of the system with the mathematical model u sed, while validation is done to ensure that the model reflects the actual situation in the field. The result of this data processing will be used to conduct analysis and evaluation to provide appropriate recommendations on determining the location of charging station in Surabaya (ReVelle et al., 1976).
Set Covering is a site allocation optimization method that aims to: Minimize the number of sites needed to cover other sites. Site those selected will be able to cover demand from other sites, so they will minimize the number of sites and save costs. The basic model in the set covering model is as follows:

I = Demand Point

J = Facility Location
Dij = distance from the demand point to the facility location point
Dc =Distance Coverage

$$Ni = \{ j \mid Dij \leq Dc \}$$

The distance between the Demand Point and the facility point fulfilled because it is less than distance as distance fulfillment

4. Results and Discussion

4.1 Data Collection

At this scrutiny performed data collection with a variety of techniques such as library study and quantitative data collec tion from various proponents of its scrutiny. On the process of modeling and simulation of the system, it is required some data to support the expansion of the model. This data was obtained from the central statistical body database to find out the number of conventional motor users in the city of Surabaya. The user data used is data from 2018 to 2020. The data used to know the demand airlift is the total number of motor graders in Surabaya in the year. The number of such users will be the consumer demand input of electric motorcycles (Table 1).

Table 1. Demand of Conventional Motorcycle Users

Province	**Residence**	**City**	**Number of Motorcycles**		
			2018	**2019**	**2020**
East Java	Surabaya	Surabaya	2.342.887	2.517.449	2.599.332

Source: Central Bureau of Statistics (BPS, 2023)

Conventional motorcycle user data obtained only until 2020, after that to obtain conventional motorcycle data until 2024 by looking at the development of conventional motorcycle users (Table 2).

Table 2. Demand Increases of Conventional Motorcycles Users

Province	**Residence**	**City**	**3% increase in number of motorcycles**			
			2021	**2022**	**2023**	**2024**
East Java	Surabaya	Surabaya	2.677.312	2.757.631	2.840.360	2.925.571

The next stage determines how many electric motorcycle users in Surabaya city include (central Surabaya, North Surabaya, East Surabaya, south Surabaya, West Surabaya) in each village. The number of users of electric motorcycles in Surabaya area will be used to measure the distance matrix in each village. Determining the candidate point of the General Electric vehicle battery exchange station (spbklu), the request point that has been obtained will be used as the candidate charging station location.

The next stage of results obtained from the determination of the number of location points is determining the city of Surabaya including central Surabaya, North Surabaya, East Sura baya, south Surabaya West Surabaya with the number of user s of electric motors.

$$\text{Determination percentage} = \frac{number\ of\ electric\ motors\ in\ Indonesia}{population\ in\ Indonesia} \times 100\%$$

$$= \frac{133225}{199176800} = 0{,}066\%$$

Determining Demand = Total Village x total percentage of electric bikes

Table 3. Electric Motor User Demand

Region	**Number of Users**
Surabaya Center	249
North Surabaya	352
East Surabaya	562
South Surabaya	478
West Surabaya	321

From that demand i choose East Surabaya because the number of electric motorcycles in East Surabaya more. Based on Table 3 determination of demand above then required matrix distance between the sub-districts. The measurement in this study was done indirectly. The distance used to determine the distance of the spbklu location point is using the help of Google Maps. This method was chosen because it is more efficient than measuring directly. The data obtained is then processed into a distance matrix, which is used as the has is in the following modeling. The data used is the distance bet ween the points of the village listed in the study.

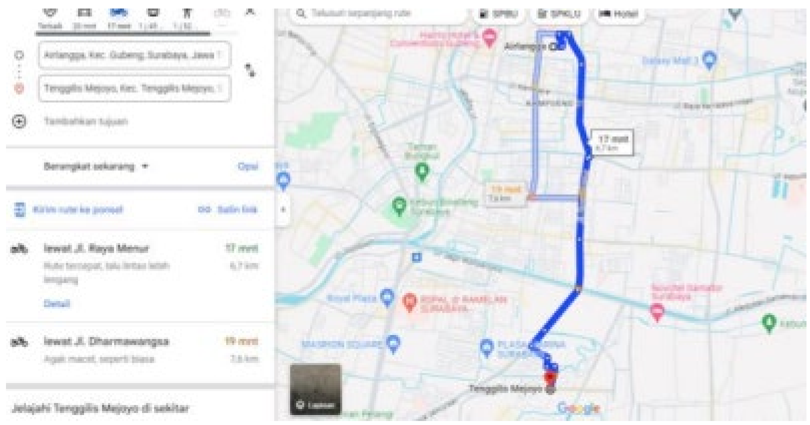

Figure 3. sample distance measurement

From the measurement process using Google Maps will be obtained distance between two points (Figure 3). This point is obtained from the point of every village in East Surabaya. It will be obtained as follows in Figure 4.

0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12
X1		4,1	2,3	1,9	1,5	2,8	10	14	10	9,3	4,9	9,7
X2	4,1		2,9	2,7	3,8	2,1	6,8	10	7,2	6,1	5,2	11
X3	2,3	2,9		0,55	2,2	1,4	9,3	13	9,7	8,6	4,4	9,2
X4	1,9	2,7	0,55		3,1	0,95	8,8	12	9,2	8,1	5,2	10
X5	1,5	3,8	2,2	3,1		3,6	9,5	13	11	8,8	4,4	9,2
X6	2,8	2,1	1,4	0,95	3,6		8,6	12	9	7,9	5,1	11
X7	10	6,8	9,3	8,8	9,5	8,6		6,4	0,80	2,1	8,4	14
X8	14	10	13	12	13	12	6,4		7,2	7,5	10	16
X9	10	7,2	9,7	9,2	11	9	0,80	7,2		3	7,8	13
X10	9,3	6,1	8,6	8,1	8,8	7,9	2,1	7,5	3		8,8	14
X11	4,9	5,2	4,4	5,2	4,4	5,1	8,4	10	7,8	8,8		5,6
X12	9,7	11	9,2	10	9,2	11	14	16	13	14	5,6	

Figure 4. The point of every village in East Surabaya

After performing the calculation of the distance matrix, the next step is to determine the optimal distance between the General Electric vehicle battery exchange stations (spbklu) to ensure efficient and even distribution (Table 4).

Table 4. Battery Capacity

Battery Capacity	1.44 kWh
Distance Traveled	50 Km
Electricity Consumption	0.0288 kWh/Km

$$20\%\ Battery \times 1.44\ kWh = 0.288\ kWh/km$$
$$D = \frac{E}{C} = \frac{0{,}0288}{0{,}288} = 10\ Km$$

D : Distance travelled in Kilometers (Km)
E : Energy consumption in kilowatt-hours (kWh)
C : Vehicle energy consumption rate (kWh/Km)

The battery level of 20% is often considered a minimum threshold that is still reliable. It aims to remind users that the remaining energy in the battery is thining and the vehicle may not be able to travel long distances if it is not immediately recharged. 20% of the battery is considered the last safe limit before the vehicle actually needs recharging. Based on calculations considering the use of 20% batteries, electric vehicles can travel 10 km before requiring recharging.

Table 5. Determination of Demand

1 day	24 hours
Charging time	4 hours
1 Spare	6 motorcycles
Spare	7
Charging capacity in 1 SPBKLU unit	42
EV motorcycles in East Surabaya	562
13,38	
14 point	

Based on Table 5 obtained 14 points of location of the General Electric vehicle battery exchange station because it will serve demand from East Surabaya as much as 562 users of electric motors. This is due because each point of the common electric vehicle battery exchange station has 8 spare battery charging. But only 7 spare can serve the battery exchange. The battery charge is carried out for 4 hours of charging. It causes the value of charging station to be opened.

4.2 Data Processing

The initial stage of data processing is the creation of mathematical models, the creation of mathematical models will be a reference in modelling using GAMS optimization software. GAMS is an ICT high level modeling system of mathematical programming and optimization that provides the constituents of programming languages (language compiler) and various related solve. Model making was preceded by a determination of decision variable, on this problem which becomes the variable is the location point charging station new will supply demand each sub-district of the city area that has been selected and decisions built or not at that location. The Decision variable is used to help make decisions in the model that researchers create.

In the process of making a modelling system the use of diagrams is required to determine the relationship and dependence between existing variables. The purpose of this research is to find out the influence of the variables in this research. From this diagram will be known the factors that influence in the model that researchers make. With the model that has been made then researchers get the model diagram as follows in Figure 5.

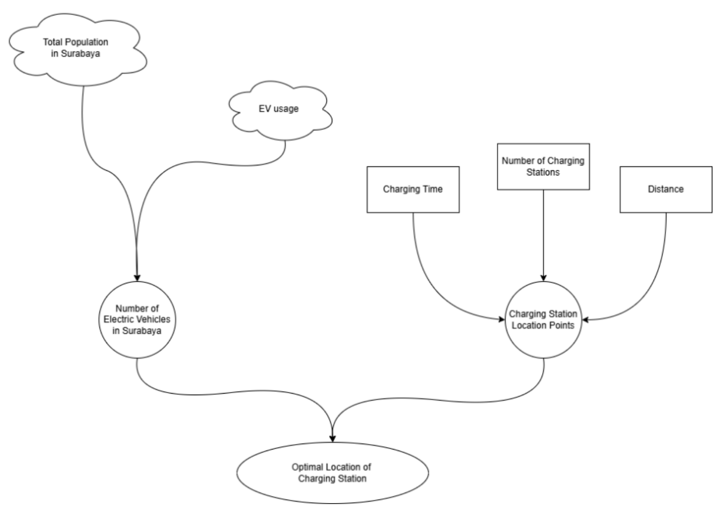

Figure 5. Influence Diagram

This diagram describes the process of determining the optimal charging station (spbklu) in Surabaya by considering variables such as number of inhabitants, users of electric vehicles, charging time, number of spbklu, and distance between stations. The number of inhabitants and users of electric motors affect the number of users of spbklu, which is the main variable in the determination of location. Charging time and distance between station s also play an important role in determining the optimal location point

Furthermore, a mathematical model is created to define the functions of objectives and constraints. The objective function is focused on minimizing the number of electric vehicle station locations, while the constraint function ensures that all controlled variables are considered to achieve an optimal solution. This model is designed to overcome the problem of location determination of spbklu efficiently.

1. Minisize purpose function

   The purpose of this final project is to minimize the number of spbklu to be built.

   For I = 1, 2, 3, …, 41

$$Minimize = \sum_{i=1}^{m} x_i$$

Electric Vehicle Battery Exchange Stations that meet the criteria. Each x_i = 0 then SPKBLU candidate is not selected. If the value x_i = 1 then SPBKLU candidate is selected.

Table 6. Candidate Demand

Variable Xi	Village	Variable Xi	Village
X1	Airlangga	X22	Pacar Keling
X2	Barata Jaya	X23	Ploso
X3	Gubeng	X24	Rangkah
X4	Kertajaya	X25	Tambaksari
X5	Mojo	X26	Dukuh Sutorejo
X6	Pucangsewu	X27	Kalijudan
X7	Gunung Anyar	X28	Kalisari
X8	Gunung Anyar Tambak	X29	Kejawan Putih
X9	Rungkut Menanggal	X30	Manyar Sabrangan
X10	Rungkut Tengah	X31	Mulyorejo
X11	Gebang Putih	X32	Kali Rungkut
X12	Keputih	X33	Kedung Baruk
X13	Klampisngasem	X34	Medokan Ayu
X14	Medokan Semampir	X35	Panjaringan Sari
X15	Menur Pumpungan	X36	Ringkut Kidul
X16	Nginden Jangkungan	X37	Wonorejo
X17	Semolowaru	X38	Kendang Sari
X18	Dukuh Setro	X39	Kutisari
X19	Gading	X40	Panjang Jiwo
X20	Kapas Madya	X41	Tenggilis Mejoyo
X21	Pacar Kembang		

The Table 6 above is the candidate demand village which may be the location of the General Electric vehicle battery exchange station (spbklu).

2. Obstacle Function

   Obstacle function is a form of boundaries that will be optimally adjusted to the purpose function. Function constraints in this final project are:

   Objection Function:

$$\sum^{41} a_{ij x_i}$$

Function constraints:

$$\sum^{X=n} 14 \le X \le 41$$

Decision Variable:

$$X_{I\,\in\{0,1\}}$$

Description:
X_i : binary variable indicating whether location I is selected (1) or not (0).
d_{ij} : parameters indicating whether location I can include req uests at point J (1 if can include, 0 if not).
N : total number of request points.

Each request point can be fulfilled by at least 1 charging station. This obstacle exists to ensure the number of charging stations opened can overcome all electric motorcycles.

4.3 Verification

Verification is a step to ensure that the model is created correctly. In this verification is due by checking the coding used. This is done by removing one of the components, as for the one used is the parameter component by eliminating 2 points. Here is a coding at the verification (Figure 6).

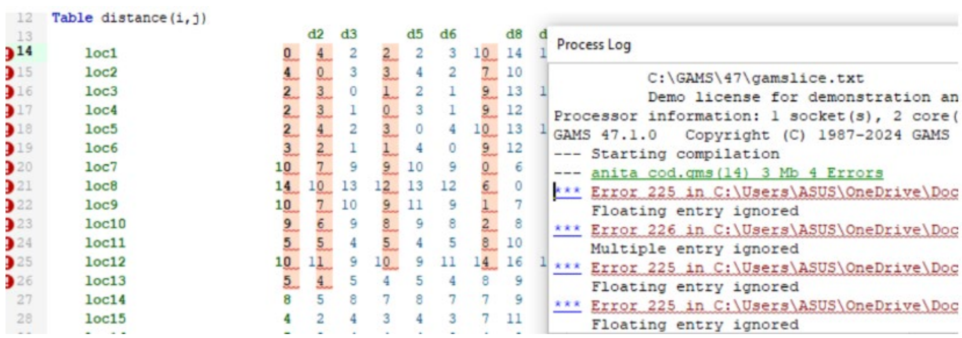

Figure 6. Verification Stage

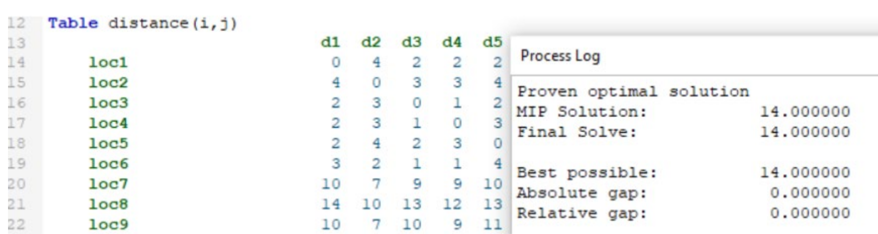

Figure 7. Proof Verification

Based on Figure 7 is known if the model that has been made does not suffer from error and can run ap propriate true sequences.

4.4 Validation

Validation is a process carried out to ensure that the model developed reflects actual conditions in the field and can be relied on in decision making. This validation aims to ensure that the results obtained from the model are truly relevant and accurate in real situations. The results obtained from the model are tested to ensure whether they reflect actual conditions in the field. In this research, validation was carried out by looking at the results from the GAMS software which showed the optimal SPBKLU location points. The model was tested several times (in the document it says three times) to ensure that the results were consistent. The same results were obtained from each trial, which shows that the model works well and is stable. Data from the model results is compared with the actual situation to ensure that the proposed location reflects the needs and conditions on the ground. The validation process is done by viewing the result s of the coding output as follows in Figure 8.

```
Process Log

Proven optimal solution
MIP Solution:          14.000000    (0 iterations, 0 nod
Final Solve:           14.000000    (0 iterations)

Best possible:         14.000000
Absolute gap:           0.000000
Relative gap:           0.000000
```

Figure 8. Proof of Validation

Based on Figure 8 it is known if the value 2 in software GAMS determines the location point of charging station obtained a result of 14 location points from 41 village. This has been proven by running the model repeat 3 times. The same results are 14 location points so that the model can be read by the system and have des cribed the real conditions.

4.5 Result Analysis

The location selection of charging station (SPBKLU) in Surabaya focused on various areas, with East Surabaya being a top priority because it has the largest number of electric motor users, which is 562 users. Compared with other regions such as central Surabaya (249 users), North Surabaya (351 users), south Surabaya (478 users), and West Surabaya (321 users), east Surabaya shows great potential for spbklu development. Based on the data, 14 charging stations points in East Surabaya are required to meet the demand of 562 users, with each station having 8 battery units, of which 7 units are available for exchange. The battery charging process takes 4 hours, which affects the number of stations that nee d to be opened.

Based on the calculation above before determining the optimal location for charging station in East Surabaya, namely Determine the maximum mileage to get the optimal location point results. Based on the results of analysis The energy consumption of electric vehicles, obtained distance results of about 10 km. However, the value of 1 in GAMS can reach 5 km so that the value of 2 can reach 10 km. This distance is selected to ensure that each electric vehicle can reach the next charging station without the risk of running out of battery, this supporting smooth travel and improving the reliability of the overall charging network. Optimization results from gams obtained 14 points of location of charging station with a distance of 10 km is enough to cover all areas of East Surabaya effectively and efficiently. So the placement of 14 points of charging station locations at strategic locations will ensure that every village in East Surabaya can be served properly, this supporting the development of adequate electric vehicle infrastructure in East Surabaya. This decision is taken taking into account not only the efficiency in the use of resources, but also the convenience and satisfaction of users in accessing charging services. The results of the optimal location in East Surabaya can be seen in the following Table 7.

Table 7. Optimization Results

No	Point	Location
1	Barata Jaya	Airlangga
		Gubeng
		Kertajaya
		Mojo
		Mulyorejo
2	Gubeng	Barata Jaya
		Pucangsewu
		Menur Pumpungan
		Nginden Jangkungan
		Panjang Jiwo
3	Gunung Anyar	Gunung Anyar
		Rungkut Menanggal
		Rungkut Tengah
		Kali Rungkut
		Rungkut Kidul
4	Gunung Anyar Tambak	Gunung Anyar Tambak
5	Keputih	Keputih
		Kejawan Putih Tambak
6	Klampisngasem	Gebang Putih
		Klampisngasem
		Semolowaru
		Manyar Sabrangan
7	Semolowaru	Klampisngasem
		Medokan Semampir
		Nginden Jangkungan
		Semolowaru
8	Pacar Kembang	Pacar Kembang
		Pacar Keling
		Ploso
		Rangkah
		Tambaksari
		Kalijudan
9	Rangkah	Dukuh Setro
		Gading
		Kapas Madya
		Pacar Kembang
		Ploso
		Rangkah
		Tambaksari
10	Dukuh Suterejo	Dukuh Suterejo
		Kalijudan
		Kalisari
		Mulyorejo
11	Kedung Baruk	Penjaringan sari
12	Medokan Ayu	Medokan Ayu
13	Wonorejo	Wonorejo
14	Kendangsari	Kendangsari
		Panjang jiwo
		Tenggilis Mejoyo

There are 14 points of location of public electric vehicle battery exchange station (spbklu) selected in East Surabaya, including various neighborhoods to ensure even access. The first point in barata jaya serves surrounding neighborhoods such as Airlangga and gubeng. Other points include gubeng, gunung anyar, gunung anyar tambak, keputih, klampisngasem, semolowaru, pasar kembang, rangogan, Dukuh sutorejo, Kedung Baruk, medokan Ayu, wonorejo, and kendangsari. Each point serves several sub-districts, ensuring a wide and efficient coverage of charging station services in East Surabaya (Figure 9).

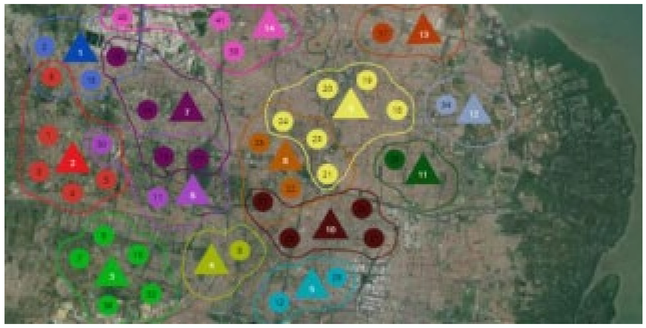

Figure 9. Mapping Result of spbklu location

4.6 Sensitivity analysis

Sensitivity analysis showed that changes to maximum coverage (Max Radius) from value of 2, 3, to 4 resulted in significant differences in the number of optimal charging station location points. At Max Radius 2, found 14 optimal locations, while at 3 and 4 values, the number decreased to 11 and 6 locations. This result shows that max radius 2 provides the best balance between good coverage area and the efficiency of the number of stations. This, 14 charging station points are enough to cover the entire area optimally without too much location in Table 8.

Table 8. Sensitivity Analysis

Maximum Coverage Radius	Optimation Result
2	14
3	11
4	6

6. Conclusion

Based on the research objectives and the results of the above research can be concluded some of the following: This study determined the optimal location point of charging station in East Surabaya based on the number of users of electric motorcycles. The result is 14 Optimal location point is found with maximum mileage of 10 km, using gams software. This research provides guidance for the development of electric vehicle infrastructure in Surabaya and can be applied by other cities. The developed model describes the needs of spbklu in East Surabaya with 14 optimal location points at 10 km. These points include Barata Jaya, gubang, gunung anyar, gunung anyar tambak, keputih, klampisngasem, semowaru, pasar kembang, rangigan, Dukuh sutorejo, Kedung Baruk, medokan Ayu, wonorejo, and kendangsari.

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Biographies

Anita Nurhayan is a graduate of the Industrial Engineering program, having successfully completed her studies with a focus on practical applications in the field. Throughout her academic journey, she developed expertise in research and writing final projects. Her research specifically delved into the field of batteries, a topic with growing relevance in today's technology-driven world. Her final project themes are valuable references for those interested in the intersection of industrial engineering and energy storage solutions. With a strong foundation in system analysis, optimization, and process improvement, Betsyeda has honed the skills to tackle real-world challenges. Having completed her research in the battery sector, she is well-versed in the complexities of battery technology, efficiency, and sustainability. Betsyeda's work contributes to the ongoing development of solutions that are critical for various industries, including energy, transportation, and electronics, positioning her as a knowledgeable professional in the field.

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Athaya Rakha Afianto is a fifth-semester student in the Industrial Engineering program with a keen interest in the field of supply chain management. His academic journey is focused on understanding and optimizing processes within industries to improve efficiency and effectiveness. Fikri's interest in supply chain stems from its critical role in ensuring smooth operations, cost management, and sustainability across various sectors. As an Industrial Engineering student, he is actively engaged in learning core subjects such as logistics, operations research, and inventory management. These courses provide him with the foundational knowledge to analyze and optimize supply chain networks. Beyond academics, Fikri is eager to apply his skills in practical scenarios, such as internships or academic projects, to gain hands-on experience. His curiosity, dedication, and passion for supply chain management make him a promising individual in his field, aiming to contribute innovative solutions in the future.

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