Location Design of Electric Vehicles Charging Facility: Distance-Based Method Approach

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Abstract
Currently, the Indonesian government is building electric vehicles to replace fossil-fueled vehicles. One of the drivers to downstream the electric vehicles is the availability of infrastructure, namely the charging station. A strategic activity that must be carried out in Supply Chain Network Design (SCND), includes decisions about the location, number, and capacity of production facilities. In this study, We used Semarang City, Indonesia as a case study. We assumed the local government of Semarang City has to ensure the provision of charging stations in collaboration with some places like malls, markets gas station, and so on, to ensure optimal coverage of charging stations with feasible distances between points. It is important to design an optimal supply chain network to achieve this goal. This research proposes a supply chain network model for charging station facilities in Semarang city to cover all consumers with the fewest number of charging stations and minimum cost. The Malls and markets located throughout Semarang city are potential locations that will be chosen as charging stations. The model used is built from a combination of models in previous relevant studies. The distance-based method is selected to achieve optimal solutions and models are executed with CPLEX applications. The results of this study are expected to provide benefits and input recommendations to the Semarang city government to support the use of Electric vehicles.

Keywords
Charging Station, Distance-based method, E-Track, Facility location, Supply Chain Network Design

1. Introduction

Electric Vehicles (EV) using the battery electric vehicle (BEV) is one of the best choices in reducing gas emissions and was developed in Indonesia because there are so many motorbike users (Sutopo *et. al*., 2013; Habibie, and Sutopo, 2020). One of the drivers to downstream the electric vehicles is the availability of infrastructure, namely the charging station (Sutopo *et. al.,* 2019; Istiqomah and Sutopo, 2020). A policy for the placement of charging station facilities is needed so that the network built covers the widest possible range of electric vehicles circulating in certain areas. Supply Chain Network Design (SCND) is a strategic activity that must be carried out in Supply Chain Management and includes decisions about the location, number, and capacity of production facilities. It aims to meet customer needs which of course can change dynamically from time to time (Klibi, 2010). The supply chain network is the result of several strategic decisions, one of which is a decision about the location of production facilities and decisions about purchasing raw materials (Wahyudin, *et al.*, 2015; Pujawan, 2017).

In this study, we used Semarang City, Indonesia as a case study. We assumed the local government of Semarang City has to ensure the provision of charging stations in collaboration with some places like malls, markets gas station, and so on, to ensure optimal coverage of charging stations with feasible distances between points. The means of providing a place for a charging station is at a gas station, but it is necessary to find the optimal location for the charging station to be built at the gas station. Only 1 unit of Public Electric Vehicle Charging Station (SPKLU) is available in Semarang City, located on Jalan Pemuda No. 93, Semarang. In providing SPKLU, this is a form of support and readiness of PLN in welcoming the era of electric vehicles. Provision of the SPLKU is also a follow-up to Presidential Regulation No. 55 of 2019 concerning the Acceleration of the Battery-Based Electric Motor Vehicle Program for Road Transportation. and will publish the ESDM Ministerial Regulation No. 13 of 2020. This order will regulate the provision of electric vehicle charging infrastructure, including standards, tariffs, and a charging station business scheme in the form of a General Electric Vehicle Charging Station.

The application of charging stations is the most significant problem for the electrical vehicle (EV) industry. There are many previous types of research related to Electric Vehicle Charging Station Facilities. Zhang *et. al.* (2017) examined the optimization of the location of electric ship charging stations based on the backup coverage model by analyzing the feasibility, reserve location models, and optimization methods. Research by Akbari M, et al (2018) discusses the optimization of the EV charging station location by applying the Genetic Algorithm, and the best position to place the charging station is obtained to meet customer demands. Likewise in the research of Pagany, et. al. 2019 and Cui *et. al.* (2018) discusses the same thing but different methods and objects of research. Akbari *et. al.* (2018) was studied optimizing the distance between charging stations, costs can be minimized. In optimizing the distance between charger stations so that they can cover all areas, it is necessary to determine public facilities that can be used as locations for charging stations.

This study aims to optimize the location selection for the charging station for the Electric Vehicle public facilities with a case study in the city of Semarang. Potential public facilities that are used as locations for Electric Vehicle charging stations are markets and malls, where these two facilities are often and easily found by the public. Then there are 4 involved entities, namely charging station providers, market owners (government), mall owners (private), and Electric Vehicle users. Of these four entities, the battery charging activity is carried out at the charging station, in which the swapped battery is moved from the charging station to the Electric Vehicle user.

2. Methods

The models in this study are the development of models in Zhang *et al.* (2017) and Bian *et. al.* (2018). From both studies, models were made to determine the optimization of charging station locations for Electric Vehicle. This study considers the maximize demand coverage and cost minimization.

2.1 Problem Description

In designing a supply chain network, things that need to be considered are the number of entities, and the flow of the supply chain. So it is necessary to create a supply chain network for the location of filling stations. Figure 1 below describes the supply chain network design process.

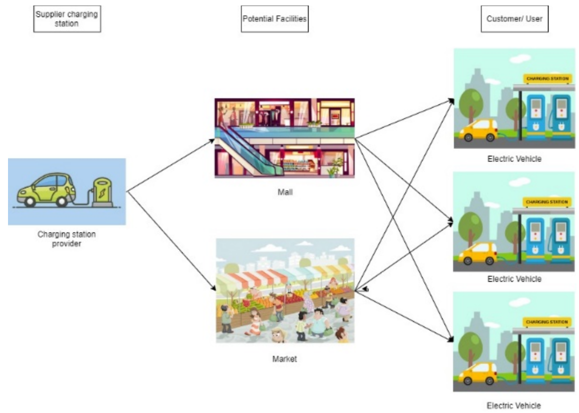

Figure 1. Supply Chain Network Design Process

The problem described in this study is to find the best number of potential facilities built to minimize the total weighted distance from the facility to the customer, assuming that all facilities can meet all customer demands and all requests are met.

2.2 Influence Diagram

The influence diagram of optimizing the location of the electric vehicle charging station can be seen in Figure 2. The purpose of this research is to optimize the location of the electric vehicle charging station in the city of Semarang by maximizing coverage and minimizing costs. The constrain is to fulfill all requests and limit the number of facilities to p to keep costs minimal. And the criteria are minimizing the total distance from facilities to customers, minimizing the number of facilities, and minimizing costs.

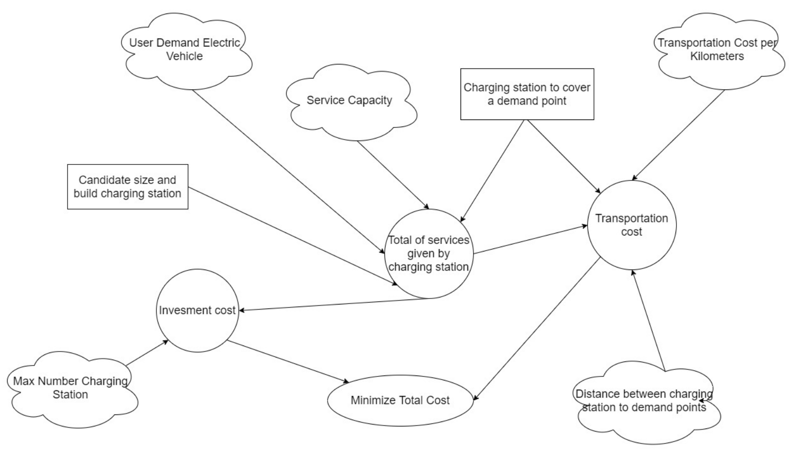

Figure 2. Influence Diagram

2.3 Mathematical Modelling

The development carried out in this research is to look for several things, as follows: Minimizing the total distance from the charging station to the user or consumer, each user or consumer must be fully served and finding several many facilities to be built. The following is a mathematical model used in this study.

Objective function:

$$Z = Min \sum_{i \in I} \sum_{m \in M} F_{im} X_{im} + Min \sum_{i \in I} \sum_{j \in J} dist_{ij} C Y_{ij}$$

Constraint :

$$\sum_{i \in I} \sum_{m \in M} X_{im} Y_{i,j} \geq 1; \quad \forall j \in J$$

$$Y_{ij} \leq \sum_{m \in M} X_{im}\,; \qquad \forall i \in I\,, j \in J$$

$$\sum_{j \in J} d_j\, Y_{ij} \ \leq \sum_{m \in M} Cap_m\, X_{im}\,, \qquad \forall i \in I$$

$$\sum_{m \in M} X_{im} \leq 1\,, \qquad \forall i \in I$$

$$\sum_{i \in I} \sum_{m \in M} X_{im} \ = P, \qquad \forall j \in J$$

$$X_{im} \in \{0,1\}, \forall i \in I, m \in M$$

$$Y_{ij} \ \in \{0,1\}, \forall i \in I, j \in J$$

The descriptions for each notation are as follows:
I = The set of charging station candidate sites
J = The set of demand points
M = Set of charging station levels
F_{im} = Investment cost to build charging station i level k
$dist_{ij}$ = The distance between charging station i to demand point j
C = Transportation cost per kilometer
d_j = demand at node j
Cap_m = The service capacity of charging station level k

$$X_{im} = \begin{cases} 1, \text{if we choose the candidate site } i \text{ and transform it into charging station level } m \\ 0, \text{otherwise} \end{cases}$$

$$Y_{ij} = \begin{cases} 1, \text{if demand point } j \text{ is covered by a charging station located at } i \\ 0, \text{otherwise} \end{cases}$$

The objective function (1) is to minimize the transformation cost. Constraint (2) states that each demand point should be covered by at least one charging station. Constraint (3) means that the service can be offered only if the charging station is located in this candidate site. Constraint (4) restricts the service capacity of the charging station. Constraint (5) means one candidate site can only be transformed into a one-grade charging station. Constraint (6) means we want to locate exactly P facilities. Finally, constraints (7) and (8) are the integrality constraint. The data collected will be processed using a distance-based approach and solving by the ILOG CPLEX software, the results of data processing are to find the location of gas stations that will be used to build charging stations.

3. Result and Analysis

Case Study in Semarang City

This research was conducted with a case study in the city of Semarang. Semarang City is a city located in the province of Central Java. This city is 373.8 km2. There are 16 districts in this city with the largest Mijen district. The daily transportation used by the people of Semarang is various, some are using motorbikes, cars, or public transportation. However, not many people use electric vehicles as private vehicles, because there are no public charging station facilities in the city of Semarang. Based on the results of the identification and data collection of districts in Semarang using Google Maps, there are 16 districts in Semarang City. The following Table 1 presents districts in Semarang City. Figure 4 below describes a map of the city of Semarang.

Table 1. District in Semarang City

No	Districts	Code
1	Semarang Tengah	A
2	Semarang Timur	B
3	Semarang Utara	C
4	Semarang Selatan	D
5	Semarang Barat	E
6	Gajah Mungkur	F

7	Ngaliyan	G
8	Mijen	H
9	Gunungpati	I
10	Candisari	J
11	Genuk	K
12	Gayamsari	L
13	Banyumanik	M
14	Pedurungan	N
15	Tembalang	O
16	Tugu	P

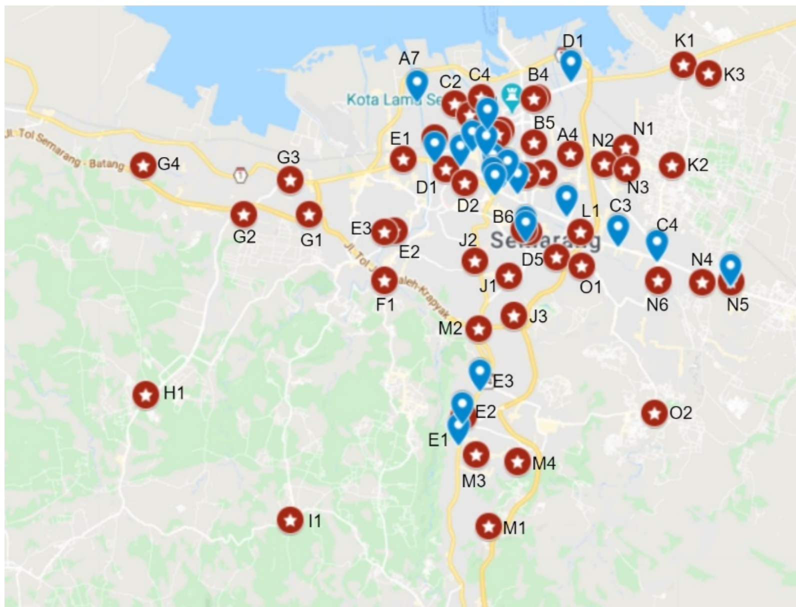

Figure 3. Semarang city map

Based on the results of identification and data collection of markets and malls in Semarang using Google Maps, there are 76 markets and malls located in the city of Semarang. Here Tables 2 and 3 present the coordinates of candidates for charging station locations.

Table 2. Mall in Semarang

No	Potential Facilities	Coordinate
1	A1	-6.990193, 110.424540
2	A2	-6.988915, 110.423993
3	A3	-6.982825, 110.411903
4	A4	-6.978834, 110.415612
5	A5	-6.986568, 110.422342
6	A6	-6.980585, 110.420180
7	A7	-6.964121, 110.398872
8	A8	-6.992273, 110.429568
9	A9	-6.972986, 110.420488
10	A10	-6.987937, 110.426438
11	B1	-6.990497, 110.421741
12	B2	-6.991883, 110.422800
13	B3	-6.982552, 110.404450
14	B4	-7.005271, 110.432136
15	B5	-7.001810, 110.433595
16	B6	-7.006351, 110.432324
17	C1	-7.020217, 110.494598

18	C2	-7.019291, 110.494416
19	C3	-7.007781, 110.460300
20	C4	-7.012191, 110.472090
21	D1	-6.958208, 110.446182
22	D2	-6.998214, 110.444392
23	E1	-7.066897, 110.411240
24	E2	-7.061445, 110.413115

Table 3. Market in Semarang

No	Potential Facilities	Coordinate
1	A1	-6.969656, 110.423933
2	A2	-6.972553, 110.423364
3	A3	-6.970412, 110.428793
4	A4	-6.979271, 110.445252
5	A5	-6.973599, 110.423740
6	A6	-6.974510, 110.426154
7	B1	-6.985163, 110.437552
8	B2	-6.985775, 110.432283
9	B3	-6.961968, 110.435778
10	B4	-6.962671, 110.434704
11	B5	-6.975827, 110.434424
12	C1	-6.974665, 110.404249
13	C2	-6.964175, 110.410687
14	C3	-6.967586, 110.415121
15	C4	-6.962071, 110.418428
16	D1	-6.984272, 110.407796
17	D2	-6.988031, 110.413930
18	D3	-7.002960, 110.433131
19	D4	-7.001971, 110.431474
20	D5	-7.010310, 110.441261
21	E1	-6.979356, 110.394880
22	E2	-7.002544, 110.392398
23	E3	-7.828032, 110.809222
24	F1	-7.017623, 110.389410
25	G1	-6.997847, 110.366443
26	G2	-7.001204, 110.351174
27	G3	-6.987125, 110.360773
28	G4	-6.973707, 110.303504
29	H1	-7.051803, 110.317092
30	I1	-7.089725, 110.360924
31	J1	-7.015950, 110.427049
32	J2	-7.011673, 110.416591
33	J3	-7.027955, 110.428409
34	K1	-6.952249, 110.479640
35	K2	-6.982524, 110.476592
36	K3	-6.955123, 110.487720
37	L1	-6.964982, 110.445710
38	L2	-7.002553, 110.448801
39	M1	-7.091490, 110.420870
40	M2	-7.031963, 110.417721
41	M3	-7.069800, 110.417215
42	M4	-7.072058, 110.429788
43	M5	-7.058219, 110.413331
44	N1	-6.977495, 110.462332

45	N2	-6.982495, 110.454820
46	N3	-6.984192, 110.462854
47	N4	-7.018070, 110.485650
48	N5	-7.017859, 110.494575
49	N6	-7.017290, 110.472087
50	O1	-7.012987, 110.449101
51	O2	-7.057171, 110.471081

Numerical Example

In this study, all citizens or communities are assumed to own motorcycles. The number of charging requests is assumed to be equal to the number of electric vehicle users. Population data is obtained through the website of the Central Statistics Agency of Semarang. Table 4 shows population data of Semarang City

Table 4. Semarang City Population Data for 2019

No	District	Area	Total Population	
			n	%
1	A	6,14	61.102	3,37%
2	B	7,70	75.762	4,18%
3	C	10,97	119.647	6,60%
4	D	5,93	70.522	3,89%
5	E	21,74	165.048	9,10%
6	F	9,07	60.679	3,34%
7	G	37,99	165.171	9,10%
8	H	57,55	76.037	4,19%
9	I	54,11	118.76	6,55%
10	J	6,54	76.857	4,24%
11	K	27,39	119.01	6,56%
12	L	6,18	83.036	4,57%
13	M	25,69	164.953	9,09%
14	N	20,72	214.689	11,83%
15	O	44,20	209.504	11,55%
16	P	31,78	33.333	1,84%
Total		373,70	1.814.110	100,00%

The distance obtained between charging station i to demand point j from google maps. So that the results obtained from the distance between the mall and the district, can be seen in Table 5.

Table 5. Data Distance between malls and district in Semarang city

District	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B1	B2	B3	B4	B5	C1	C2	C3	C4	D1	D2	E1	E2	E3
A	2	1.7	1.8	0.85	1.3	0.16	5.3	2.6	1	2.3	2.2	0.95	2.7	4.6	4.7	10.7	10.3	6.5	9.2	4.6	4.4	13.7	11.8	9.8
B	3.4	3.1	3.9	3.3	3.4	3.7	7.8	3	2.4	3.1	4.2	4.1	5.2	3.8	3.9	9.5	9.2	6	8	3.3	4	13.8	11.9	9.9
C	6.3	5.6	3.6	2.9	4.1	4.1	4.4	6.6	3.3	6.3	6.2	3.3	4.6	8.5	8.6	19.4	19	15.2	17.9	5.4	8.4	24.1	15	13
D	1.4	1.6	3.8	3.6	2.4	2.7	6.2	1	3.4	1.7	1.4	3.4	3.6	1.1	1.2	8.4	8.1	4.3	7	6.4	2.2	10.9	9.2	7.3
E	6.2	6	5.6	5.1	5.7	6.3	4.4	6.9	5.6	6.6	6.5	5.6	4.9	8.9	9	14.9	14.6	10.7	13.4	9.1	8.7	20.7	15.9	14
F	4.7	4.5	5.1	5.8	5.3	5.5	7.8	5.4	6.3	5.1	4.2	6.2	5.9	4.2	4.3	13.5	15.6	9.2	11.7	9.9	7.2	11	7.9	6
G	13.7	13.4	13	12.6	13.1	13.8	12.4	14.3	13.1	14	13.9	13	12.4	16.3	16.4	27.3	27	23.1	25.9	16.6	16.2	24.4	19.7	17.8
H	17.2	17	16.6	16.2	17.2	17.4	16	17.9	16.6	17.6	17.5	16.6	15.9	19.9	20	28.4	28	24.2	26.9	20.2	19.7	20.2	20.9	18.8
I	16.5	16.3	15.6	16.3	16.5	17.4	16.8	17.2	16.8	16.9	16.1	16.8	15.4	20.3	17.4	28.5	28.1	24.3	27	27.8	23.9	13.6	14.4	15.7
J	4.6	5.2	7.4	7.3	6.1	6.4	9.8	4.1	7.1	4.9	5	7.1	7.1	3.2	3.4	10.6	10.2	6.4	8.4	9.5	5.2	8.7	7	5
K	10.9	10.5	9.9	9.3	10.9	9.5	13.7	10.4	8.4	10.5	11.6	8.4	10.8	11.2	11.3	8.6	8.3	6.7	7.1	5.6	10.5	22	19.1	17.8
L	3.2	3.8	6.6	5.9	4.7	5	8.3	2.7	5.7	3.5	3.5	5.7	5.7	3.1	3.2	6.3	5.9	2.1	4.8	6.4	0.75	13.5	11.6	10.3
M	12.4	12.2	13.8	14.2	13	13.2	16.2	12	14	12.8	11.9	13.9	13.6	11	11.3	18.2	17.9	14	16.7	17.5	13.7	2.1	2.8	4.1
N	6.7	7.3	9.1	8.4	6.7	6.9	11.9	6.3	7.5	7	7.1	7.6	9.3	6.7	6.8	4.7	4.3	2.1	3.2	7.3	4.8	16.6	14.9	13.6
O	9	9.6	12.3	11.7	10.5	10.7	13.9	8.6	11.5	9.3	9.4	11.4	11.2	6.7	6.9	8.2	7.9	6.6	5.2	12.2	7.1	10.2	9.6	7.6
P	13.7	13.5	13.1	12.7	13.2	13.9	12.5	14.4	13.1	14.1	14	13.1	12.4	16.4	16.5	27.4	27.1	23.3	25.9	16.7	16.2	24.5	19.8	17.8

Table 6. Data distance between market and district in Semarang city

District	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3	F1	G1	G2	G3	G4	H1	I1	J1	J2	J3	K1	K2	K3	L1	L2
A	3	2.2	2.5	2	1.5	4	3.9	5.5	4.8	5.8	6.5	6.9	8.2	10.7	7.7	14.9	17.2	17.9	6.4	4.9	7.6	9.7	8.2	10.5	5	6.7
B	4.2	3.4	3.4	4.4	4.2	3.5	3.7	5.1	7.5	7.9	8.5	9.2	10.7	13.2	10.2	17.4	19.6	20.3	6	6.7	6.7	8.4	5.5	9.2	2.3	6.1
C	0.7	1.5	1.6	4.2	4.3	6.8	6.7	8.4	5.2	6.8	7.3	9.1	8.4	10.8	7.9	15.5	17.8	20.6	9.3	7.9	11.2	10.5	10	11.3	6	9.6
D	5.5	4.7	5.1	3.1	2.6	0.8	0.6	2.5	5.9	5.6	6	7	9.1	11.6	8.6	15.8	17	18	2.6	3.8	4.1	12.8	9.2	13.3	5.4	3.5
E	6	6.2	6.8	4.5	6	8.2	8.2	9.8	1.6	3.7	4	6.2	4	6.9	3	11.1	13.4	16.1	8.9	7.9	10.5	14	13.8	14.8	9.6	11
F	8.9	6.9	8	4.4	4.8	4.4	4.6	5.7	7.6	5.8	6	3.5	9.6	12.1	9.2	16.3	14.7	14.2	3.9	2.1	4.5	20.3	14.2	20.8	9.6	9
G	13.5	13.7	14.6	12	13.4	15.7	15.6	17.7	10.2	11.1	11.5	13.6	6.9	4.5	7.6	6.3	8.7	16.4	16.3	15.3	18.2	22.7	24.1	23.5	17	18.5
H	17.1	17.3	18.2	15.5	15.5	19.7	19.2	21.3	13.7	11.6	14.6	11.4	10.4	8.6	11.1	9.9	0.2	8.9	18.4	16.9	22.9	26.2	24.8	27.1	20.7	22
I	17.9	18.1	18.4	15	15.2	17.5	17.3	18.9	14.6	11.3	13.2	10.3	11.4	13.9	14.5	19.9	8.5	2.7	16.6	16.6	21	32.8	25	33.3	20.8	21.3
J	9.1	8.4	8.6	6.4	5.6	2.7	2.8	3	9.2	7.8	8	7	11.7	14.8	11.2	19.4	19.2	17.3	0.7	3	1.4	14.9	11.3	15.4	8.4	5.2
K	10	10.6	9.2	10.4	10.7	10.9	11.1	10.6	13.1	13.9	14.4	19.7	16.3	18.8	15.8	23	25.3	26.3	15.1	14.4	13.4	2.3	2.5	2.8	6.4	8.2
L	6.2	5.4	5.3	5.3	4.7	4	4.2	4.3	8	8.7	9	10.1	11.2	13.7	10.7	17.9	20.1	20.9	6.4	7.3	7.1	8.6	4.5	9.1	2.4	4.5
M	15.6	15.7	15.7	13.2	12.5	10.5	10.7	10.9	16	14.3	14.3	10.5	13.6	18.3	15.4	24	22.9	12.6	9.4	9.5	9.7	22.5	17.6	23	19.3	14.2
N	9.2	8.4	8.3	8.8	7.4	6.4	6.6	6	11.6	11.4	11.7	13	14.8	17.3	14.3	21.5	23.1	24.1	8.1	9.7	8.8	7.9	3.6	8.4	5.7	3.2
O	13.5	12.7	13	10.8	10	7	7.2	6.1	13.6	12.5	12.7	13.3	16.8	19.2	16.3	26.1	23.9	21.4	8.1	9.7	8.9	13	9.5	13.5	11.8	5.8
P	13.6	13.8	14.7	12	13.5	15.8	15.6	18.7	10.2	11.1	11.5	13.7	7.9	8.8	6.1	4.8	14.4	20.6	16.4	15.4	17.2	21.8	24.2	22.6	17.1	18.5

District	M1	M2	M3	M4	M5	N1	N2	N3	N4	N5	N6	O1	O2	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	C1
A	16.2	7.9	12.9	13.6	11.1	6.6	5.8	6.9	10.7	10.7	8.5	6.5	13	1.3	1.2	1.3	4.1	1.2	2.4	3.4	2.8	3.3	3.2	2.6	4.4
B	16.3	8	12.7	13.7	11.2	3.8	3.1	5	9.6	9.6	7.4	6	12.2	2.2	2.4	2.2	2.5	2.4	0.9	1.7	1.9	1.6	1.4	0.5	7.1
C	26.7	11.1	16.1	16.8	14.3	8	7.3	9.2	13.6	13.6	11.3	9.4	15.9	3.4	3.6	3.4	6.6	3.6	3.9	6.1	5.8	4.1	4	5.1	2.6
D	13.7	5.3	10.3	11.1	8.5	6.2	5.6	5.8	8.1	8.1	6.3	3.4	9.5	4	4.1	4.4	5.2	4.1	3.4	2.7	1.9	5.3	5.1	3	5.5
E	19.7	11.4	16.4	17.1	15.2	11.1	10.4	11.9	15	15	12.8	10.8	17.3	6.6	6.9	6.7	10.1	6.9	7.1	8	7.5	7.9	7.8	8.2	4.3
F	12.4	4	9	9.8	7.2	11.2	9.8	10.8	14.2	14.2	10.5	6.5	12.4	6.8	6.5	6.7	9.4	6.5	7.6	6.9	6.4	8.6	8.5	7.2	6.8
G	26.1	15.8	22.7	23.5	18.5	18.6	17.9	19.8	27	27	22.1	18.6	24.7	14	14.4	14.2	17.2	14.4	14.5	15.5	14.6	15.3	15.2	15.7	11.7
H	18.7	19.8	20.6	22.1	21.4	22.2	21.5	23.3	26	26	24.9	21	29.3	17.3	17.9	17.8	20.8	17.9	18	19	18.2	18.9	18.8	19.3	15.3
I	12.1	18.1	14.1	15.6	14.9	22.3	21.6	22.6	30.4	30.4	25	19.4	22.8	17.8	18.3	17.9	21.2	18.3	18.3	18.7	18.2	19.7	19.6	19	16.1
J	11.4	3.1	8.1	8.8	6.3	8.3	7.7	7.9	10.2	10.2	7.8	3.9	10	7	7.3	7.4	8.1	7.3	6.4	5.7	4.8	8.2	8.1	6	9.1
K	21.6	16.1	19	17.4	19.1	4.5	5.3	4.1	7.7	7.7	6.4	9.2	11.4	8	8.6	8.4	7.2	8.6	7.4	8.7	9.3	6.8	6.8	8.1	12.7
L	18.3	8.5	13.5	14.3	11.7	2.8	1.8	2.8	8.3	8.3	6	4.3	10.4	3.9	4.5	4.3	1.4	4.5	3.2	2.3	2.4	4.1	4	2.9	7.6
M	3.4	6.6	0.6	1.3	2.6	15.6	16.5	16	18.2	18.2	12.8	11.8	7.5	14.9	14.2	14.4	14.1	14.2	14.2	13.6	12.7	15.1	15	13.9	15.5
N	19.3	11.6	15	13.5	13.3	3.5	3.1	3	4.7	4.7	2.5	4.7	7.4	6.9	7.4	7.2	4.3	7.4	6.2	5	5.1	7.1	7	6.4	11.2
O	11.1	9.4	8.5	6.9	8.9	8.5	8.3	8.1	7.2	7.2	4.6	4.7	2.4	11.3	11.6	11.7	9.8	11.6	10.7	9.7	9.1	12.8	13	10.3	13.2
P	27.1	15.9	21	23.5	20	18.7	17.9	19.8	27.5	27.5	20.3	18.7	24.8	14.1	14.4	14.2	17.3	14.4	14.6	15.5	15	15.4	15.3	16.2	11.8

After the desired data has been collected, it will be used to run the model using the ILOG CPLEX software, where this software is a tool that can be used to solve supply chain problems according to the decision level and the main activity cycle. Operation functions in the ILOG CPLEX are used as coding functions in creating calculation algorithms. The functions that exist in the ILOG CPLEX are basic functions that can be used to solve simple to quite complex problems (Sutopo, et. al., 2016).

3.3 Result

From the results of operation using ILOG CPLEX obtained the results that optimum results from the charging station location there are 4 locations with each district one charging point charging station with the following details.

Table 7. Selected Location from Malls

No	Selected Location	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	A4	v	v	v		v		v	v	v							v
2	B4				v		v				v						
3	C3											v	v		v	v	
4	E1													v			

Table 8. Selected Location from market

No	Selected Location	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	D1	**v**	**v**	**v**	**v**	**v**	**v**				**v**		**v**				**v**
2	H1							**v**	**v**	**v**							
3	M3													**v**			
4	N6											**v**			**v**	**v**	

From 4 locations, this charging station can maximize the coverage of selected districts and with the decision of 1 location point in each district, so that these results can answer the objectives. This model can provide input to local governments regarding the optimal solution in determining the location of the charging station. However, the weakness of this model is that it still needed to further study about risk and uncertainty of total costs when the government decides to open more charging stations so that the government cannot estimate the budget funds needed for charging station construction projects. And another risk is that the government cannot anticipate queues and estimate the number of queues at charging stations. This is because the model does not consider scheduling and traffic congestion.

4. Conclusion

The development of a supply chain network model for charging station cases in Semarang has been carried out. The model has been run taking into account the location of the selected candidate's charging station. This model can provide input to local governments on optimal solutions in determining the location of Electric Vehicle charging stations. However, the weakness of this model is that it still uses numeric examples in determining the demand of electric vehicle users, so that the results obtained have not fully covered the demand in the city of Semarang. Therefore, the shortcomings and limitations of this model need to be accommodated in further research by improving data collection and processing methods and adding scheduling parameters, traffic density, and maximum battery capacity as well as the duration of recharging on the model, to answer the problem in a real and accurate way under real conditions.

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